PGMcpp: PRIMED Grid Modelling (in C++)

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Chapter 1

Hierarchical Index

1.1 Class Hierarchy

This inheritance list is sorted roughly, but not completely, alphabetically:

Chapter 2

Class Index

2.1 Class List

Here are the classes, structs, unions and interfaces with brief descriptions:

Chapter 3

File Index

3.1 File List

Here is a list of all files with brief descriptions:

Chapter 4

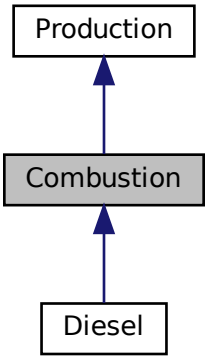
Class Documentation

4.1 Combustion Class Reference

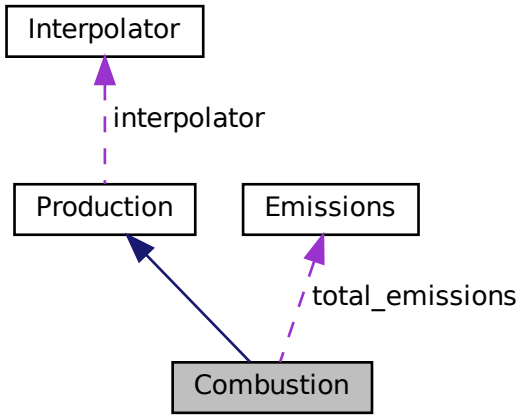
The root of the Combustion branch of the Production hierarchy. This branch contains derived classes which model the production of energy by way of combustibles.

`#include <Combustion.h>`

Inheritance diagram for Combustion:



Collaboration diagram for Combustion:



Public Member Functions

- Combustion (void)

  Constructor (dummy) for the Combustion class.
- Combustion (int, double, CombustionInputs, std::vector< double > *)

  Constructor (intended) for the Combustion class.
- virtual void handleReplacement (int)

  Method to handle asset replacement and capital cost incursion, if applicable.
- void computeFuelAndEmissions (void)

  Helper method to compute the total fuel consumption and emissions over the Model run.
- void computeEconomics (std::vector< double > *)

  Helper method to compute key economic metrics for the Model run.
- virtual double requestProductionkW (int, double, double)
- virtual double commit (int, double, double, double)

  Method which takes in production and load for the current timestep, computes and records dispatch and curtailment, and then returns remaining load.
- double getFuelConsumptionL (double, double)

  Method which takes in production and returns volume of fuel burned over the given interval of time.
- Emissions getEmissionskg (double)

  Method which takes in volume of fuel consumed and returns mass spectrum of resulting emissions.
- void writeResults (std::string, std::vector< double > *, int, int=-1)

  Method which writes Combustion results to an output directory.
- virtual ~Combustion (void)

  Destructor for the Combustion class.

Public Attributes

- CombustionType type

  The type (CombustionType) of the asset.
- FuelMode fuel_mode

  The fuel mode to use in modelling fuel consumption.
- Emissions total_emissions

  An Emissions structure for holding total emissions [kg].
- double fuel_cost_L

  The cost of fuel [1/L] (undefined currency).
- double nominal_fuel_escalation_annual

  The nominal, annual fuel escalation rate to use in computing model economics.
- double real_fuel_escalation_annual

  The real, annual fuel escalation rate used in computing model economics. Is computed from the given nominal inflation and discount rates.
- double linear_fuel_slope_LkWh

  The slope [L/kWh] to use in computing linearized fuel consumption. This is fuel consumption per unit energy produced.
- double linear_fuel_intercept_LkWh

  The intercept [L/kWh] to use in computing linearized fuel consumption. This is fuel consumption per unit energy produced.
- double cycle_charging_setpoint

  The cycle charging set point (the load ratio at which to produce when running in cycle charging mode).
- double CO2_emissions_intensity_kgL

  Carbon dioxide (CO2) emissions intensity [kg/L].
- double CO_emissions_intensity_kgL

  Carbon monoxide (CO) emissions intensity [kg/L].
- double NOx_emissions_intensity_kgL

  Nitrogen oxide (NOx) emissions intensity [kg/L].
- double SOx_emissions_intensity_kgL

  Sulfur oxide (SOx) emissions intensity [kg/L].
- double CH4_emissions_intensity_kgL

  Methane (CH4) emissions intensity [kg/L].
- double PM_emissions_intensity_kgL

  Particulate Matter (PM) emissions intensity [kg/L].
- double total_fuel_consumed_L

  The total fuel consumed [L] over a model run.
- std::string fuel_mode_str

  A string describing the fuel mode of the asset.
- std::vector< double > fuel_consumption_vec_L

  A vector of fuel consumed [L] over each modelling time step.
- std::vector< double > fuel_cost_vec

  A vector of fuel costs (undefined currency) incurred over each modelling time step. These costs are not discounted (i.e., these are actual costs).
- std::vector< double > CO2_emissions_vec_kg

  A vector of carbon dioxide (CO2) emitted [kg] over each modelling time step.
- std::vector< double > CO_emissions_vec_kg

  A vector of carbon monoxide (CO) emitted [kg] over each modelling time step.
- std::vector< double > NOx_emissions_vec_kg

  A vector of nitrogen oxide (NOx) emitted [kg] over each modelling time step.
- std::vector< double > SOx_emissions_vec_kg

  A vector of sulfur oxide (SOx) emitted [kg] over each modelling time step.
- std::vector< double > CH4_emissions_vec_kg

  A vector of methane (CH4) emitted [kg] over each modelling time step.
- std::vector< double > PM_emissions_vec_kg

  A vector of particulate matter (PM) emitted [kg] over each modelling time step.

Private Member Functions

- void __checkInputs (CombustionInputs)

  Helper method to check inputs to the Combustion constructor.
- virtual void __writeSummary (std::string)
- virtual void __writeTimeSeries (std::string, std::vector< double > *, int=-1)

4.1.1 Detailed Description

The root of the Combustion branch of the Production hierarchy. This branch contains derived classes which model the production of energy by way of combustibles.

4.1.2 Constructor & Destructor Documentation

4.1.2.1 Combustion() [1/2]

```
Combustion::Combustion (
            void  )
```

Constructor (dummy) for the Combustion class.

```
117 {
118     return;
119 }   /* Combustion() */
```

4.1.2.2 Combustion() [2/2]

```
Combustion::Combustion (
            int n_points,
            double n_years,
            CombustionInputs combustion_inputs,
            std::vector< double > * time_vec_hrs_ptr )
```

Constructor (intended) for the Combustion class.

Parameters

n_points	The number of points in the modelling time series.
n_years	The number of years being modelled.
combustion_inputs	A structure of Combustion constructor inputs.
time_vec_hrs_ptr	A pointer to the vector containing the modelling time series.

```
151   :
152 Production(
153     n_points,
154     n_years,
155     combustion_inputs.production_inputs,
156     time_vec_hrs_ptr
157 )
```

```
158 {
159     //  1. check inputs
160     this->__checkInputs(combustion_inputs);
161 
162     //  2. set attributes
163     this->fuel_mode = combustion_inputs.fuel_mode;
164 
165     switch (this->fuel_mode) {
166         case (FuelMode :: FUEL_MODE_LINEAR): {
167             this->fuel_mode_str = "FUEL_MODE_LINEAR";
168 
169             break;
170         }
171 
172         case (FuelMode :: FUEL_MODE_LOOKUP): {
173             this->fuel_mode_str = "FUEL_MODE_LOOKUP";
174 
175             this->interpolator.addData1D(
176                 0,
177                 combustion_inputs.path_2_fuel_interp_data
178             );
179 
180             break;
181         }
182 
183         default: {
184             std::string error_str = "ERROR:  Combustion():  ";
185             error_str += "fuel mode ";
186             error_str += std::to_string(this->fuel_mode);
187             error_str += " not recognized";
188 
189             #ifdef _WIN32
190                 std::cout « error_str « std::endl;
191             #endif
192 
193             throw std::runtime_error(error_str);
194 
195             break;
196         }
197     }
198 
199     this->fuel_cost_L = 0;
200     this->nominal_fuel_escalation_annual =
201         combustion_inputs.nominal_fuel_escalation_annual;
202 
203     this->real_fuel_escalation_annual = this->computeRealDiscountAnnual(
204         combustion_inputs.nominal_fuel_escalation_annual,
205         combustion_inputs.production_inputs.nominal_discount_annual
206     );
207 
208     this->linear_fuel_slope_LkWh = 0;
209     this->linear_fuel_intercept_LkWh = 0;
210 
211     this->cycle_charging_setpoint = combustion_inputs.cycle_charging_setpoint;
212 
213     this->CO2_emissions_intensity_kgL = 0;
214     this->CO_emissions_intensity_kgL = 0;
215     this->NOx_emissions_intensity_kgL = 0;
216     this->SOx_emissions_intensity_kgL = 0;
217     this->CH4_emissions_intensity_kgL = 0;
218     this->PM_emissions_intensity_kgL = 0;
219 
220     this->total_fuel_consumed_L = 0;
221 
222     this->fuel_consumption_vec_L.resize(this->n_points, 0);
223     this->fuel_cost_vec.resize(this->n_points, 0);
224 
225     this->CO2_emissions_vec_kg.resize(this->n_points, 0);
226     this->CO_emissions_vec_kg.resize(this->n_points, 0);
227     this->NOx_emissions_vec_kg.resize(this->n_points, 0);
228     this->SOx_emissions_vec_kg.resize(this->n_points, 0);
229     this->CH4_emissions_vec_kg.resize(this->n_points, 0);
230     this->PM_emissions_vec_kg.resize(this->n_points, 0);
231 
232     //  3. construction print
233     if (this->print_flag) {
234         std::cout « "Combustion object constructed at " « this « std::endl;
235     }
236 
237     return;
238 }   /* Combustion() */
```

4.1.2.3 ~Combustion()

```
Combustion::~Combustion (
            void  )  [virtual]
```

Destructor for the Combustion class.

```
576 {
577     //  1. destruction print
578     if (this->print_flag) {
579         std::cout « "Combustion object at " « this « " destroyed" « std::endl;
580     }
581
582     return;
583 }   /* ~Combustion() */
```

4.1.3 Member Function Documentation

4.1.3.1 __checkInputs()

```
void Combustion::__checkInputs (
            CombustionInputs combustion_inputs )  [private]
```

Helper method to check inputs to the Combustion constructor.

Parameters

combustion_inputs	A structure of Combustion constructor inputs.

```
65 {
66     // 1. if FUEL_MODE_LOOKUP, check that path is given
67     if (
68         combustion_inputs.fuel_mode == FuelMode :: FUEL_MODE_LOOKUP and
69         combustion_inputs.path_2_fuel_interp_data.empty()
70     ) {
71         std::string error_str = "ERROR:  Combustion()  fuel mode was set to ";
72         error_str += "FuelMode::FUEL_MODE_LOOKUP, but no path to fuel interpolation ";
73         error_str += "data was given";
74
75         #ifdef _WIN32
76             std::cout « error_str « std::endl;
77         #endif
78
79         throw std::invalid_argument(error_str);
80     }
81
82     // 2. cycle charging setpoint
83     if (
84         combustion_inputs.cycle_charging_setpoint < 0 or
85         combustion_inputs.cycle_charging_setpoint > 1
86     ) {
87         std::string error_str = "ERROR:  Combustion()  cycle charging set point ";
88         error_str += "must be in the closed interval [0, 1].";
89
90         #ifdef _WIN32
91             std::cout « error_str « std::endl;
92         #endif
93
94         throw std::invalid_argument(error_str);
95     }
96
97     return;
98 }   /* __checkInputs() */
```

4.1.3.2 __writeSummary()

```
virtual void Combustion::__writeSummary (
            std::string  )  [inline], [private], [virtual]
```

Reimplemented in Diesel.

```
131 {return;}
```

4.1.3.3 __writeTimeSeries()

```
virtual void Combustion::__writeTimeSeries (
            std::string ,
            std::vector< double > * ,
            int  = -1 )  [inline], [private], [virtual]
```

Reimplemented in Diesel.

```
136         {return;}
```

4.1.3.4 commit()

```
double Combustion::commit (
            int timestep,
            double dt_hrs,
            double production_kW,
            double load_kW )  [virtual]
```

Method which takes in production and load for the current timestep, computes and records dispatch and curtailment, and then returns remaining load.

Parameters

timestep	The timestep (i.e., time series index) for the request.
dt_hrs	The interval of time [hrs] associated with the timestep.
production_kW	The production [kW] of the asset in this timestep.
load_kW	The load [kW] passed to the asset in this timestep.

Returns

The load [kW] remaining after the dispatch is deducted from it.

Reimplemented from Production.

Reimplemented in Diesel.

```
368 {
369     //  1. invoke base class method
370     load_kW = Production :: commit(
371         timestep,
372         dt_hrs,
373         production_kW,
374         load_kW
```

```
375     );
376
377
378     if (this->is_running) {
379         //  2. compute and record fuel consumption
380         double fuel_consumed_L = this->getFuelConsumptionL(dt_hrs, production_kW);
381         this->fuel_consumption_vec_L[timestep] = fuel_consumed_L;
382
383         //  3. compute and record emissions
384         Emissions emissions = this->getEmissionskg(fuel_consumed_L);
385         this->CO2_emissions_vec_kg[timestep] = emissions.CO2_kg;
386         this->CO_emissions_vec_kg[timestep] = emissions.CO_kg;
387         this->NOx_emissions_vec_kg[timestep] = emissions.NOx_kg;
388         this->SOx_emissions_vec_kg[timestep] = emissions.SOx_kg;
389         this->CH4_emissions_vec_kg[timestep] = emissions.CH4_kg;
390         this->PM_emissions_vec_kg[timestep] = emissions.PM_kg;
391
392         //  4. incur fuel costs
393         this->fuel_cost_vec[timestep] = fuel_consumed_L * this->fuel_cost_L;
394     }
395
396     return load_kW;
397 }   /* commit() */
```

4.1.3.5 computeEconomics()

```
void Combustion::computeEconomics (
            std::vector< double > * time_vec_hrs_ptr )  [virtual]
```

Helper method to compute key economic metrics for the Model run.

Ref: HOMER [2023b]

Parameters

time_vec_hrs_ptr	A pointer to the time_vec_hrs attribute of the ElectricalLoad.

Reimplemented from Production.

```
312 {
313     //  1. account for fuel costs in net present cost
314     double t_hrs = 0;
315     double real_fuel_escalation_scalar = 0;
316
317     for (int i = 0; i < this->n_points; i++) {
318         t_hrs = time_vec_hrs_ptr->at(i);
319
320         real_fuel_escalation_scalar = 1.0 / pow(
321             1 + this->real_fuel_escalation_annual,
322             t_hrs / 8760
323         );
324
325         this->net_present_cost += real_fuel_escalation_scalar * this->fuel_cost_vec[i];
326     }
327
328     //  2. invoke base class method
329     Production :: computeEconomics(time_vec_hrs_ptr);
330
331     return;
332 }   /* computeEconomics() */
```

4.1.3.6 computeFuelAndEmissions()

```
void Combustion::computeFuelAndEmissions (
            void  )
```

Helper method to compute the total fuel consumption and emissions over the Model run.

```
280 {
281     for (int i = 0; i < n_points; i++) {
282         this->total_fuel_consumed_L += this->fuel_consumption_vec_L[i];
283 
284         this->total_emissions.CO2_kg += this->CO2_emissions_vec_kg[i];
285         this->total_emissions.CO_kg += this->CO_emissions_vec_kg[i];
286         this->total_emissions.NOx_kg += this->NOx_emissions_vec_kg[i];
287         this->total_emissions.SOx_kg += this->SOx_emissions_vec_kg[i];
288         this->total_emissions.CH4_kg += this->CH4_emissions_vec_kg[i];
289         this->total_emissions.PM_kg += this->PM_emissions_vec_kg[i];
290     }
291 
292     return;
293 }   /* computeFuelAndEmissions() */
```

4.1.3.7 getEmissionskg()

```
Emissions Combustion::getEmissionskg (
            double fuel_consumed_L )
```

Method which takes in volume of fuel consumed and returns mass spectrum of resulting emissions.

Parameters

fuel_consumed_L	The volume of fuel consumed [L].

Returns

A structure containing the mass spectrum of resulting emissions.

```
476                                                     {
477     Emissions emissions;
478 
479     emissions.CO2_kg = this->CO2_emissions_intensity_kgL * fuel_consumed_L;
480     emissions.CO_kg = this->CO_emissions_intensity_kgL * fuel_consumed_L;
481     emissions.NOx_kg = this->NOx_emissions_intensity_kgL * fuel_consumed_L;
482     emissions.SOx_kg = this->SOx_emissions_intensity_kgL * fuel_consumed_L;
483     emissions.CH4_kg = this->CH4_emissions_intensity_kgL * fuel_consumed_L;
484     emissions.PM_kg = this->PM_emissions_intensity_kgL * fuel_consumed_L;
485 
486     return emissions;
487 }   /* getEmissionskg() */
```

4.1.3.8 getFuelConsumptionL()

```
double Combustion::getFuelConsumptionL (
            double dt_hrs,
            double production_kW )
```

Method which takes in production and returns volume of fuel burned over the given interval of time.

Parameters

dt_hrs	The interval of time [hrs] associated with the timestep.
production_kW	The production [kW] of the asset in this timestep.

Returns

The volume of fuel consumed [L].

```
419 {
420     double fuel_consumed_L = 0;
421 
422     switch (this->fuel_mode) {
423         case (FuelMode :: FUEL_MODE_LINEAR): {
424             fuel_consumed_L = (
425                 this->linear_fuel_slope_LkWh * production_kW +
426                 this->linear_fuel_intercept_LkWh * this->capacity_kW
427             ) * dt_hrs;
428 
429             break;
430         }
431 
432         case (FuelMode :: FUEL_MODE_LOOKUP): {
433             double load_ratio = production_kW / this->capacity_kW;
434 
435             fuel_consumed_L = this->interpolator.interp1D(0, load_ratio) * dt_hrs;
436 
437             break;
438         }
439 
440         default: {
441             std::string error_str = "ERROR:  Combustion::getFuelConsumptionL():  ";
442             error_str += "fuel mode ";
443             error_str += std::to_string(this->fuel_mode);
444             error_str += " not recognized";
445 
446             #ifdef _WIN32
447                 std::cout « error_str « std::endl;
448             #endif
449 
450             throw std::runtime_error(error_str);
451 
452             break;
453         }
454     }
455 
456     return fuel_consumed_L;
457 } /* getFuelConsumptionL() */
```

4.1.3.9 handleReplacement()

```
void Combustion::handleReplacement (
            int timestep )  [virtual]
```

Method to handle asset replacement and capital cost incursion, if applicable.

Parameters

timestep	The current time step of the Model run.

Reimplemented from Production.

Reimplemented in Diesel.

```
256 {
257     //  1. reset attributes
258     //...
259 
260     //  2. invoke base class method
261     Production :: handleReplacement(timestep);
262 
263     return;
264 }   /* __handleReplacement() */
```

4.1.3.10 requestProductionkW()

```
virtual double Combustion::requestProductionkW (
            int ,
            double ,
            double  )  [inline], [virtual]
```

Reimplemented in Diesel.

```
184 {return 0;}
```

4.1.3.11 writeResults()

```
void Combustion::writeResults (
            std::string write_path,
            std::vector< double > * time_vec_hrs_ptr,
            int combustion_index,
            int max_lines = -1 )
```

Method which writes Combustion results to an output directory.

Parameters

write_path	A path (either relative or absolute) to the directory location where results are to be written. If already exists, will overwrite.
time_vec_hrs_ptr	A pointer to the time_vec_hrs attribute of the ElectricalLoad.
combustion_index	An integer which corresponds to the index of the Combustion asset in the Model.
max_lines	The maximum number of lines of output to write. If <0, then all available lines are written. If =0, then only summary results are written.

```
523 {
524     //  1. handle sentinel
525     if (max_lines < 0) {
526         max_lines = this->n_points;
527     }
528 
529     //  2. create subdirectories
530     write_path += "Production/";
531     if (not std::filesystem::is_directory(write_path)) {
532         std::filesystem::create_directory(write_path);
533     }
534 
535     write_path += "Combustion/";
536     if (not std::filesystem::is_directory(write_path)) {
537         std::filesystem::create_directory(write_path);
538     }
539 
540     write_path += this->type_str;
541     write_path += "_";
542     write_path += std::to_string(int(ceil(this->capacity_kW)));
543     write_path += "kW_idx";
544     write_path += std::to_string(combustion_index);
545     write_path += "/";
546     std::filesystem::create_directory(write_path);
547 
548     //  3. write summary
549     this->__writeSummary(write_path);
550 
551     //  4. write time series
552     if (max_lines > this->n_points) {
553         max_lines = this->n_points;
554     }
555 
556     if (max_lines > 0) {
557         this->__writeTimeSeries(write_path, time_vec_hrs_ptr, max_lines);
558     }
```

```
559
560     return;
561 }   /* writeResults() */
```

4.1.4 Member Data Documentation

4.1.4.1 CH4_emissions_intensity_kgL

```
double Combustion::CH4_emissions_intensity_kgL
```

Methane (CH4) emissions intensity [kg/L].

4.1.4.2 CH4_emissions_vec_kg

```
std::vector<double> Combustion::CH4_emissions_vec_kg
```

A vector of methane (CH4) emitted [kg] over each modelling time step.

4.1.4.3 CO2_emissions_intensity_kgL

```
double Combustion::CO2_emissions_intensity_kgL
```

Carbon dioxide (CO2) emissions intensity [kg/L].

4.1.4.4 CO2_emissions_vec_kg

```
std::vector<double> Combustion::CO2_emissions_vec_kg
```

A vector of carbon dioxide (CO2) emitted [kg] over each modelling time step.

4.1.4.5 CO_emissions_intensity_kgL

```
double Combustion::CO_emissions_intensity_kgL
```

Carbon monoxide (CO) emissions intensity [kg/L].

4.1.4.6 CO_emissions_vec_kg

```
std::vector<double> Combustion::CO_emissions_vec_kg
```

A vector of carbon monoxide (CO) emitted [kg] over each modelling time step.

4.1.4.7 cycle_charging_setpoint

```
double Combustion::cycle_charging_setpoint
```

The cycle charging set point (the load ratio at which to produce when running in cycle charging mode).

4.1.4.8 fuel_consumption_vec_L

```
std::vector<double> Combustion::fuel_consumption_vec_L
```

A vector of fuel consumed [L] over each modelling time step.

4.1.4.9 fuel_cost_L

```
double Combustion::fuel_cost_L
```

The cost of fuel [1/L] (undefined currency).

4.1.4.10 fuel_cost_vec

```
std::vector<double> Combustion::fuel_cost_vec
```

A vector of fuel costs (undefined currency) incurred over each modelling time step. These costs are not discounted (i.e., these are actual costs).

4.1.4.11 fuel_mode

```
FuelMode Combustion::fuel_mode
```

The fuel mode to use in modelling fuel consumption.

4.1.4.12 fuel_mode_str

```
std::string Combustion::fuel_mode_str
```

A string describing the fuel mode of the asset.

4.1.4.13 linear_fuel_intercept_LkWh

```
double Combustion::linear_fuel_intercept_LkWh
```

The intercept [L/kWh] to use in computing linearized fuel consumption. This is fuel consumption per unit energy produced.

4.1.4.14 linear_fuel_slope_LkWh

```
double Combustion::linear_fuel_slope_LkWh
```

The slope [L/kWh] to use in computing linearized fuel consumption. This is fuel consumption per unit energy produced.

4.1.4.15 nominal_fuel_escalation_annual

```
double Combustion::nominal_fuel_escalation_annual
```

The nominal, annual fuel escalation rate to use in computing model economics.

4.1.4.16 NOx_emissions_intensity_kgL

```
double Combustion::NOx_emissions_intensity_kgL
```

Nitrogen oxide (NOx) emissions intensity [kg/L].

4.1.4.17 NOx_emissions_vec_kg

```
std::vector<double> Combustion::NOx_emissions_vec_kg
```

A vector of nitrogen oxide (NOx) emitted [kg] over each modelling time step.

4.1.4.18 PM_emissions_intensity_kgL

```
double Combustion::PM_emissions_intensity_kgL
```

Particulate Matter (PM) emissions intensity [kg/L].

4.1.4.19 PM_emissions_vec_kg

```
std::vector<double> Combustion::PM_emissions_vec_kg
```

A vector of particulate matter (PM) emitted [kg] over each modelling time step.

4.1.4.20 real_fuel_escalation_annual

```
double Combustion::real_fuel_escalation_annual
```

The real, annual fuel escalation rate used in computing model economics. Is computed from the given nominal inflation and discount rates.

4.1.4.21 SOx_emissions_intensity_kgL

```
double Combustion::SOx_emissions_intensity_kgL
```

Sulfur oxide (SOx) emissions intensity [kg/L].

4.1.4.22 SOx_emissions_vec_kg

```
std::vector<double> Combustion::SOx_emissions_vec_kg
```

A vector of sulfur oxide (SOx) emitted [kg] over each modelling time step.

4.1.4.23 total_emissions

```
Emissions Combustion::total_emissions
```

An Emissions structure for holding total emissions [kg].

4.1.4.24 total_fuel_consumed_L

```
double Combustion::total_fuel_consumed_L
```

The total fuel consumed [L] over a model run.

4.1.4.25 type

```
CombustionType Combustion::type
```

The type (CombustionType) of the asset.

The documentation for this class was generated from the following files:

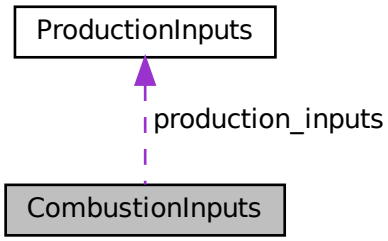
- header/Production/Combustion/Combustion.h
- source/Production/Combustion/Combustion.cpp

4.2 CombustionInputs Struct Reference

A structure which bundles the necessary inputs for the Combustion constructor. Provides default values for every necessary input. Note that this structure encapsulates ProductionInputs.

```
#include <Combustion.h>
```

Collaboration diagram for CombustionInputs:



Public Attributes

- ProductionInputs production_inputs

  An encapsulated ProductionInputs instance.
- FuelMode fuel_mode = FuelMode :: FUEL_MODE_LINEAR

  The fuel mode to use in modelling fuel consumption.
- double nominal_fuel_escalation_annual = 0.05

  The nominal, annual fuel escalation rate to use in computing model economics.
- double cycle_charging_setpoint = 0.85

  The cycle charging set point (the load ratio at which to produce when running in cycle charging mode).
- std::string path_2_fuel_interp_data = ""

  A path (either relative or absolute) to a set of fuel consumption data.

4.2.1 Detailed Description

A structure which bundles the necessary inputs for the Combustion constructor. Provides default values for every necessary input. Note that this structure encapsulates ProductionInputs.

4.2.2 Member Data Documentation

4.2.2.1 cycle_charging_setpoint

```
double CombustionInputs::cycle_charging_setpoint = 0.85
```

The cycle charging set point (the load ratio at which to produce when running in cycle charging mode).

4.2.2.2 fuel_mode

```
FuelMode CombustionInputs::fuel_mode = FuelMode ::  FUEL_MODE_LINEAR
```

The fuel mode to use in modelling fuel consumption.

4.2.2.3 nominal_fuel_escalation_annual

```
double CombustionInputs::nominal_fuel_escalation_annual = 0.05
```

The nominal, annual fuel escalation rate to use in computing model economics.

4.2.2.4 path_2_fuel_interp_data

```
std::string CombustionInputs::path_2_fuel_interp_data = ""
```

A path (either relative or absolute) to a set of fuel consumption data.

4.2.2.5 production_inputs

```
ProductionInputs CombustionInputs::production_inputs
```

An encapsulated ProductionInputs instance.

The documentation for this struct was generated from the following file:

- header/Production/Combustion/Combustion.h

4.3 Controller Class Reference

A class which contains a various dispatch control logic. Intended to serve as a component class of Model.

`#include <Controller.h>`

Public Member Functions

- Controller (void)

  Constructor for the Controller class.
- void setControlMode (ControlMode)
- void init (ElectricalLoad *, std::vector< Renewable * > *, Resources *, std::vector< Combustion * > *)

  Method to initialize the Controller component of the Model.
- void applyDispatchControl (ElectricalLoad *, Resources *, std::vector< Combustion * > *, std::vector< Noncombustion * > *, std::vector< Renewable * > *, std::vector< Storage * > *)

  Method to apply dispatch control at every point in the modelling time series.
- void clear (void)

  Method to clear all attributes of the Controller object.
- ~Controller (void)

  Destructor for the Controller class.

Public Attributes

- ControlMode control_mode

  The ControlMode that is active in the Model.
- std::string control_string

  A string describing the active ControlMode.
- std::vector< double > net_load_vec_kW

  A vector of net load values [kW] at each point in the modelling time series. Net load is defined as load minus all available Renewable production.
- std::vector< double > missed_load_vec_kW

  A vector of missed load values [kW] at each point in the modelling time series.
- std::map< double, std::vector< bool > > combustion_map

  A map of all possible combustion states, for use in determining optimal dispatch.

Private Member Functions

- void __computeNetLoad (ElectricalLoad *, std::vector< Renewable * > *, Resources *)

  Helper method to compute and populate the net load vector.
- void __constructCombustionMap (std::vector< Combustion * > *)

  Helper method to construct a Combustion map, for use in determining.
- void __applyLoadFollowingControl_CHARGING (int, ElectricalLoad *, Resources *, std::vector< Combustion * > *, std::vector< Noncombustion * > *, std::vector< Renewable * > *, std::vector< Storage * > *)

  Helper method to apply load following control action for given timestep of the Model run when net load <= 0;.
- void __applyLoadFollowingControl_DISCHARGING (int, ElectricalLoad *, Resources *, std::vector< Combustion * > *, std::vector< Noncombustion * > *, std::vector< Renewable * > *, std::vector< Storage * > *)

  Helper method to apply load following control action for given timestep of the Model run when net load > 0;.

- void __applyCycleChargingControl_CHARGING (int, ElectricalLoad *, Resources *, std::vector< Combustion * > *, std::vector< Noncombustion * > *, std::vector< Renewable * > *, std::vector< Storage * > *)

  Helper method to apply cycle charging control action for given timestep of the Model run when net load <= 0. Simply defaults to load following control.
- void __applyCycleChargingControl_DISCHARGING (int, ElectricalLoad *, Resources *, std::vector< Combustion * > *, std::vector< Noncombustion * > *, std::vector< Renewable * > *, std::vector< Storage * > *)

  Helper method to apply cycle charging control action for given timestep of the Model run when net load > 0. Defaults to load following control if no depleted storage assets.
- void __handleStorageCharging (int, double, std::list< Storage * >, std::vector< Combustion * > *, std::vector< Noncombustion * > *, std::vector< Renewable * > *)

  Helper method to handle the charging of the given Storage assets.
- void __handleStorageCharging (int, double, std::vector< Storage * > *, std::vector< Combustion * > *, std::vector< Noncombustion * > *, std::vector< Renewable * > *)

  Helper method to handle the charging of the given Storage assets.
- double __getRenewableProduction (int, double, Renewable *, Resources *)

  Helper method to compute the production from the given Renewable asset at the given point in time.
- double __handleCombustionDispatch (int, double, double, std::vector< Combustion * > *, bool)

  bool is_cycle_charging)
- double __handleNoncombustionDispatch (int, double, double, std::vector< Noncombustion * > *, Resources *)
- double __handleStorageDischarging (int, double, double, std::list< Storage * >)

  Helper method to handle the discharging of the given Storage assets.

4.3.1 Detailed Description

A class which contains a various dispatch control logic. Intended to serve as a component class of Model.

4.3.2 Constructor & Destructor Documentation

4.3.2.1 Controller()

```
Controller::Controller (
            void  )
```

Constructor for the Controller class.

```
1273 {
1274     return;
1275 }   /* Controller() */
```

4.3.2.2 ~Controller()

```
Controller::~Controller (
            void  )
```

Destructor for the Controller class.

```
1519 {
1520     this->clear();
1521
1522     return;
1523 }   /* ~Controller() */
```

4.3.3 Member Function Documentation

4.3.3.1 __applyCycleChargingControl_CHARGING()

```
void Controller::__applyCycleChargingControl_CHARGING (
            int timestep,
            ElectricalLoad * electrical_load_ptr,
            Resources * resources_ptr,
            std::vector< Combustion * > * combustion_ptr_vec_ptr,
            std::vector< Noncombustion * > * noncombustion_ptr_vec_ptr,
            std::vector< Renewable * > * renewable_ptr_vec_ptr,
            std::vector< Storage * > * storage_ptr_vec_ptr )  [private]
```

Helper method to apply cycle charging control action for given timestep of the Model run when net load <= 0. Simply defaults to load following control.

Parameters

timestep	The current time step of the Model run.
electrical_load_ptr	A pointer to the ElectricalLoad component of the Model.
resources_ptr	A pointer to the Resources component of the Model.
combustion_ptr_vec_ptr	A pointer to the Combustion pointer vector of the Model.
noncombustion_ptr_vec_ptr	A pointer to the Noncombustion pointer vector of the Model.
renewable_ptr_vec_ptr	A pointer to the Renewable pointer vector of the Model.
storage_ptr_vec_ptr	A pointer to the Storage pointer vector of the Model.

```
475 {
476     //  1. default to load following
477     this->__applyLoadFollowingControl_CHARGING(
478         timestep,
479         electrical_load_ptr,
480         resources_ptr,
481         combustion_ptr_vec_ptr,
482         noncombustion_ptr_vec_ptr,
483         renewable_ptr_vec_ptr,
484         storage_ptr_vec_ptr
485     );
486
487     return;
488 }   /* __applyCycleChargingControl_CHARGING() */
```

4.3.3.2 __applyCycleChargingControl_DISCHARGING()

```
void Controller::__applyCycleChargingControl_DISCHARGING (
            int timestep,
            ElectricalLoad * electrical_load_ptr,
            Resources * resources_ptr,
            std::vector< Combustion * > * combustion_ptr_vec_ptr,
            std::vector< Noncombustion * > * noncombustion_ptr_vec_ptr,
            std::vector< Renewable * > * renewable_ptr_vec_ptr,
            std::vector< Storage * > * storage_ptr_vec_ptr )  [private]
```

Helper method to apply cycle charging control action for given timestep of the Model run when net load > 0. Defaults to load following control if no depleted storage assets.

Parameters

timestep	The current time step of the Model run.
electrical_load_ptr	A pointer to the ElectricalLoad component of the Model.
resources_ptr	A pointer to the Resources component of the Model.
combustion_ptr_vec_ptr	A pointer to the Combustion pointer vector of the Model.
noncombustion_ptr_vec_ptr	A pointer to the Noncombustion pointer vector of the Model.
renewable_ptr_vec_ptr	A pointer to the Renewable pointer vector of the Model.
storage_ptr_vec_ptr	A pointer to the Storage pointer vector of the Model.

curtailment

```
536 {
537     //  1. get dt_hrs, net load
538     double dt_hrs = electrical_load_ptr->dt_vec_hrs[timestep];
539     double net_load_kW = this->net_load_vec_kW[timestep];
540 
541     //  2. partition Storage assets into depleted and non-depleted
542     std::list<Storage*> depleted_storage_ptr_list;
543     std::list<Storage*> nondepleted_storage_ptr_list;
544 
545     Storage* storage_ptr;
546     for (size_t i = 0; i < storage_ptr_vec_ptr->size(); i++) {
547         storage_ptr = storage_ptr_vec_ptr->at(i);
548 
549         if (storage_ptr->is_depleted) {
550             depleted_storage_ptr_list.push_back(storage_ptr);
551         }
552 
553         else {
554             nondepleted_storage_ptr_list.push_back(storage_ptr);
555         }
556     }
557 
558     //  3. discharge non-depleted storage assets
559     net_load_kW = this->__handleStorageDischarging(
560         timestep,
561         dt_hrs,
562         net_load_kW,
563         nondepleted_storage_ptr_list
564     );
565 
566     //  4. request optimal production from all Noncombustion assets
567     net_load_kW = this->__handleNoncombustionDispatch(
568         timestep,
569         dt_hrs,
570         net_load_kW,
571         noncombustion_ptr_vec_ptr,
572         resources_ptr
573     );
574 
575     //  5. request optimal production from all Combustion assets
576     //     default to load following if no depleted storage
577     if (depleted_storage_ptr_list.empty()) {
578         net_load_kW = this->__handleCombustionDispatch(
579             timestep,
580             dt_hrs,
581             net_load_kW,
582             combustion_ptr_vec_ptr,
583             false   // is_cycle_charging
584         );
585     }
586 
587     else {
588         net_load_kW = this->__handleCombustionDispatch(
589             timestep,
590             dt_hrs,
591             net_load_kW,
592             combustion_ptr_vec_ptr,
593             true    // is_cycle_charging
594         );
595     }
596 
597     //  6. attempt to charge depleted Storage assets using any and all available
599     //     charge priority is Combustion, then Renewable
600     this->__handleStorageCharging(
601         timestep,
602         dt_hrs,
603         depleted_storage_ptr_list,
```

```
604         combustion_ptr_vec_ptr,
605         noncombustion_ptr_vec_ptr,
606         renewable_ptr_vec_ptr
607     );
608 
609     //  7. record any missed load
610     if (net_load_kW > 1e-6) {
611         this->missed_load_vec_kW[timestep] = net_load_kW;
612     }
613 
614     return;
615 }   /* __applyCycleChargingControl_DISCHARGING() */
```

4.3.3.3 __applyLoadFollowingControl_CHARGING()

```
void Controller::__applyLoadFollowingControl_CHARGING (
              int timestep,
              ElectricalLoad * electrical_load_ptr,
              Resources * resources_ptr,
              std::vector< Combustion * > * combustion_ptr_vec_ptr,
              std::vector< Noncombustion * > * noncombustion_ptr_vec_ptr,
              std::vector< Renewable * > * renewable_ptr_vec_ptr,
              std::vector< Storage * > * storage_ptr_vec_ptr )  [private]
```

Helper method to apply load following control action for given timestep of the Model run when net load <= 0;.

Parameters

timestep	The current time step of the Model run.
electrical_load_ptr	A pointer to the ElectricalLoad component of the Model.
resources_ptr	A pointer to the Resources component of the Model.
combustion_ptr_vec_ptr	A pointer to the Combustion pointer vector of the Model.
noncombustion_ptr_vec_ptr	A pointer to the Noncombustion pointer vector of the Model.
renewable_ptr_vec_ptr	A pointer to the Renewable pointer vector of the Model.
storage_ptr_vec_ptr	A pointer to the Storage pointer vector of the Model.

```
280 {
281     //  1. get dt_hrs, set net load
282     double dt_hrs = electrical_load_ptr->dt_vec_hrs[timestep];
283     double net_load_kW = 0;
284 
285     //  2. request zero production from all Combustion assets
286     this->__handleCombustionDispatch(
287         timestep,
288         dt_hrs,
289         net_load_kW,
290         combustion_ptr_vec_ptr,
291         false   // is_cycle_charging
292     );
293 
294     //  3. request zero production from all Noncombustion assets
295     this->__handleNoncombustionDispatch(
296         timestep,
297         dt_hrs,
298         net_load_kW,
299         noncombustion_ptr_vec_ptr,
300         resources_ptr
301     );
302 
303     //  4. attempt to charge all Storage assets using any and all available curtailment
304     //     charge priority is Combustion, then Renewable
305     this->__handleStorageCharging(
306         timestep,
307         dt_hrs,
308         storage_ptr_vec_ptr,
309         combustion_ptr_vec_ptr,
310         noncombustion_ptr_vec_ptr,
```

```
311         renewable_ptr_vec_ptr
312     );
313
314     return;
315 }   /* __applyLoadFollowingControl_CHARGING() */
```

4.3.3.4 __applyLoadFollowingControl_DISCHARGING()

```
void Controller::__applyLoadFollowingControl_DISCHARGING (
              int timestep,
              ElectricalLoad * electrical_load_ptr,
              Resources * resources_ptr,
              std::vector< Combustion * > * combustion_ptr_vec_ptr,
              std::vector< Noncombustion * > * noncombustion_ptr_vec_ptr,
              std::vector< Renewable * > * renewable_ptr_vec_ptr,
              std::vector< Storage * > * storage_ptr_vec_ptr )  [private]
```

Helper method to apply load following control action for given timestep of the Model run when net load > 0;.

Parameters

timestep	The current time step of the Model run.
electrical_load_ptr	A pointer to the ElectricalLoad component of the Model.
resources_ptr	A pointer to the Resources component of the Model.
combustion_ptr_vec_ptr	A pointer to the Combustion pointer vector of the Model.
noncombustion_ptr_vec_ptr	A pointer to the Noncombustion pointer vector of the Model.
renewable_ptr_vec_ptr	A pointer to the Renewable pointer vector of the Model.
storage_ptr_vec_ptr	A pointer to the Storage pointer vector of the Model.

curtailment

```
362 {
363     //  1. get dt_hrs, net load
364     double dt_hrs = electrical_load_ptr->dt_vec_hrs[timestep];
365     double net_load_kW = this->net_load_vec_kW[timestep];
366
367     //  2. partition Storage assets into depleted and non-depleted
368     std::list<Storage*> depleted_storage_ptr_list;
369     std::list<Storage*> nondepleted_storage_ptr_list;
370
371     Storage* storage_ptr;
372     for (size_t i = 0; i < storage_ptr_vec_ptr->size(); i++) {
373         storage_ptr = storage_ptr_vec_ptr->at(i);
374
375         if (storage_ptr->is_depleted) {
376             depleted_storage_ptr_list.push_back(storage_ptr);
377         }
378
379         else {
380             nondepleted_storage_ptr_list.push_back(storage_ptr);
381         }
382     }
383
384     //  3. discharge non-depleted storage assets
385     net_load_kW = this->__handleStorageDischarging(
386         timestep,
387         dt_hrs,
388         net_load_kW,
389         nondepleted_storage_ptr_list
390     );
391
392     //  4. request optimal production from all Noncombustion assets
393     net_load_kW = this->__handleNoncombustionDispatch(
394         timestep,
395         dt_hrs,
396         net_load_kW,
```

```
397         noncombustion_ptr_vec_ptr,
398         resources_ptr
399     );
400
401     //  5. request optimal production from all Combustion assets
402     net_load_kW = this->__handleCombustionDispatch(
403         timestep,
404         dt_hrs,
405         net_load_kW,
406         combustion_ptr_vec_ptr,
407         false   // is_cycle_charging
408     );
409
410     //  6. attempt to charge depleted Storage assets using any and all available
412     //     charge priority is Combustion, then Renewable
413     this->__handleStorageCharging(
414         timestep,
415         dt_hrs,
416         depleted_storage_ptr_list,
417         combustion_ptr_vec_ptr,
418         noncombustion_ptr_vec_ptr,
419         renewable_ptr_vec_ptr
420     );
421
422     //  7. record any missed load
423     if (net_load_kW > 1e-6) {
424         this->missed_load_vec_kW[timestep] = net_load_kW;
425     }
426
427     return;
428 }   /* __applyLoadFollowingControl_DISCHARGING() */
```

4.3.3.5 __computeNetLoad()

```
void Controller::__computeNetLoad (
              ElectricalLoad * electrical_load_ptr,
              std::vector< Renewable * > * renewable_ptr_vec_ptr,
              Resources * resources_ptr )  [private]
```

Helper method to compute and populate the net load vector.

The net load at a given point in time is defined as the load at that point in time, minus the sum of all Renewable production at that point in time. Therefore, a negative net load indicates a surplus of Renewable production, and a positive net load indicates a deficit of Renewable production.

Parameters

electrical_load_ptr	A pointer to the ElectricalLoad component of the Model.
renewable_ptr_vec_ptr	A pointer to the Renewable pointer vector of the Model.
resources_ptr	A pointer to the Resources component of the Model.

```
82 {
83     //  1. init
84     this->net_load_vec_kW.resize(electrical_load_ptr->n_points, 0);
85     this->missed_load_vec_kW.resize(electrical_load_ptr->n_points, 0);
86
87     //  2. populate net load vector
88     double dt_hrs = 0;
89     double load_kW = 0;
90     double net_load_kW = 0;
91     double production_kW = 0;
92
93     Renewable* renewable_ptr;
94
95     for (int i = 0; i < electrical_load_ptr->n_points; i++) {
96         dt_hrs = electrical_load_ptr->dt_vec_hrs[i];
97         load_kW = electrical_load_ptr->load_vec_kW[i];
98         net_load_kW = load_kW;
99
100         for (size_t j = 0; j < renewable_ptr_vec_ptr->size(); j++) {
```

```
101             renewable_ptr = renewable_ptr_vec_ptr->at(j);
102
103             production_kW = this->__getRenewableProduction(
104                 i,
105                 dt_hrs,
106                 renewable_ptr,
107                 resources_ptr
108             );
109
110             load_kW = renewable_ptr->commit(
111                 i,
112                 dt_hrs,
113                 production_kW,
114                 load_kW
115             );
116
117             net_load_kW -= production_kW;
118         }
119
120         this->net_load_vec_kW[i] = net_load_kW;
121     }
122
123     return;
124 }   /* __computeNetLoad() */
```

4.3.3.6 __constructCombustionMap()

```
void Controller::__constructCombustionMap (
            std::vector< Combustion * > * combustion_ptr_vec_ptr )  [private]
```

Helper method to construct a Combustion map, for use in determining.

Parameters

combustion_ptr_vec_ptr	A pointer to the Combustion pointer vector of the Model.

```
146 {
147     //  1. get state table dimensions
148     int n_cols = combustion_ptr_vec_ptr->size();
149     int n_rows = pow(2, n_cols);
150
151     //  2. init state table (all possible on/off combinations)
152     std::vector<std::vector<bool» state_table;
153     state_table.resize(n_rows, {});
154
155     int x = 0;
156     for (int i = 0; i < n_rows; i++) {
157         state_table[i].resize(n_cols, false);
158
159         x = i;
160         for (int j = 0; j < n_cols; j++) {
161             if (x % 2 == 0) {
162                 state_table[i][j] = true;
163             }
164             x /= 2;
165         }
166     }
167
168     //  3. construct combustion map (handle duplicates by keeping rows with minimum
169     //     trues)
170     double total_capacity_kW = 0;
171     int truth_count = 0;
172     int current_truth_count = 0;
173
174     for (int i = 0; i < n_rows; i++) {
175         total_capacity_kW = 0;
176         truth_count = 0;
177         current_truth_count = 0;
178
179         for (int j = 0; j < n_cols; j++) {
180             if (state_table[i][j]) {
181                 total_capacity_kW += combustion_ptr_vec_ptr->at(j)->capacity_kW;
182                 truth_count++;
183             }
184         }
```

```
185
186         if (this->combustion_map.count(total_capacity_kW) > 0) {
187             for (int j = 0; j < n_cols; j++) {
188                 if (this->combustion_map[total_capacity_kW][j]) {
189                     current_truth_count++;
190                 }
191             }
192
193             if (truth_count < current_truth_count) {
194                 this->combustion_map.erase(total_capacity_kW);
195             }
196         }
197
198         this->combustion_map.insert(
199             std::pair<double, std::vector<bool>> (
200                 total_capacity_kW,
201                 state_table[i]
202             )
203         );
204     }
205
206     /*
207     // ==== TEST PRINT ==== //
208     std::cout << std::endl;
209
210     std::cout << "\t\t";
211     for (size_t i = 0; i < combustion_ptr_vec_ptr->size(); i++) {
212         std::cout << combustion_ptr_vec_ptr->at(i)->capacity_kW << "\t";
213     }
214     std::cout << std::endl;
215
216     std::map<double, std::vector<bool>::iterator iter;
217     for (
218         iter = this->combustion_map.begin();
219         iter != this->combustion_map.end();
220         iter++
221     ) {
222         std::cout << iter->first << ":\t{\t";
223
224         for (size_t i = 0; i < iter->second.size(); i++) {
225             std::cout << iter->second[i] << "\t";
226         }
227         std::cout << "}" << std::endl;
228     }
229     // ==== END TEST PRINT ==== //
230     //*/
231
232     return;
233 }   /* __constructCombustionTable() */
```

4.3.3.7 __getRenewableProduction()

```
double Controller::__getRenewableProduction (
            int timestep,
            double dt_hrs,
            Renewable * renewable_ptr,
            Resources * resources_ptr )  [private]
```

Helper method to compute the production from the given Renewable asset at the given point in time.

Parameters

timestep	The current time step of the Model run.
dt_hrs	The interval of time [hrs] associated with the action.
renewable_ptr	A pointer to the Renewable asset.
resources_ptr	A pointer to the Resources component of the Model.

Returns

The production [kW] of the Renewable asset.

```
904 {
905     double production_kW = 0;
906 
907     switch (renewable_ptr->type) {
908         case (RenewableType :: SOLAR): {
909             double resource_value = 0;
910 
911             if (not renewable_ptr->normalized_production_series_given) {
912                 resource_value =
913                     resources_ptr->resource_map_1D[renewable_ptr->resource_key][timestep];
914             }
915 
916             production_kW = renewable_ptr->computeProductionkW(
917                 timestep,
918                 dt_hrs,
919                 resource_value
920             );
921 
922             break;
923         }
924 
925         case (RenewableType :: TIDAL): {
926             double resource_value = 0;
927 
928             if (not renewable_ptr->normalized_production_series_given) {
929                 resource_value =
930                     resources_ptr->resource_map_1D[renewable_ptr->resource_key][timestep];
931             }
932 
933             production_kW = renewable_ptr->computeProductionkW(
934                 timestep,
935                 dt_hrs,
936                 resource_value
937             );
938 
939             break;
940         }
941 
942         case (RenewableType :: WAVE): {
943             double significant_wave_height_m = 0;
944             double energy_period_s = 0;
945 
946             if (not renewable_ptr->normalized_production_series_given) {
947                 significant_wave_height_m =
948                     resources_ptr->resource_map_2D[renewable_ptr->resource_key][timestep][0];
949 
950                 energy_period_s =
951                     resources_ptr->resource_map_2D[renewable_ptr->resource_key][timestep][1];
952             }
953 
954             production_kW = renewable_ptr->computeProductionkW(
955                 timestep,
956                 dt_hrs,
957                 significant_wave_height_m,
958                 energy_period_s
959             );
960 
961             break;
962         }
963 
964         case (RenewableType :: WIND): {
965             double resource_value = 0;
966 
967             if (not renewable_ptr->normalized_production_series_given) {
968                 resource_value =
969                     resources_ptr->resource_map_1D[renewable_ptr->resource_key][timestep];
970             }
971 
972             production_kW = renewable_ptr->computeProductionkW(
973                 timestep,
974                 dt_hrs,
975                 resource_value
976             );
977 
978             break;
979         }
980 
981         default: {
982             std::string error_str = "ERROR:  Controller::__getRenewableProduction():  ";
983             error_str += "renewable type ";
984             error_str += std::to_string(renewable_ptr->type);
985             error_str += " not recognized";
986 
987             #ifdef _WIN32
```

```
988                 std::cout « error_str « std::endl;
989             #endif
990
991             throw std::runtime_error(error_str);
992
993             break;
994         }
995     }
996
997     return production_kW;
998 }   /* __getRenewableProduction() */
```

4.3.3.8 __handleCombustionDispatch()

```
double Controller::__handleCombustionDispatch (
              int timestep,
              double dt_hrs,
              double net_load_kW,
              std::vector< Combustion * > * combustion_ptr_vec_ptr,
              bool is_cycle_charging )  [private]
```

bool is_cycle_charging)

Helper method to handle the optimal dispatch of Combustion assets. Dispatches for 1.2x the received net load, so as to ensure a "20% spinning reserve". Dispatches a minimum number of Combustion assets, which then share the load proportional to their rated capacities.

Parameters

timestep	The current time step of the Model run.
dt_hrs	The interval of time [hrs] associated with the action.
net_load_kW	The net load [kW] before the dispatch is deducted from it.
combustion_ptr_vec_ptr	A pointer to the Combustion pointer vector of the Model.
is_cycle_charging	A boolean which defines whether to apply cycle charging logic or not.

Returns

The net load [kW] remaining after the dispatch is deducted from it.

```
1041 {
1042     //  1. get minimal Combustion dispatch
1043     double target_production_kW = 1.2 * net_load_kW;
1044     double total_capacity_kW = 0;
1045
1046     std::map<double, std::vector<bool»::iterator iter = this->combustion_map.begin();
1047     while (iter != std::prev(this->combustion_map.end(), 1)) {
1048         if (target_production_kW <= total_capacity_kW) {
1049             break;
1050         }
1051
1052         iter++;
1053         total_capacity_kW = iter->first;
1054     }
1055
1056     //  2. share load proportionally (by rated capacity) over active Combustion assets
1057     Combustion* combustion_ptr;
1058     double production_kW = 0;
1059     double request_kW = 0;
1060     double _net_load_kW = net_load_kW;
1061
1062     for (size_t i = 0; i < this->combustion_map[total_capacity_kW].size(); i++) {
1063         combustion_ptr = combustion_ptr_vec_ptr->at(i);
1064
1065         if (total_capacity_kW > 0) {
```

```
1066             request_kW =
1067                 int(this->combustion_map[total_capacity_kW][i]) *
1068                 net_load_kW *
1069                 (combustion_ptr->capacity_kW / total_capacity_kW);
1070         }
1071
1072         else {
1073             request_kW = 0;
1074         }
1075
1076         if (is_cycle_charging and request_kW > 0) {
1077             if (request_kW < combustion_ptr->cycle_charging_setpoint * combustion_ptr->capacity_kW) {
1078                 request_kW = combustion_ptr->cycle_charging_setpoint * combustion_ptr->capacity_kW;
1079             }
1080         }
1081
1082         production_kW = combustion_ptr->requestProductionkW(
1083             timestep,
1084             dt_hrs,
1085             request_kW
1086         );
1087
1088         _net_load_kW = combustion_ptr->commit(
1089             timestep,
1090             dt_hrs,
1091             production_kW,
1092             _net_load_kW
1093         );
1094     }
1095
1096     return _net_load_kW;
1097 }   /* __handleCombustionDispatch() */
```

4.3.3.9 __handleNoncombustionDispatch()

```
double Controller::__handleNoncombustionDispatch (
            int timestep,
            double dt_hrs,
            double net_load_kW,
            std::vector< Noncombustion * > * noncombustion_ptr_vec_ptr,
            Resources * resources_ptr )  [private]
1138 {
1139     Noncombustion* noncombustion_ptr;
1140     double production_kW = 0;
1141
1142     for (size_t i = 0; i < noncombustion_ptr_vec_ptr->size(); i++) {
1143         noncombustion_ptr = noncombustion_ptr_vec_ptr->at(i);
1144
1145         switch (noncombustion_ptr->type) {
1146             case (NoncombustionType :: HYDRO): {
1147                 double resource_value = 0;
1148
1149                 if (not noncombustion_ptr->normalized_production_series_given) {
1150                     resource_value =
1151                         resources_ptr->resource_map_1D[noncombustion_ptr->resource_key][timestep];
1152                 }
1153
1154                 production_kW = noncombustion_ptr->requestProductionkW(
1155                     timestep,
1156                     dt_hrs,
1157                     net_load_kW,
1158                     resource_value
1159                 );
1160
1161                 net_load_kW = noncombustion_ptr->commit(
1162                     timestep,
1163                     dt_hrs,
1164                     production_kW,
1165                     net_load_kW,
1166                     resource_value
1167                 );
1168
1169                 break;
1170             }
1171
1172             default: {
1173                 production_kW = noncombustion_ptr->requestProductionkW(
```

```
1174                     timestep,
1175                     dt_hrs,
1176                     net_load_kW
1177                 );
1178 
1179                 net_load_kW = noncombustion_ptr->commit(
1180                     timestep,
1181                     dt_hrs,
1182                     production_kW,
1183                     net_load_kW
1184                 );
1185 
1186                 break;
1187             }
1188         }
1189     }
1190 
1191     return net_load_kW;
1192 }   /* __handleNoncombustionDispatch() */
```

4.3.3.10 __handleStorageCharging() [1/2]

```
void Controller::__handleStorageCharging (
            int timestep,
            double dt_hrs,
            std::list< Storage * > storage_ptr_list,
            std::vector< Combustion * > * combustion_ptr_vec_ptr,
            std::vector< Noncombustion * > * noncombustion_ptr_vec_ptr,
            std::vector< Renewable * > * renewable_ptr_vec_ptr )  [private]
```

Helper method to handle the charging of the given Storage assets.

Parameters

timestep	The current time step of the Model run.
dt_hrs	The interval of time [hrs] associated with the action.
storage_ptr_list	A list of pointers to the Storage assets that are to be charged.
combustion_ptr_vec_ptr	A pointer to the Combustion pointer vector of the Model.
noncombustion_ptr_vec_ptr	A pointer to the Noncombustion pointer vector of the Model.
renewable_ptr_vec_ptr	A pointer to the Renewable pointer vector of the Model.

```
658 {
659     double acceptable_kW = 0;
660     double curtailment_kW = 0;
661 
662     Storage* storage_ptr;
663     Combustion* combustion_ptr;
664     Noncombustion* noncombustion_ptr;
665     Renewable* renewable_ptr;
666 
667     std::list<Storage*>::iterator iter;
668     for (
669         iter = storage_ptr_list.begin();
670         iter != storage_ptr_list.end();
671         iter++
672     ){
673         storage_ptr = (*iter);
674 
675         //  1. attempt to charge from Combustion curtailment first
676         for (size_t i = 0; i < combustion_ptr_vec_ptr->size(); i++) {
677             combustion_ptr = combustion_ptr_vec_ptr->at(i);
678             curtailment_kW = combustion_ptr->curtailment_vec_kW[timestep];
679 
680             if (curtailment_kW <= 0) {
681                 continue;
682             }
683 
684             acceptable_kW = storage_ptr->getAcceptablekW(dt_hrs);
```

```
685
686             if (acceptable_kW > curtailment_kW) {
687                 acceptable_kW = curtailment_kW;
688             }
689
690             combustion_ptr->curtailment_vec_kW[timestep] -= acceptable_kW;
691             combustion_ptr->storage_vec_kW[timestep] += acceptable_kW;
692             storage_ptr->power_kW += acceptable_kW;
693         }
694
695         //  2. attempt to charge from Noncombustion curtailment second
696         for (size_t i = 0; i < noncombustion_ptr_vec_ptr->size(); i++) {
697             noncombustion_ptr = noncombustion_ptr_vec_ptr->at(i);
698             curtailment_kW = noncombustion_ptr->curtailment_vec_kW[timestep];
699
700             if (curtailment_kW <= 0) {
701                 continue;
702             }
703
704             acceptable_kW = storage_ptr->getAcceptablekW(dt_hrs);
705
706             if (acceptable_kW > curtailment_kW) {
707                 acceptable_kW = curtailment_kW;
708             }
709
710             noncombustion_ptr->curtailment_vec_kW[timestep] -= acceptable_kW;
711             noncombustion_ptr->storage_vec_kW[timestep] += acceptable_kW;
712             storage_ptr->power_kW += acceptable_kW;
713         }
714
715         //  3. attempt to charge from Renewable curtailment third
716         for (size_t i = 0; i < renewable_ptr_vec_ptr->size(); i++) {
717             renewable_ptr = renewable_ptr_vec_ptr->at(i);
718             curtailment_kW = renewable_ptr->curtailment_vec_kW[timestep];
719
720             if (curtailment_kW <= 0) {
721                 continue;
722             }
723
724             acceptable_kW = storage_ptr->getAcceptablekW(dt_hrs);
725
726             if (acceptable_kW > curtailment_kW) {
727                 acceptable_kW = curtailment_kW;
728             }
729
730             renewable_ptr->curtailment_vec_kW[timestep] -= acceptable_kW;
731             renewable_ptr->storage_vec_kW[timestep] += acceptable_kW;
732             storage_ptr->power_kW += acceptable_kW;
733         }
734
735         //  4. commit charge
736         storage_ptr->commitCharge(
737             timestep,
738             dt_hrs,
739             storage_ptr->power_kW
740         );
741     }
742
743     return;
744 }   /* __handleStorageCharging() */
```

4.3.3.11 __handleStorageCharging() [2/2]

```
void Controller::__handleStorageCharging (
            int timestep,
            double dt_hrs,
            std::vector< Storage * > * storage_ptr_vec_ptr,
            std::vector< Combustion * > * combustion_ptr_vec_ptr,
            std::vector< Noncombustion * > * noncombustion_ptr_vec_ptr,
            std::vector< Renewable * > * renewable_ptr_vec_ptr )  [private]
```

Helper method to handle the charging of the given Storage assets.

Parameters

timestep	The current time step of the Model run.
dt_hrs	The interval of time [hrs] associated with the action.
storage_ptr_vec_ptr	A pointer to a vector of pointers to the Storage assets that are to be charged.
combustion_ptr_vec_ptr	A pointer to the Combustion pointer vector of the Model.
noncombustion_ptr_vec_ptr	A pointer to the Noncombustion pointer vector of the Model.
renewable_ptr_vec_ptr	A pointer to the Renewable pointer vector of the Model.

```
787 {
788     double acceptable_kW = 0;
789     double curtailment_kW = 0;
790 
791     Storage* storage_ptr;
792     Combustion* combustion_ptr;
793     Noncombustion* noncombustion_ptr;
794     Renewable* renewable_ptr;
795 
796     for (size_t j = 0; j < storage_ptr_vec_ptr->size(); j++) {
797         storage_ptr = storage_ptr_vec_ptr->at(j);
798 
799         //  1. attempt to charge from Combustion curtailment first
800         for (size_t i = 0; i < combustion_ptr_vec_ptr->size(); i++) {
801             combustion_ptr = combustion_ptr_vec_ptr->at(i);
802             curtailment_kW = combustion_ptr->curtailment_vec_kW[timestep];
803 
804             if (curtailment_kW <= 0) {
805                 continue;
806             }
807 
808             acceptable_kW = storage_ptr->getAcceptablekW(dt_hrs);
809 
810             if (acceptable_kW > curtailment_kW) {
811                 acceptable_kW = curtailment_kW;
812             }
813 
814             combustion_ptr->curtailment_vec_kW[timestep] -= acceptable_kW;
815             combustion_ptr->storage_vec_kW[timestep] += acceptable_kW;
816             storage_ptr->power_kW += acceptable_kW;
817         }
818 
819         //  2. attempt to charge from Noncombustion curtailment second
820         for (size_t i = 0; i < noncombustion_ptr_vec_ptr->size(); i++) {
821             noncombustion_ptr = noncombustion_ptr_vec_ptr->at(i);
822             curtailment_kW = noncombustion_ptr->curtailment_vec_kW[timestep];
823 
824             if (curtailment_kW <= 0) {
825                 continue;
826             }
827 
828             acceptable_kW = storage_ptr->getAcceptablekW(dt_hrs);
829 
830             if (acceptable_kW > curtailment_kW) {
831                 acceptable_kW = curtailment_kW;
832             }
833 
834             noncombustion_ptr->curtailment_vec_kW[timestep] -= acceptable_kW;
835             noncombustion_ptr->storage_vec_kW[timestep] += acceptable_kW;
836             storage_ptr->power_kW += acceptable_kW;
837         }
838 
839         //  3. attempt to charge from Renewable curtailment third
840         for (size_t i = 0; i < renewable_ptr_vec_ptr->size(); i++) {
841             renewable_ptr = renewable_ptr_vec_ptr->at(i);
842             curtailment_kW = renewable_ptr->curtailment_vec_kW[timestep];
843 
844             if (curtailment_kW <= 0) {
845                 continue;
846             }
847 
848             acceptable_kW = storage_ptr->getAcceptablekW(dt_hrs);
849 
850             if (acceptable_kW > curtailment_kW) {
851                 acceptable_kW = curtailment_kW;
852             }
853 
854             renewable_ptr->curtailment_vec_kW[timestep] -= acceptable_kW;
855             renewable_ptr->storage_vec_kW[timestep] += acceptable_kW;
856             storage_ptr->power_kW += acceptable_kW;
857         }
858 
```

```
859         //  4. commit charge
860         storage_ptr->commitCharge(
861             timestep,
862             dt_hrs,
863             storage_ptr->power_kW
864         );
865     }
866 
867     return;
868 }   /* __handleStorageCharging() */
```

4.3.3.12 __handleStorageDischarging()

```
double Controller::__handleStorageDischarging (
            int timestep,
            double dt_hrs,
            double net_load_kW,
            std::list< Storage * > storage_ptr_list )  [private]
```

Helper method to handle the discharging of the given Storage assets.

Parameters

timestep	The current time step of the Model run.
dt_hrs	The interval of time [hrs] associated with the action.
storage_ptr_list	A list of pointers to the Storage assets that are to be discharged.

Returns

The net load [kW] remaining after the discharge is deducted from it.

```
1226 {
1227     double discharging_kW = 0;
1228 
1229     Storage* storage_ptr;
1230 
1231     std::list<Storage*>::iterator iter;
1232     for (
1233         iter = storage_ptr_list.begin();
1234         iter != storage_ptr_list.end();
1235         iter++
1236     ){
1237         storage_ptr = (*iter);
1238 
1239         discharging_kW = storage_ptr->getAvailablekW(dt_hrs);
1240 
1241         if (discharging_kW > net_load_kW) {
1242             discharging_kW = net_load_kW;
1243         }
1244 
1245         net_load_kW = storage_ptr->commitDischarge(
1246             timestep,
1247             dt_hrs,
1248             discharging_kW,
1249             net_load_kW
1250         );
1251     }
1252 
1253     return net_load_kW;
1254 }   /* __handleStorageDischarging() */
```

4.3.3.13 applyDispatchControl()

```
void Controller::applyDispatchControl (
            ElectricalLoad * electrical_load_ptr,
            Resources * resources_ptr,
            std::vector< Combustion * > * combustion_ptr_vec_ptr,
            std::vector< Noncombustion * > * noncombustion_ptr_vec_ptr,
            std::vector< Renewable * > * renewable_ptr_vec_ptr,
            std::vector< Storage * > * storage_ptr_vec_ptr )
```

Method to apply dispatch control at every point in the modelling time series.

Parameters

electrical_load_ptr	A pointer to the ElectricalLoad component of the Model.
resources_ptr	A pointer to the Resources component of the Model.
combustion_ptr_vec_ptr	A pointer to the Combustion pointer vector of the Model.
noncombustion_ptr_vec_ptr	A pointer to the Noncombustion pointer vector of the Model.
renewable_ptr_vec_ptr	A pointer to the Renewable pointer vector of the Model.
storage_ptr_vec_ptr	A pointer to the Storage pointer vector of the Model.

```
1406 {
1407     for (int i = 0; i < electrical_load_ptr->n_points; i++) {
1408         switch (this->control_mode) {
1409             case (ControlMode :: LOAD_FOLLOWING): {
1410                 if (this->net_load_vec_kW[i] <= 0) {
1411                     this->__applyLoadFollowingControl_CHARGING(
1412                         i,
1413                         electrical_load_ptr,
1414                         resources_ptr,
1415                         combustion_ptr_vec_ptr,
1416                         noncombustion_ptr_vec_ptr,
1417                         renewable_ptr_vec_ptr,
1418                         storage_ptr_vec_ptr
1419                     );
1420                 }
1421 
1422                 else {
1423                     this->__applyLoadFollowingControl_DISCHARGING(
1424                         i,
1425                         electrical_load_ptr,
1426                         resources_ptr,
1427                         combustion_ptr_vec_ptr,
1428                         noncombustion_ptr_vec_ptr,
1429                         renewable_ptr_vec_ptr,
1430                         storage_ptr_vec_ptr
1431                     );
1432                 }
1433 
1434                 break;
1435             }
1436 
1437             case (ControlMode :: CYCLE_CHARGING): {
1438                 if (this->net_load_vec_kW[i] <= 0) {
1439                     this->__applyCycleChargingControl_CHARGING(
1440                         i,
1441                         electrical_load_ptr,
1442                         resources_ptr,
1443                         combustion_ptr_vec_ptr,
1444                         noncombustion_ptr_vec_ptr,
1445                         renewable_ptr_vec_ptr,
1446                         storage_ptr_vec_ptr
1447                     );
1448                 }
1449 
1450                 else {
1451                     this->__applyCycleChargingControl_DISCHARGING(
1452                         i,
1453                         electrical_load_ptr,
1454                         resources_ptr,
1455                         combustion_ptr_vec_ptr,
1456                         noncombustion_ptr_vec_ptr,
1457                         renewable_ptr_vec_ptr,
1458                         storage_ptr_vec_ptr
```

```
1459                     );
1460                 }
1461
1462                 break;
1463             }
1464
1465             default: {
1466                 std::string error_str = "ERROR:  Controller :: applyDispatchControl():  ";
1467                 error_str += "control mode ";
1468                 error_str += std::to_string(this->control_mode);
1469                 error_str += " not recognized";
1470
1471                 #ifdef _WIN32
1472                     std::cout << error_str << std::endl;
1473                 #endif
1474
1475                 throw std::runtime_error(error_str);
1476
1477                 break;
1478             }
1479         }
1480     }
1481
1482     return;
1483 }   /* applyDispatchControl() */
```

4.3.3.14 clear()

```
void Controller::clear (
            void  )
```

Method to clear all attributes of the Controller object.

```
1498 {
1499     this->net_load_vec_kW.clear();
1500     this->missed_load_vec_kW.clear();
1501     this->combustion_map.clear();
1502
1503     return;
1504 }   /* clear() */
```

4.3.3.15 init()

```
void Controller::init (
            ElectricalLoad * electrical_load_ptr,
            std::vector< Renewable * > * renewable_ptr_vec_ptr,
            Resources * resources_ptr,
            std::vector< Combustion * > * combustion_ptr_vec_ptr )
```

Method to initialize the Controller component of the Model.

Parameters

electrical_load_ptr	A pointer to the ElectricalLoad component of the Model.
renewable_ptr_vec_ptr	A pointer to the Renewable pointer vector of the Model.
resources_ptr	A pointer to the Resources component of the Model.
combustion_ptr_vec_ptr	A pointer to the Combustion pointer vector of the Model.

```
1356 {
1357     //  1. compute net load
1358     this->__computeNetLoad(electrical_load_ptr, renewable_ptr_vec_ptr, resources_ptr);
1359
```

```
1360     //  2. construct Combustion table
1361     this->__constructCombustionMap(combustion_ptr_vec_ptr);
1362
1363     return;
1364 }    /* init() */
```

4.3.3.16 setControlMode()

```
void Controller::setControlMode (
             ControlMode control_mode )
```

Parameters

control_mode	The ControlMode which is to be active in the Controller.

```
1290 {
1291     this->control_mode = control_mode;
1292
1293     switch(control_mode) {
1294         case (ControlMode :: LOAD_FOLLOWING): {
1295             this->control_string = "LOAD_FOLLOWING";
1296
1297             break;
1298         }
1299
1300         case (ControlMode :: CYCLE_CHARGING): {
1301             this->control_string = "CYCLE_CHARGING";
1302
1303             break;
1304         }
1305
1306         default: {
1307             std::string error_str = "ERROR:  Controller :: setControlMode():  ";
1308                 error_str += "control mode ";
1309                 error_str += std::to_string(control_mode);
1310                 error_str += " not recognized";
1311
1312                 #ifdef _WIN32
1313                     std::cout « error_str « std::endl;
1314                 #endif
1315
1316                 throw std::runtime_error(error_str);
1317
1318             break;
1319         }
1320     }
1321
1322     return;
1323 }    /* setControlMode() */
```

4.3.4 Member Data Documentation

4.3.4.1 combustion_map

```
std::map<double, std::vector<bool> > Controller::combustion_map
```

A map of all possible combustion states, for use in determining optimal dispatch.

4.3.4.2 control_mode

```
ControlMode Controller::control_mode
```

The ControlMode that is active in the Model.

4.3.4.3 control_string

```
std::string Controller::control_string
```

A string describing the active ControlMode.

4.3.4.4 missed_load_vec_kW

```
std::vector<double> Controller::missed_load_vec_kW
```

A vector of missed load values [kW] at each point in the modelling time series.

4.3.4.5 net_load_vec_kW

```
std::vector<double> Controller::net_load_vec_kW
```

A vector of net load values [kW] at each point in the modelling time series. Net load is defined as load minus all available Renewable production.

The documentation for this class was generated from the following files:

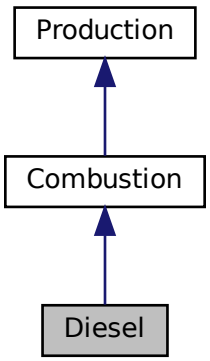
- header/Controller.h
- source/Controller.cpp

4.4 Diesel Class Reference

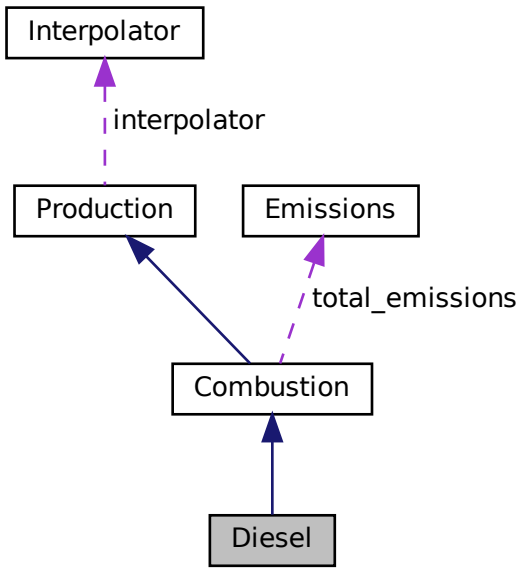
A derived class of the Combustion branch of Production which models production using a diesel generator.

`#include <Diesel.h>`

Inheritance diagram for Diesel:



Collaboration diagram for Diesel:



Public Member Functions

- Diesel (void)

  Constructor (dummy) for the Diesel class.
- Diesel (int, double, DieselInputs, std::vector< double > *)

  Constructor (intended) for the Diesel class.
- void handleReplacement (int)

  Method to handle asset replacement and capital cost incursion, if applicable.
- double requestProductionkW (int, double, double)

  Method which takes in production request, and then returns what the asset can deliver (subject to operating constraints, etc.).
- double commit (int, double, double, double)

  Method which takes in production and load for the current timestep, computes and records dispatch and curtailment, and then returns remaining load.
- ~Diesel (void)

  Destructor for the Diesel class.

Public Attributes

- double minimum_load_ratio

  The minimum load ratio of the asset. That is, when the asset is producing, it must produce at least this ratio of its rated capacity.
- double minimum_runtime_hrs

  The minimum runtime [hrs] of the asset. This is the minimum time that must elapse between successive starts and stops.
- double time_since_last_start_hrs

  The time that has elapsed [hrs] since the last start of the asset.

Private Member Functions

- void __checkInputs (DieselInputs)

  Helper method to check inputs to the Diesel constructor.
- void __handleStartStop (int, double, double)

  Helper method (private) to handle the starting/stopping of the diesel generator. The minimum runtime constraint is enforced in this method.
- double __getGenericFuelSlope (void)

  Helper method to generate a generic, linearized fuel consumption slope for a diesel generator.
- double __getGenericFuelIntercept (void)

  Helper method to generate a generic, linearized fuel consumption intercept for a diesel generator.
- double __getGenericCapitalCost (void)

  Helper method to generate a generic diesel generator capital cost.
- double __getGenericOpMaintCost (void)

  Helper method (private) to generate a generic diesel generator operation and maintenance cost. This is a cost incurred per unit energy produced.
- void __writeSummary (std::string)

  Helper method to write summary results for Diesel.
- void __writeTimeSeries (std::string, std::vector< double > *, int=-1)

  Helper method to write time series results for Diesel.

4.4.1 Detailed Description

A derived class of the Combustion branch of Production which models production using a diesel generator.

4.4.2 Constructor & Destructor Documentation

4.4.2.1 Diesel() [1/2]

```
Diesel::Diesel (
            void  )
```

Constructor (dummy) for the Diesel class.

```
632 {
633     return;
634 }   /* Diesel() */
```

4.4.2.2 Diesel() [2/2]

```
Diesel::Diesel (
            int n_points,
            double n_years,
            DieselInputs diesel_inputs,
            std::vector< double > * time_vec_hrs_ptr )
```

Constructor (intended) for the Diesel class.

Parameters

n_points	The number of points in the modelling time series.
n_years	The number of years being modelled.
diesel_inputs	A structure of Diesel constructor inputs.
time_vec_hrs_ptr	A pointer to the vector containing the modelling time series.

```
666   :
667 Combustion(
668     n_points,
669     n_years,
670     diesel_inputs.combustion_inputs,
671     time_vec_hrs_ptr
672 )
673 {
674     //  1. check inputs
675     this->__checkInputs(diesel_inputs);
676 
677     //  2. set attributes
678     this->type = CombustionType :: DIESEL;
679     this->type_str = "DIESEL";
680 
681     this->replace_running_hrs = diesel_inputs.replace_running_hrs;
682 
683     this->fuel_cost_L = diesel_inputs.fuel_cost_L;
684 
685     this->minimum_load_ratio = diesel_inputs.minimum_load_ratio;
686     this->minimum_runtime_hrs = diesel_inputs.minimum_runtime_hrs;
687     this->time_since_last_start_hrs = 0;
```

```
688
689     this->CO2_emissions_intensity_kgL = diesel_inputs.CO2_emissions_intensity_kgL;
690     this->CO_emissions_intensity_kgL = diesel_inputs.CO_emissions_intensity_kgL;
691     this->NOx_emissions_intensity_kgL = diesel_inputs.NOx_emissions_intensity_kgL;
692     this->SOx_emissions_intensity_kgL = diesel_inputs.SOx_emissions_intensity_kgL;
693     this->CH4_emissions_intensity_kgL = diesel_inputs.CH4_emissions_intensity_kgL;
694     this->PM_emissions_intensity_kgL = diesel_inputs.PM_emissions_intensity_kgL;
695
696     if (diesel_inputs.linear_fuel_slope_LkWh < 0) {
697         this->linear_fuel_slope_LkWh = this->__getGenericFuelSlope();
698     }
699     else {
700         this->linear_fuel_slope_LkWh = diesel_inputs.linear_fuel_slope_LkWh;
701     }
702
703     if (diesel_inputs.linear_fuel_intercept_LkWh < 0) {
704         this->linear_fuel_intercept_LkWh = this->__getGenericFuelIntercept();
705     }
706     else {
707         this->linear_fuel_intercept_LkWh = diesel_inputs.linear_fuel_intercept_LkWh;
708     }
709
710     if (diesel_inputs.capital_cost < 0) {
711         this->capital_cost = this->__getGenericCapitalCost();
712     }
713     else {
714         this->capital_cost = diesel_inputs.capital_cost;
715     }
716
717     if (diesel_inputs.operation_maintenance_cost_kWh < 0) {
718         this->operation_maintenance_cost_kWh = this->__getGenericOpMaintCost();
719     }
720     else {
721         this->operation_maintenance_cost_kWh =
722             diesel_inputs.operation_maintenance_cost_kWh;
723     }
724
725     if (not this->is_sunk) {
726         this->capital_cost_vec[0] = this->capital_cost;
727     }
728
729     //  3. construction print
730     if (this->print_flag) {
731         std::cout « "Diesel object constructed at " « this « std::endl;
732     }
733
734     return;
735 }   /* Diesel() */
```

4.4.2.3 ~Diesel()

```
Diesel::~Diesel (
            void  )
```

Destructor for the Diesel class.

```
897 {
898     //  1. destruction print
899     if (this->print_flag) {
900         std::cout « "Diesel object at " « this « " destroyed" « std::endl;
901     }
902
903     return;
904 }   /* ~Diesel() */
```

4.4.3 Member Function Documentation

4.4.3.1 __checkInputs()

```
void Diesel::__checkInputs (
            DieselInputs diesel_inputs )  [private]
```

Helper method to check inputs to the Diesel constructor.

Parameters

diesel_inputs	A structure of Diesel constructor inputs.

```
64 {
65     //  1. check fuel_cost_L
66     if (diesel_inputs.fuel_cost_L < 0) {
67         std::string error_str = "ERROR:  Diesel():  ";
68         error_str += "DieselInputs::fuel_cost_L must be >= 0";
69 
70         #ifdef _WIN32
71             std::cout << error_str << std::endl;
72         #endif
73 
74         throw std::invalid_argument(error_str);
75     }
76 
77     //  2. check CO2_emissions_intensity_kgL
78     if (diesel_inputs.CO2_emissions_intensity_kgL < 0) {
79         std::string error_str = "ERROR:  Diesel():  ";
80         error_str += "DieselInputs::CO2_emissions_intensity_kgL must be >= 0";
81 
82         #ifdef _WIN32
83             std::cout << error_str << std::endl;
84         #endif
85 
86         throw std::invalid_argument(error_str);
87     }
88 
89     //  3. check CO_emissions_intensity_kgL
90         if (diesel_inputs.CO_emissions_intensity_kgL < 0) {
91         std::string error_str = "ERROR:  Diesel():  ";
92         error_str += "DieselInputs::CO_emissions_intensity_kgL must be >= 0";
93 
94         #ifdef _WIN32
95             std::cout << error_str << std::endl;
96         #endif
97 
98         throw std::invalid_argument(error_str);
99     }
100 
101     //  4. check NOx_emissions_intensity_kgL
102     if (diesel_inputs.NOx_emissions_intensity_kgL < 0) {
103         std::string error_str = "ERROR:  Diesel():  ";
104         error_str += "DieselInputs::NOx_emissions_intensity_kgL must be >= 0";
105 
106         #ifdef _WIN32
107             std::cout << error_str << std::endl;
108         #endif
109 
110         throw std::invalid_argument(error_str);
111     }
112 
113     //  5. check SOx_emissions_intensity_kgL
114     if (diesel_inputs.SOx_emissions_intensity_kgL < 0) {
115         std::string error_str = "ERROR:  Diesel():  ";
116         error_str += "DieselInputs::SOx_emissions_intensity_kgL must be >= 0";
117 
118         #ifdef _WIN32
119             std::cout << error_str << std::endl;
120         #endif
121 
122         throw std::invalid_argument(error_str);
123     }
124 
125     //  6. check CH4_emissions_intensity_kgL
126     if (diesel_inputs.CH4_emissions_intensity_kgL < 0) {
127         std::string error_str = "ERROR:  Diesel():  ";
128         error_str += "DieselInputs::CH4_emissions_intensity_kgL must be >= 0";
129 
130         #ifdef _WIN32
131             std::cout << error_str << std::endl;
132         #endif
133 
134         throw std::invalid_argument(error_str);
135     }
136 
137     //  7. check PM_emissions_intensity_kgL
138     if (diesel_inputs.PM_emissions_intensity_kgL < 0) {
139         std::string error_str = "ERROR:  Diesel():  ";
140         error_str += "DieselInputs::PM_emissions_intensity_kgL must be >= 0";
141 
142         #ifdef _WIN32
143             std::cout << error_str << std::endl;
144         #endif
145 
```

```
146         throw std::invalid_argument(error_str);
147     }
148 
149     //  8. check minimum_load_ratio
150     if (diesel_inputs.minimum_load_ratio < 0) {
151         std::string error_str = "ERROR:  Diesel():  ";
152         error_str += "DieselInputs::minimum_load_ratio must be >= 0";
153 
154         #ifdef _WIN32
155             std::cout << error_str << std::endl;
156         #endif
157 
158         throw std::invalid_argument(error_str);
159     }
160 
161     //  9. check minimum_runtime_hrs
162     if (diesel_inputs.minimum_runtime_hrs < 0) {
163         std::string error_str = "ERROR:  Diesel():  ";
164         error_str += "DieselInputs::minimum_runtime_hrs must be >= 0";
165 
166         #ifdef _WIN32
167             std::cout << error_str << std::endl;
168         #endif
169 
170         throw std::invalid_argument(error_str);
171     }
172 
173     //  10. check replace_running_hrs
174     if (diesel_inputs.replace_running_hrs <= 0) {
175         std::string error_str = "ERROR:  Diesel():  ";
176         error_str += "DieselInputs::replace_running_hrs must be > 0";
177 
178         #ifdef _WIN32
179             std::cout << error_str << std::endl;
180         #endif
181 
182         throw std::invalid_argument(error_str);
183     }
184 
185     return;
186 }   /* __checkInputs() */
```

4.4.3.2 __getGenericCapitalCost()

```
double Diesel::__getGenericCapitalCost (
            void  )  [private]
```

Helper method to generate a generic diesel generator capital cost.

This model was obtained by way of surveying an assortment of published diesel generator costs, and then constructing a best fit model. Note that this model expresses cost in terms of Canadian dollars [CAD].

Returns

A generic capital cost for the diesel generator [CAD].

```
263 {
264     double capital_cost_per_kW = 1000 * pow(this->capacity_kW, -0.425) + 800;
265 
266     return capital_cost_per_kW * this->capacity_kW;
267 }   /* __getGenericCapitalCost() */
```

4.4.3.3 __getGenericFuelIntercept()

```
double Diesel::__getGenericFuelIntercept (
            void  )  [private]
```

Helper method to generate a generic, linearized fuel consumption intercept for a diesel generator.

This model was obtained by way of surveying an assortment of published diesel generator fuel consumption data, and then constructing a best fit model.

Ref: HOMER [2023c]
Ref: HOMER [2023d]

Returns

A generic fuel intercept coefficient for the diesel generator [L/kWh].

```
238 {
239     double linear_fuel_intercept_LkWh = 0.0940 * pow(this->capacity_kW, -0.2735);
240
241     return linear_fuel_intercept_LkWh;
242 }   /* __getGenericFuelIntercept() */
```

4.4.3.4 __getGenericFuelSlope()

```
double Diesel::__getGenericFuelSlope (
            void  )  [private]
```

Helper method to generate a generic, linearized fuel consumption slope for a diesel generator.

This model was obtained by way of surveying an assortment of published diesel generator fuel consumption data, and then constructing a best fit model.

Ref: HOMER [2023c]
Ref: HOMER [2023e]

Returns

A generic fuel slope for the diesel generator [L/kWh].

```
210 {
211     double linear_fuel_slope_LkWh = 0.4234 * pow(this->capacity_kW, -0.1012);
212
213     return linear_fuel_slope_LkWh;
214 }   /* __getGenericFuelSlope() */
```

4.4.3.5 __getGenericOpMaintCost()

```
double Diesel::__getGenericOpMaintCost (
            void  )  [private]
```

Helper method (private) to generate a generic diesel generator operation and maintenance cost. This is a cost incurred per unit energy produced.

This model was obtained by way of surveying an assortment of published diesel generator costs, and then constructing a best fit model. Note that this model expresses cost in terms of Canadian dollars per kiloWatt-hour production [CAD/kWh].

Returns

A generic operation and maintenance cost, per unit energy produced, for the diesel generator [CAD/kWh].

```
291 {
292     double operation_maintenance_cost_kWh = 0.05 * pow(this->capacity_kW, -0.2) + 0.05;
293 
294     return operation_maintenance_cost_kWh;
295 }   /* __getGenericOpMaintCost() */
```

4.4.3.6 __handleStartStop()

```
void Diesel::__handleStartStop (
            int timestep,
            double dt_hrs,
            double production_kW )  [private]
```

Helper method (private) to handle the starting/stopping of the diesel generator. The minimum runtime constraint is enforced in this method.

Parameters

timestep	The current time step of the Model run.
dt_hrs	The interval of time [hrs] associated with the action.
production_kW	The current rate of production [kW] of the generator.

```
325 {
326     /*
327      *  Helper method (private) to handle the starting/stopping of the diesel
328      *  generator. The minimum runtime constraint is enforced in this method.
329      */
330 
331     if (this->is_running) {
332         // handle stopping
333         if (
334             production_kW <= 0 and
335             this->time_since_last_start_hrs >= this->minimum_runtime_hrs
336         ) {
337             this->is_running = false;
338         }
339     }
340 
341     else {
342         // handle starting
343         if (production_kW > 0) {
344             this->is_running = true;
345             this->n_starts++;
346             this->time_since_last_start_hrs = 0;
347         }
348     }
349 
```

```
350     return;
351 }   /* __handleStartStop() */
```

4.4.3.7 __writeSummary()

```
void Diesel::__writeSummary (
            std::string write_path )  [private], [virtual]
```

Helper method to write summary results for Diesel.

Parameters

write_path	A path (either relative or absolute) to the directory location where results are to be written. If already exists, will overwrite.

Reimplemented from Combustion.

```
370 {
371     //  1. create filestream
372     write_path += "summary_results.md";
373     std::ofstream ofs;
374     ofs.open(write_path, std::ofstream::out);
375 
376     //  2. write to summary results (markdown)
377     ofs « "# ";
378     ofs « std::to_string(int(ceil(this->capacity_kW)));
379     ofs « " kW DIESEL Summary Results\n";
380     ofs « "\n--------\n\n";
381 
382     //  2.1. Production attributes
383     ofs « "## Production Attributes\n";
384     ofs « "\n";
385 
386     ofs « "Capacity: " « this->capacity_kW « " kW  \n";
387     ofs « "\n";
388 
389     ofs « "Production Override: (N = 0 / Y = 1): "
390         « this->normalized_production_series_given « "  \n";
391     if (this->normalized_production_series_given) {
392         ofs « "Path to Normalized Production Time Series: "
393             « this->path_2_normalized_production_time_series « "  \n";
394     }
395     ofs « "\n";
396 
397     ofs « "Sunk Cost (N = 0 / Y = 1): " « this->is_sunk « "  \n";
398     ofs « "Capital Cost: " « this->capital_cost « "  \n";
399     ofs « "Operation and Maintenance Cost: " « this->operation_maintenance_cost_kWh
400         « " per kWh produced  \n";
401     ofs « "Nominal Inflation Rate (annual): " « this->nominal_inflation_annual
402         « "  \n";
403     ofs « "Nominal Discount Rate (annual): " « this->nominal_discount_annual
404         « "  \n";
405     ofs « "Real Discount Rate (annual): " « this->real_discount_annual « "  \n";
406     ofs « "\n";
407 
408     ofs « "Replacement Running Hours: " « this->replace_running_hrs « "  \n";
409     ofs « "\n--------\n\n";
410 
411     //  2.2. Combustion attributes
412     ofs « "## Combustion Attributes\n";
413     ofs « "\n";
414 
415     ofs « "Cycle Charging Setpoint: " « this->cycle_charging_setpoint « "\n";
416     ofs « "\n";
417 
418     ofs « "Fuel Cost: " « this->fuel_cost_L « " per L  \n";
419     ofs « "Nominal Fuel Escalation Rate (annual): "
420         « this->nominal_fuel_escalation_annual « "  \n";
421     ofs « "Real Fuel Escalation Rate (annual): "
422         « this->real_fuel_escalation_annual « "  \n";
423     ofs « "\n";
424 
425     ofs « "Fuel Mode: " « this->fuel_mode_str « "  \n";
```

```
426     switch (this->fuel_mode) {
427         case (FuelMode :: FUEL_MODE_LINEAR): {
428             ofs « "Linear Fuel Slope: " « this->linear_fuel_slope_LkWh
429                 « " L/kWh  \n";
430             ofs « "Linear Fuel Intercept Coefficient: "
431                 « this->linear_fuel_intercept_LkWh « " L/kWh  \n";
432             ofs « "\n";
433 
434             break;
435         }
436 
437         case (FuelMode :: FUEL_MODE_LOOKUP): {
438             ofs « "Fuel Consumption Data: " « this->interpolator.path_map_1D[0]
439                 « "  \n";
440 
441             break;
442         }
443 
444         default: {
445             // write nothing!
446 
447             break;
448         }
449     }
450 
451     ofs « "Carbon Dioxide (CO2) Emissions Intensity: "
452         « this->CO2_emissions_intensity_kgL « " kg/L  \n";
453 
454     ofs « "Carbon Monoxide (CO) Emissions Intensity: "
455         « this->CO_emissions_intensity_kgL « " kg/L  \n";
456 
457     ofs « "Nitrogen Oxides (NOx) Emissions Intensity: "
458         « this->NOx_emissions_intensity_kgL « " kg/L  \n";
459 
460     ofs « "Sulfur Oxides (SOx) Emissions Intensity: "
461         « this->SOx_emissions_intensity_kgL « " kg/L  \n";
462 
463     ofs « "Methane (CH4) Emissions Intensity: "
464         « this->CH4_emissions_intensity_kgL « " kg/L  \n";
465 
466     ofs « "Particulate Matter (PM) Emissions Intensity: "
467         « this->PM_emissions_intensity_kgL « " kg/L  \n";
468 
469     ofs « "\n--------\n\n";
470 
471     //  2.3. Diesel attributes
472     ofs « "## Diesel Attributes\n";
473     ofs « "\n";
474 
475     ofs « "Minimum Load Ratio: " « this->minimum_load_ratio « "  \n";
476     ofs « "Minimum Runtime: " « this->minimum_runtime_hrs « " hrs  \n";
477 
478     ofs « "\n--------\n\n";
479 
480     //  2.4. Diesel Results
481     ofs « "## Results\n";
482     ofs « "\n";
483 
484     ofs « "Net Present Cost: " « this->net_present_cost « "  \n";
485     ofs « "\n";
486 
487     ofs « "Total Dispatch: " « this->total_dispatch_kWh
488         « " kWh  \n";
489 
490     ofs « "Levellized Cost of Energy: " « this->levellized_cost_of_energy_kWh
491         « " per kWh dispatched  \n";
492     ofs « "\n";
493 
494     ofs « "Running Hours: " « this->running_hours « "  \n";
495     ofs « "Starts: " « this->n_starts « "  \n";
496     ofs « "Replacements: " « this->n_replacements « "  \n";
497 
498     ofs « "Total Fuel Consumed: " « this->total_fuel_consumed_L « " L "
499         « "(Annual Average: " « this->total_fuel_consumed_L / this->n_years
500         « " L/yr)  \n";
501     ofs « "\n";
502 
503     ofs « "Total Carbon Dioxide (CO2) Emissions: " «
504         this->total_emissions.CO2_kg « " kg "
505         « "(Annual Average: " «  this->total_emissions.CO2_kg / this->n_years
506         « " kg/yr)  \n";
507 
508     ofs « "Total Carbon Monoxide (CO) Emissions: " «
509         this->total_emissions.CO_kg « " kg "
510         « "(Annual Average: " «  this->total_emissions.CO_kg / this->n_years
511         « " kg/yr)  \n";
512 
```

```
513     ofs « "Total Nitrogen Oxides (NOx) Emissions: " «
514         this->total_emissions.NOx_kg « " kg "
515         « "(Annual Average: " «  this->total_emissions.NOx_kg / this->n_years
516         « " kg/yr)  \n";
517
518     ofs « "Total Sulfur Oxides (SOx) Emissions: " «
519         this->total_emissions.SOx_kg « " kg "
520         « "(Annual Average: " «  this->total_emissions.SOx_kg / this->n_years
521         « " kg/yr)  \n";
522
523     ofs « "Total Methane (CH4) Emissions: " « this->total_emissions.CH4_kg « " kg "
524         « "(Annual Average: " «  this->total_emissions.CH4_kg / this->n_years
525         « " kg/yr)  \n";
526
527     ofs « "Total Particulate Matter (PM) Emissions: " «
528         this->total_emissions.PM_kg « " kg "
529         « "(Annual Average: " «  this->total_emissions.PM_kg / this->n_years
530         « " kg/yr)  \n";
531
532     ofs « "\n--------\n\n";
533
534     ofs.close();
535     return;
536 }   /* __writeSummary() */
```

4.4.3.8 __writeTimeSeries()

```
void Diesel::__writeTimeSeries (
              std::string write_path,
              std::vector< double > * time_vec_hrs_ptr,
              int max_lines = -1 )  [private], [virtual]
```

Helper method to write time series results for Diesel.

Parameters

write_path	A path (either relative or absolute) to the directory location where results are to be written. If already exists, will overwrite.
time_vec_hrs_ptr	A pointer to the time_vec_hrs attribute of the ElectricalLoad.
max_lines	The maximum number of lines of output to write.

Reimplemented from Combustion.

```
566 {
567     //  1. create filestream
568     write_path += "time_series_results.csv";
569     std::ofstream ofs;
570     ofs.open(write_path, std::ofstream::out);
571
572     //  2. write time series results (comma separated value)
573     ofs « "Time (since start of data) [hrs],";
574     ofs « "Production [kW],";
575     ofs « "Dispatch [kW],";
576     ofs « "Storage [kW],";
577     ofs « "Curtailment [kW],";
578     ofs « "Is Running (N = 0 / Y = 1),";
579     ofs « "Fuel Consumption [L],";
580     ofs « "Fuel Cost (actual),";
581     ofs « "Carbon Dioxide (CO2) Emissions [kg],";
582     ofs « "Carbon Monoxide (CO) Emissions [kg],";
583     ofs « "Nitrogen Oxides (NOx) Emissions [kg],";
584     ofs « "Sulfur Oxides (SOx) Emissions [kg],";
585     ofs « "Methane (CH4) Emissions [kg],";
586     ofs « "Particulate Matter (PM) Emissions [kg],";
587     ofs « "Capital Cost (actual),";
588     ofs « "Operation and Maintenance Cost (actual),";
589     ofs « "\n";
590
591     for (int i = 0; i < max_lines; i++) {
592         ofs « time_vec_hrs_ptr->at(i) « ",";
593         ofs « this->production_vec_kW[i] « ",";
```

```
594         ofs « this->dispatch_vec_kW[i] « ",";
595         ofs « this->storage_vec_kW[i] « ",";
596         ofs « this->curtailment_vec_kW[i] « ",";
597         ofs « this->is_running_vec[i] « ",";
598         ofs « this->fuel_consumption_vec_L[i] « ",";
599         ofs « this->fuel_cost_vec[i] « ",";
600         ofs « this->CO2_emissions_vec_kg[i] « ",";
601         ofs « this->CO_emissions_vec_kg[i] « ",";
602         ofs « this->NOx_emissions_vec_kg[i] « ",";
603         ofs « this->SOx_emissions_vec_kg[i] « ",";
604         ofs « this->CH4_emissions_vec_kg[i] « ",";
605         ofs « this->PM_emissions_vec_kg[i] « ",";
606         ofs « this->capital_cost_vec[i] « ",";
607         ofs « this->operation_maintenance_cost_vec[i] « ",";
608         ofs « "\n";
609     }
610
611     ofs.close();
612     return;
613 }   /* __writeTimeSeries() */
```

4.4.3.9 commit()

```
double Diesel::commit (
            int timestep,
            double dt_hrs,
            double production_kW,
            double load_kW )  [virtual]
```

Method which takes in production and load for the current timestep, computes and records dispatch and curtailment, and then returns remaining load.

Parameters

timestep	The timestep (i.e., time series index) for the request.
dt_hrs	The interval of time [hrs] associated with the timestep.
production_kW	The production [kW] of the asset in this timestep.
load_kW	The load [kW] passed to the asset in this timestep.

Returns

The load [kW] remaining after the dispatch is deducted from it.

Reimplemented from Combustion.

```
855 {
856     //  1. handle start/stop, enforce minimum runtime constraint
857     this->__handleStartStop(timestep, dt_hrs, production_kW);
858
859     //  2. invoke base class method
860     load_kW = Combustion :: commit(
861         timestep,
862         dt_hrs,
863         production_kW,
864         load_kW
865     );
866
867     if (this->is_running) {
868         //  3. log time since last start
869         this->time_since_last_start_hrs += dt_hrs;
870
871         //  4. correct operation and maintenance costs (should be non-zero if idling)
872         if (production_kW <= 0) {
873             double produced_kWh = 0.01 * this->capacity_kW * dt_hrs;
874
875             double operation_maintenance_cost =
```

```
876                 this->operation_maintenance_cost_kWh * produced_kWh;
877             this->operation_maintenance_cost_vec[timestep] = operation_maintenance_cost;
878         }
879     }
880
881     return load_kW;
882 }   /* commit() */
```

4.4.3.10 handleReplacement()

```
void Diesel::handleReplacement (
            int timestep )  [virtual]
```

Method to handle asset replacement and capital cost incursion, if applicable.

Parameters

timestep	The current time step of the Model run.

Reimplemented from Combustion.

```
753 {
754     //  1. reset attributes
755     this->time_since_last_start_hrs = 0;
756
757     //  2. invoke base class method
758     Combustion :: handleReplacement(timestep);
759
760     return;
761 }   /* __handleReplacement() */
```

4.4.3.11 requestProductionkW()

```
double Diesel::requestProductionkW (
            int timestep,
            double dt_hrs,
            double request_kW )  [virtual]
```

Method which takes in production request, and then returns what the asset can deliver (subject to operating constraints, etc.).

Parameters

timestep	The timestep (i.e., time series index) for the request.
dt_hrs	The interval of time [hrs] associated with the timestep.
request_kW	The requested production [kW].

Returns

The production [kW] delivered by the diesel generator.

Reimplemented from Combustion.

```
793 {
```

```
794     //  0. given production time series override
795     if (this->normalized_production_series_given) {
796         double production_kW = Production :: getProductionkW(timestep);
797 
798         return production_kW;
799     }
800 
801     //  1. return on request of zero
802     if (request_kW <= 0) {
803         return 0;
804     }
805 
806     double deliver_kW = request_kW;
807 
808     //  2. enforce capacity constraint
809     if (deliver_kW > this->capacity_kW) {
810         deliver_kW = this->capacity_kW;
811     }
812 
813     //  3. enforce minimum load ratio
814     if (deliver_kW < this->minimum_load_ratio * this->capacity_kW) {
815         deliver_kW = this->minimum_load_ratio * this->capacity_kW;
816     }
817 
818     return deliver_kW;
819 }   /* requestProductionkW() */
```

4.4.4 Member Data Documentation

4.4.4.1 minimum_load_ratio

`double Diesel::minimum_load_ratio`

The minimum load ratio of the asset. That is, when the asset is producing, it must produce at least this ratio of its rated capacity.

4.4.4.2 minimum_runtime_hrs

`double Diesel::minimum_runtime_hrs`

The minimum runtime [hrs] of the asset. This is the minimum time that must elapse between successive starts and stops.

4.4.4.3 time_since_last_start_hrs

`double Diesel::time_since_last_start_hrs`

The time that has elapsed [hrs] since the last start of the asset.

The documentation for this class was generated from the following files:

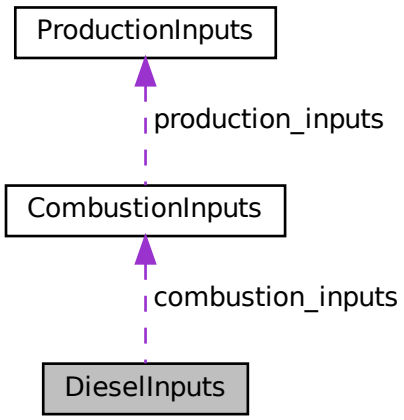
- header/Production/Combustion/Diesel.h
- source/Production/Combustion/Diesel.cpp

4.5 DieselInputs Struct Reference

A structure which bundles the necessary inputs for the Diesel constructor. Provides default values for every necessary input. Note that this structure encapsulates CombustionInputs.

`#include <Diesel.h>`

Collaboration diagram for DieselInputs:



Public Attributes

- CombustionInputs combustion_inputs

  An encapsulated CombustionInputs instance.
- double replace_running_hrs = 30000

  The number of running hours after which the asset must be replaced. Overwrites the ProductionInputs attribute.
- double capital_cost = -1

  The capital cost of the asset (undefined currency). -1 is a sentinel value, which triggers a generic cost model on construction (in fact, any negative value here will trigger). Note that the generic cost model is in terms of Canadian dollars [CAD].
- double operation_maintenance_cost_kWh = -1

  The operation and maintenance cost of the asset [1/kWh] (undefined currency). This is a cost incurred per unit of energy produced. -1 is a sentinel value, which triggers a generic cost model on construction (in fact, any negative value here will trigger). Note that the generic cost model is in terms of Canadian dollars [CAD/kWh].
- double fuel_cost_L = 1.70

  The cost of fuel [1/L] (undefined currency).
- double minimum_load_ratio = 0.2

  The minimum load ratio of the asset. That is, when the asset is producing, it must produce at least this ratio of its rated capacity.
- double minimum_runtime_hrs = 4

  The minimum runtime [hrs] of the asset. This is the minimum time that must elapse between successive starts and stops.
- double linear_fuel_slope_LkWh = -1

The slope [L/kWh] to use in computing linearized fuel consumption. This is fuel consumption per unit energy produced. -1 is a sentinel value, which triggers a generic fuel consumption model on construction (in fact, any negative value here will trigger).

- double linear_fuel_intercept_LkWh = -1

  The intercept [L/kWh] to use in computing linearized fuel consumption. This is fuel consumption per unit energy produced. -1 is a sentinel value, which triggers a generic fuel consumption model on construction (in fact, any negative value here will trigger).
- double CO2_emissions_intensity_kgL = 2.7

  Carbon dioxide (CO2) emissions intensity [kg/L].
- double CO_emissions_intensity_kgL = 0.0178

  Carbon monoxide (CO) emissions intensity [kg/L].
- double NOx_emissions_intensity_kgL = 0.0014

  Nitrogen oxide (NOx) emissions intensity [kg/L].
- double SOx_emissions_intensity_kgL = 0.0042

  Sulfur oxide (SOx) emissions intensity [kg/L].
- double CH4_emissions_intensity_kgL = 0.0007

  Methane (CH4) emissions intensity [kg/L].
- double PM_emissions_intensity_kgL = 0.0001

  Particulate Matter (PM) emissions intensity [kg/L].

4.5.1 Detailed Description

A structure which bundles the necessary inputs for the Diesel constructor. Provides default values for every necessary input. Note that this structure encapsulates CombustionInputs.

Ref: HOMER [2023c]
Ref: HOMER [2023d]
Ref: HOMER [2023e]
Ref: NRCan [2014]
Ref: CIMAC [2008]

4.5.2 Member Data Documentation

4.5.2.1 capital_cost

```
double DieselInputs::capital_cost = -1
```

The capital cost of the asset (undefined currency). -1 is a sentinel value, which triggers a generic cost model on construction (in fact, any negative value here will trigger). Note that the generic cost model is in terms of Canadian dollars [CAD].

4.5.2.2 CH4_emissions_intensity_kgL

```
double DieselInputs::CH4_emissions_intensity_kgL = 0.0007
```

Methane (CH4) emissions intensity [kg/L].

4.5.2.3 CO2_emissions_intensity_kgL

```
double DieselInputs::CO2_emissions_intensity_kgL = 2.7
```

Carbon dioxide (CO2) emissions intensity [kg/L].

4.5.2.4 CO_emissions_intensity_kgL

```
double DieselInputs::CO_emissions_intensity_kgL = 0.0178
```

Carbon monoxide (CO) emissions intensity [kg/L].

4.5.2.5 combustion_inputs

```
CombustionInputs DieselInputs::combustion_inputs
```

An encapsulated CombustionInputs instance.

4.5.2.6 fuel_cost_L

```
double DieselInputs::fuel_cost_L = 1.70
```

The cost of fuel [1/L] (undefined currency).

4.5.2.7 linear_fuel_intercept_LkWh

```
double DieselInputs::linear_fuel_intercept_LkWh = -1
```

The intercept [L/kWh] to use in computing linearized fuel consumption. This is fuel consumption per unit energy produced. -1 is a sentinel value, which triggers a generic fuel consumption model on construction (in fact, any negative value here will trigger).

4.5.2.8 linear_fuel_slope_LkWh

```
double DieselInputs::linear_fuel_slope_LkWh = -1
```

The slope [L/kWh] to use in computing linearized fuel consumption. This is fuel consumption per unit energy produced. -1 is a sentinel value, which triggers a generic fuel consumption model on construction (in fact, any negative value here will trigger).

4.5.2.9 minimum_load_ratio

```
double DieselInputs::minimum_load_ratio = 0.2
```

The minimum load ratio of the asset. That is, when the asset is producing, it must produce at least this ratio of its rated capacity.

4.5.2.10 minimum_runtime_hrs

```
double DieselInputs::minimum_runtime_hrs = 4
```

The minimum runtime [hrs] of the asset. This is the minimum time that must elapse between successive starts and stops.

4.5.2.11 NOx_emissions_intensity_kgL

```
double DieselInputs::NOx_emissions_intensity_kgL = 0.0014
```

Nitrogen oxide (NOx) emissions intensity [kg/L].

4.5.2.12 operation_maintenance_cost_kWh

```
double DieselInputs::operation_maintenance_cost_kWh = -1
```

The operation and maintenance cost of the asset [1/kWh] (undefined currency). This is a cost incurred per unit of energy produced. -1 is a sentinel value, which triggers a generic cost model on construction (in fact, any negative value here will trigger). Note that the generic cost model is in terms of Canadian dollars [CAD/kWh].

4.5.2.13 PM_emissions_intensity_kgL

```
double DieselInputs::PM_emissions_intensity_kgL = 0.0001
```

Particulate Matter (PM) emissions intensity [kg/L].

4.5.2.14 replace_running_hrs

```
double DieselInputs::replace_running_hrs = 30000
```

The number of running hours after which the asset must be replaced. Overwrites the ProductionInputs attribute.

4.5.2.15 SOx_emissions_intensity_kgL

```
double DieselInputs::SOx_emissions_intensity_kgL = 0.0042
```

Sulfur oxide (SOx) emissions intensity [kg/L].

The documentation for this struct was generated from the following file:

- header/Production/Combustion/Diesel.h

4.6 ElectricalLoad Class Reference

A class which contains time and electrical load data. Intended to serve as a component class of Model.

```
#include <ElectricalLoad.h>
```

Public Member Functions

- ElectricalLoad (void)

  Constructor (dummy) for the ElectricalLoad class.
- ElectricalLoad (std::string)

  Constructor (intended) for the ElectricalLoad class.
- void readLoadData (std::string)

  Method to read electrical load data into an already existing ElectricalLoad object. Clears and overwrites any existing attribute values.
- void clear (void)

  Method to clear all attributes of the ElectricalLoad object.
- ~ElectricalLoad (void)

  Destructor for the ElectricalLoad class.

Public Attributes

- int n_points

  The number of points in the modelling time series.
- double n_years

  The number of years being modelled (inferred from time_vec_hrs).
- double min_load_kW

  The minimum [kW] of the given electrical load time series.
- double mean_load_kW

  The mean, or average, [kW] of the given electrical load time series.
- double max_load_kW

  The maximum [kW] of the given electrical load time series.
- std::string path_2_electrical_load_time_series

  A string defining the path (either relative or absolute) to the given electrical load time series.
- std::vector< double > time_vec_hrs

  A vector to hold a given sequence of model times [hrs]. This defines the modelling time series.
- std::vector< double > dt_vec_hrs

  A vector to hold a sequence of model time deltas [hrs].
- std::vector< double > load_vec_kW

  A vector to hold a given sequence of electrical load values [kW].

4.6.1 Detailed Description

A class which contains time and electrical load data. Intended to serve as a component class of Model.

4.6.2 Constructor & Destructor Documentation

4.6.2.1 ElectricalLoad() [1/2]

```
ElectricalLoad::ElectricalLoad (
            void  )
```

Constructor (dummy) for the ElectricalLoad class.

```
62 {
63     return;
64 }   /* ElectricalLoad() */
```

4.6.2.2 ElectricalLoad() [2/2]

```
ElectricalLoad::ElectricalLoad (
            std::string path_2_electrical_load_time_series )
```

Constructor (intended) for the ElectricalLoad class.

Parameters

path_2_electrical_load_time_series	A string defining the path (either relative or absolute) to the given electrical load time series.

```
82 {
83     this->readLoadData(path_2_electrical_load_time_series);
84
85     return;
86 }   /* ElectricalLoad() */
```

4.6.2.3 ~ElectricalLoad()

```
ElectricalLoad::~ElectricalLoad (
            void  )
```

Destructor for the ElectricalLoad class.

```
209 {
210     this->clear();
211     return;
212 }   /* ~ElectricalLoad() */
```

4.6.3 Member Function Documentation

4.6.3.1 clear()

```
void ElectricalLoad::clear (
            void  )
```

Method to clear all attributes of the ElectricalLoad object.

```
182 {
183     this->n_points = 0;
184     this->n_years = 0;
185     this->min_load_kW = 0;
186     this->mean_load_kW = 0;
187     this->max_load_kW = 0;
188 
189     this->path_2_electrical_load_time_series.clear();
190     this->time_vec_hrs.clear();
191     this->dt_vec_hrs.clear();
192     this->load_vec_kW.clear();
193 
194     return;
195 }   /* clear() */
```

4.6.3.2 readLoadData()

```
void ElectricalLoad::readLoadData (
            std::string path_2_electrical_load_time_series )
```

Method to read electrical load data into an already existing ElectricalLoad object. Clears and overwrites any existing attribute values.

Parameters

path_2_electrical_load_time_series	A string defining the path (either relative or absolute) to the given electrical load time series.

```
104 {
105     //  1. clear
106     this->clear();
107 
108     //  2. init CSV reader, record path
109     io::CSVReader<2> CSV(path_2_electrical_load_time_series);
110 
111     CSV.read_header(
112         io::ignore_extra_column,
113         "Time (since start of data) [hrs]",
114         "Electrical Load [kW]"
115     );
116 
117     this->path_2_electrical_load_time_series = path_2_electrical_load_time_series;
118 
119     //  3. read in time and load data, increment n_points, track min and max load
120     double time_hrs = 0;
121     double load_kW = 0;
122     double load_sum_kW = 0;
123 
124     this->n_points = 0;
125 
126     this->min_load_kW = std::numeric_limits<double>::infinity();
127     this->max_load_kW = -1 * std::numeric_limits<double>::infinity();
128 
129     while (CSV.read_row(time_hrs, load_kW)) {
130         this->time_vec_hrs.push_back(time_hrs);
131         this->load_vec_kW.push_back(load_kW);
132 
133         load_sum_kW += load_kW;
134 
135         this->n_points++;
136 
137         if (this->min_load_kW > load_kW) {
138             this->min_load_kW = load_kW;
139         }
140 
```

```
141         if (this->max_load_kW < load_kW) {
142             this->max_load_kW = load_kW;
143         }
144     }
145
146     //  4. compute mean load
147     this->mean_load_kW = load_sum_kW / this->n_points;
148
149     //  5. set number of years (assuming 8,760 hours per year)
150     this->n_years = this->time_vec_hrs[this->n_points - 1] / 8760;
151
152     //  6. populate dt_vec_hrs
153     this->dt_vec_hrs.resize(n_points, 0);
154
155     for (int i = 0; i < n_points; i++) {
156         if (i == n_points - 1) {
157             this->dt_vec_hrs[i] = this->dt_vec_hrs[i - 1];
158         }
159
160         else {
161             double dt_hrs = this->time_vec_hrs[i + 1] - this->time_vec_hrs[i];
162
163             this->dt_vec_hrs[i] = dt_hrs;
164         }
165     }
166
167     return;
168 }   /* readLoadData() */
```

4.6.4 Member Data Documentation

4.6.4.1 dt_vec_hrs

`std::vector<double> ElectricalLoad::dt_vec_hrs`

A vector to hold a sequence of model time deltas [hrs].

4.6.4.2 load_vec_kW

`std::vector<double> ElectricalLoad::load_vec_kW`

A vector to hold a given sequence of electrical load values [kW].

4.6.4.3 max_load_kW

`double ElectricalLoad::max_load_kW`

The maximum [kW] of the given electrical load time series.

4.6.4.4 mean_load_kW

```
double ElectricalLoad::mean_load_kW
```

The mean, or average, [kW] of the given electrical load time series.

4.6.4.5 min_load_kW

```
double ElectricalLoad::min_load_kW
```

The minimum [kW] of the given electrical load time series.

4.6.4.6 n_points

```
int ElectricalLoad::n_points
```

The number of points in the modelling time series.

4.6.4.7 n_years

```
double ElectricalLoad::n_years
```

The number of years being modelled (inferred from time_vec_hrs).

4.6.4.8 path_2_electrical_load_time_series

```
std::string ElectricalLoad::path_2_electrical_load_time_series
```

A string defining the path (either relative or absolute) to the given electrical load time series.

4.6.4.9 time_vec_hrs

```
std::vector<double> ElectricalLoad::time_vec_hrs
```

A vector to hold a given sequence of model times [hrs]. This defines the modelling time series.

The documentation for this class was generated from the following files:

- header/ElectricalLoad.h
- source/ElectricalLoad.cpp

4.7 Emissions Struct Reference

A structure which bundles the emitted masses of various emissions chemistries.

`#include <Combustion.h>`

Public Attributes

- double CO2_kg = 0
  The mass of carbon dioxide (CO2) emitted [kg].
- double CO_kg = 0
  The mass of carbon monoxide (CO) emitted [kg].
- double NOx_kg = 0
  The mass of nitrogen oxides (NOx) emitted [kg].
- double SOx_kg = 0
  The mass of sulfur oxides (SOx) emitted [kg].
- double CH4_kg = 0
  The mass of methane (CH4) emitted [kg].
- double PM_kg = 0
  The mass of particulate matter (PM) emitted [kg].

4.7.1 Detailed Description

A structure which bundles the emitted masses of various emissions chemistries.

4.7.2 Member Data Documentation

4.7.2.1 CH4_kg

`double Emissions::CH4_kg = 0`

The mass of methane (CH4) emitted [kg].

4.7.2.2 CO2_kg

`double Emissions::CO2_kg = 0`

The mass of carbon dioxide (CO2) emitted [kg].

4.7.2.3 CO_kg

```
double Emissions::CO_kg = 0
```

The mass of carbon monoxide (CO) emitted [kg].

4.7.2.4 NOx_kg

```
double Emissions::NOx_kg = 0
```

The mass of nitrogen oxides (NOx) emitted [kg].

4.7.2.5 PM_kg

```
double Emissions::PM_kg = 0
```

The mass of particulate matter (PM) emitted [kg].

4.7.2.6 SOx_kg

```
double Emissions::SOx_kg = 0
```

The mass of sulfur oxides (SOx) emitted [kg].

The documentation for this struct was generated from the following file:

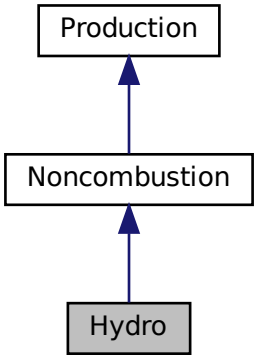
- header/Production/Combustion/Combustion.h

4.8 Hydro Class Reference

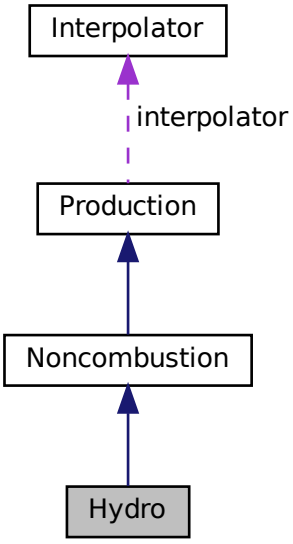
A derived class of the Noncombustion branch of Production which models production using a hydroelectric asset (either with reservoir or not).

`#include <Hydro.h>`

Inheritance diagram for Hydro:



Collaboration diagram for Hydro:



Public Member Functions

- Hydro (void)

  Constructor (dummy) for the Hydro class.
- Hydro (int, double, HydroInputs, std::vector< double > *)

  Constructor (intended) for the Hydro class.
- void handleReplacement (int)

  Method to handle asset replacement and capital cost incursion, if applicable.
- double requestProductionkW (int, double, double, double)

  Method which takes in production request, and then returns what the asset can deliver (subject to operating constraints, etc.).
- double commit (int, double, double, double, double)

  Method which takes in production and load for the current timestep, computes and records dispatch and curtailment, and then returns remaining load.
- ~Hydro (void)

  Destructor for the Hydro class.

Public Attributes

- HydroTurbineType turbine_type

  The type of hydroelectric turbine model to use.
- double fluid_density_kgm3

  The density [kg/m3] of the hydroelectric working fluid.
- double net_head_m

  The net head [m] of the asset.
- double reservoir_capacity_m3

  The capacity [m3] of the hydro reservoir.
- double init_reservoir_state

  The initial state of the reservoir (where state is volume of stored fluid divided by capacity).
- double stored_volume_m3

  The volume [m3] of stored fluid.
- double minimum_power_kW

  The minimum power [kW] that the asset can produce. Corresponds to minimum productive flow.
- double minimum_flow_m3hr

  The minimum required flow [m3/hr] for the asset to produce. Corresponds to minimum power.
- double maximum_flow_m3hr

  The maximum productive flow [m3/hr] that the asset can support.
- std::vector< double > turbine_flow_vec_m3hr

  A vector of the turbine flow [m3/hr] at each point in the modelling time series.
- std::vector< double > spill_rate_vec_m3hr

  A vector of the spill rate [m3/hr] at each point in the modelling time series.
- std::vector< double > stored_volume_vec_m3

  A vector of the stored volume [m3] in the reservoir at each point in the modelling time series.

Private Member Functions

- void __checkInputs (HydroInputs)

  Helper method to check inputs to the Hydro constructor.
- void __initInterpolator (void)

  Helper method to set up turbine and generator efficiency interpolation.
- double __getGenericCapitalCost (void)

  Helper method to generate a generic hydroelectric capital cost.
- double __getGenericOpMaintCost (void)

  Helper method (private) to generate a generic hydroelectric operation and maintenance cost. This is a cost incurred per unit energy produced.
- double __getEfficiencyFactor (double)

  Helper method to compute the efficiency factor (product of turbine and generator efficiencies).
- double __getMinimumFlowm3hr (void)

  Helper method to compute and return the minimum required flow for production, based on turbine type.
- double __getMaximumFlowm3hr (void)

  Helper method to compute and return the maximum productive flow, based on turbine type.
- double __flowToPower (double)

  Helper method to translate a given flow into a corresponding power output.
- double __powerToFlow (double)

  Helper method to translate a given power output into a corresponding flow.
- double __getAvailableFlow (double, double)

  Helper method to determine what flow is currently available to the turbine.
- double __getAcceptableFlow (double)

  Helper method to determine what flow is currently acceptable by the reservoir.
- void __updateState (int, double, double, double)

  Helper method to update and log flow and reservoir state.
- void __writeSummary (std::string)

  Helper method to write summary results for Hydro.
- void __writeTimeSeries (std::string, std::vector< double > *, int=-1)

  Helper method to write time series results for Hydro.

4.8.1 Detailed Description

A derived class of the Noncombustion branch of Production which models production using a hydroelectric asset (either with reservoir or not).

4.8.2 Constructor & Destructor Documentation

4.8.2.1 Hydro() [1/2]

```
Hydro::Hydro (
            void  )
```

Constructor (dummy) for the Hydro class.

```
859 {
860     return;
861 }   /* Hydro() */
```

4.8.2.2 Hydro() [2/2]

```
Hydro::Hydro (
            int n_points,
            double n_years,
            HydroInputs hydro_inputs,
            std::vector< double > * time_vec_hrs_ptr )
```

Constructor (intended) for the Hydro class.

Parameters

n_points	The number of points in the modelling time series.
n_years	The number of years being modelled.
hydro_inputs	A structure of Hydro constructor inputs.
time_vec_hrs_ptr	A pointer to the vector containing the modelling time series.

```
893   :
894 Noncombustion(
895     n_points,
896     n_years,
897     hydro_inputs.noncombustion_inputs,
898     time_vec_hrs_ptr
899 )
900 {
901     //  1. check inputs
902     this->__checkInputs(hydro_inputs);
903 
904     //  2. set attributes
905     this->type = NoncombustionType :: HYDRO;
906     this->type_str = "HYDRO";
907 
908     this->resource_key = hydro_inputs.resource_key;
909 
910     this->turbine_type = hydro_inputs.turbine_type;
911 
912     this->fluid_density_kgm3 = hydro_inputs.fluid_density_kgm3;
913     this->net_head_m = hydro_inputs.net_head_m;
914 
915     this->reservoir_capacity_m3 = hydro_inputs.reservoir_capacity_m3;
916     this->init_reservoir_state = hydro_inputs.init_reservoir_state;
917     this->stored_volume_m3 =
918         hydro_inputs.init_reservoir_state * hydro_inputs.reservoir_capacity_m3;
919 
920     this->minimum_power_kW = 0.1 * this->capacity_kW;   // <-- NEED TO DOUBLE CHECK THAT THIS MAKES
      SENSE IN GENERAL
921 
922     this->__initInterpolator();
923 
924     this->minimum_flow_m3hr = this->__getMinimumFlowm3hr();
925     this->maximum_flow_m3hr = this->__getMaximumFlowm3hr();
926 
927     this->turbine_flow_vec_m3hr.resize(this->n_points, 0);
928     this->spill_rate_vec_m3hr.resize(this->n_points, 0);
929     this->stored_volume_vec_m3.resize(this->n_points, 0);
930 
931     if (hydro_inputs.capital_cost < 0) {
932         this->capital_cost = this->__getGenericCapitalCost();
933     }
934     else {
935         this->capital_cost = hydro_inputs.capital_cost;
936     }
937 
938     if (hydro_inputs.operation_maintenance_cost_kWh < 0) {
939         this->operation_maintenance_cost_kWh = this->__getGenericOpMaintCost();
940     }
941     else {
942         this->operation_maintenance_cost_kWh =
943             hydro_inputs.operation_maintenance_cost_kWh;
944     }
945 
946     if (not this->is_sunk) {
947         this->capital_cost_vec[0] = this->capital_cost;
948     }
949 
950     return;
951 }   /* Hydro() */
```

4.8.2.3 ~Hydro()

```
Hydro::~Hydro (
            void  )
```

Destructor for the Hydro class.

```
1125 {
1126     //  1. destruction print
1127     if (this->print_flag) {
1128         std::cout « "Hydro object at " « this « " destroyed" « std::endl;
1129     }
1130
1131     return;
1132 }   /* ~Hydro() */
```

4.8.3 Member Function Documentation

4.8.3.1 __checkInputs()

```
void Hydro::__checkInputs (
            HydroInputs hydro_inputs )  [private]
```

Helper method to check inputs to the Hydro constructor.

Parameters

hydro_inputs	A structure of Hydro constructor inputs.

```
64 {
65     //  1. check fluid_density_kgm3
66     if (hydro_inputs.fluid_density_kgm3 <= 0) {
67         std::string error_str = "ERROR:  Hydro():  fluid_density_kgm3 must be > 0";
68
69         #ifdef _WIN32
70             std::cout « error_str « std::endl;
71         #endif
72
73         throw std::invalid_argument(error_str);
74     }
75
76     //  2. check net_head_m
77     if (hydro_inputs.net_head_m <= 0) {
78         std::string error_str = "ERROR:  Hydro():  net_head_m must be > 0";
79
80         #ifdef _WIN32
81             std::cout « error_str « std::endl;
82         #endif
83
84         throw std::invalid_argument(error_str);
85     }
86
87     //  3. check reservoir_capacity_m3
88     if (hydro_inputs.reservoir_capacity_m3 < 0) {
89         std::string error_str = "ERROR:  Hydro():  reservoir_capacity_m3 must be >= 0";
90
91         #ifdef _WIN32
92             std::cout « error_str « std::endl;
93         #endif
94
95         throw std::invalid_argument(error_str);
96     }
97
```

```
98      //  4. check init_reservoir_state
99      if (
100         hydro_inputs.init_reservoir_state < 0 or
101         hydro_inputs.init_reservoir_state > 1
102     ) {
103         std::string error_str = "ERROR:  Hydro():  init_reservoir_state must be in ";
104         error_str += "the closed interval [0, 1]";
105
106         #ifdef _WIN32
107             std::cout « error_str « std::endl;
108         #endif
109
110         throw std::invalid_argument(error_str);
111     }
112
113     return;
114 }   /* __checkInputs() */
```

4.8.3.2 __flowToPower()

```
double Hydro::__flowToPower (
            double flow_m3hr )  [private]
```

Helper method to translate a given flow into a corresponding power output.

Ref: Truelove [2023b]

Parameters

flow_m3hr	The flow [m3/hr] through the turbine.

Returns

The power output [kW] corresponding to a given flow [m3/hr].

```
452 {
453     //  1. return on less than minimum flow
454     if (flow_m3hr < this->minimum_flow_m3hr) {
455         return 0;
456     }
457
458     //  2. interpolate flow to power
459     double power_kW = this->interpolator.interp1D(
460         HydroInterpKeys :: FLOW_TO_POWER_INTERP_KEY,
461         flow_m3hr
462     );
463
464     return power_kW;
465 }   /* __flowToPower() */
```

4.8.3.3 __getAcceptableFlow()

```
double Hydro::__getAcceptableFlow (
            double dt_hrs )  [private]
```

Helper method to determine what flow is currently acceptable by the reservoir.

Parameters

dt_hrs	The interval of time [hrs] associated with the timestep.

Returns

The flow [m3/hr] currently acceptable by the reservoir.

```
554 {
555     //  1. if no reservoir, return
556     if (this->reservoir_capacity_m3 <= 0) {
557         return 0;
558     }
559 
560     //  2. compute acceptable based on room in reservoir
561     double acceptable_m3hr = (this->reservoir_capacity_m3 - this->stored_volume_m3) /
562         dt_hrs;
563 
564     return acceptable_m3hr;
565 }   /* __getAcceptableFlow() */
```

4.8.3.4 __getAvailableFlow()

```
double Hydro::__getAvailableFlow (
            double dt_hrs,
            double hydro_resource_m3hr )  [private]
```

Helper method to determine what flow is currently available to the turbine.

Parameters

dt_hrs	The interval of time [hrs] associated with the timestep.
hydro_resource_m3hr	The currently available hydro flow resource [m3/hr].

Returns

The flow [m3/hr] currently available through the turbine.

```
521 {
522     //  1. init to flow available from stored volume in reservoir
523     double flow_m3hr = this->stored_volume_m3 / dt_hrs;
524 
525     //  2. add flow available from resource
526     flow_m3hr += hydro_resource_m3hr;
527 
528     //  3. cap at maximum flow
529     if (flow_m3hr > this->maximum_flow_m3hr) {
530         flow_m3hr = this->maximum_flow_m3hr;
531     }
532 
533     return flow_m3hr;
534 }   /* __getAvailableFlow() */
```

4.8.3.5 __getEfficiencyFactor()

```
double Hydro::__getEfficiencyFactor (
            double power_kW )  [private]
```

Helper method to compute the efficiency factor (product of turbine and generator efficiencies).

Ref: Truelove [2023b]

Parameters

power_kW	The power requested of the hydro plant.

Returns

The product of the turbine and generator efficiencies.

```
350 {
351     //  1. return on zero
352     if (power_kW <= 0) {
353         return 0;
354     }
355 
356     //  2. compute power ratio (clip to [0, 1])
357     double power_ratio = power_kW / this->capacity_kW;
358 
359     if (power_ratio < 0) {
360         power_ratio = 0;
361     }
362 
363     else if (power_ratio > 1) {
364         power_ratio = 1;
365     }
366 
367 
368     //  3. init efficiency factor to the turbine efficiency
369     double efficiency_factor = this->interpolator.interp1D(
370         HydroInterpKeys :: TURBINE_EFFICIENCY_INTERP_KEY,
371         power_ratio
372     );
373 
374     //  4. include generator efficiency
375     efficiency_factor *= this->interpolator.interp1D(
376         HydroInterpKeys :: GENERATOR_EFFICIENCY_INTERP_KEY,
377         power_ratio
378     );
379 
380     return efficiency_factor;
381 }   /* __getEfficiencyFactor() */
```

4.8.3.6 __getGenericCapitalCost()

```
double Hydro::__getGenericCapitalCost (
            void  )  [private]
```

Helper method to generate a generic hydroelectric capital cost.

This model was obtained by way of ...

Returns

A generic capital cost for the hydroelectric asset [CAD].

```
299 {
300     double capital_cost_per_kW = 1000; //<-- WIP: need something better here!
301 
302     return capital_cost_per_kW * this->capacity_kW + 15000000; //<-- WIP: need something better here!
303 }   /* __getGenericCapitalCost() */
```

4.8.3.7 __getGenericOpMaintCost()

```
double Hydro::__getGenericOpMaintCost (
            void  )  [private]
```

Helper method (private) to generate a generic hydroelectric operation and maintenance cost. This is a cost incurred per unit energy produced.

This model was obtained by way of ...

Returns

A generic operation and maintenance cost, per unit energy produced, for the hydroelectric asset [CAD/kWh].

```
324 {
325     double operation_maintenance_cost_kWh = 0.05;  //<-- WIP: need something better here!
326
327     return operation_maintenance_cost_kWh;
328 }   /* __getGenericOpMaintCost() */
```

4.8.3.8 __getMaximumFlowm3hr()

```
double Hydro::__getMaximumFlowm3hr (
            void  )  [private]
```

Helper method to compute and return the maximum productive flow, based on turbine type.

This helper method assumes that the maximum flow is that which is associated with a power ratio of 1.

Ref: Truelove [2023b]

Returns

The maximum productive flow [m3/hr].

```
429 {
430     return this->__powerToFlow(this->capacity_kW);
431 }   /* __getMaximumFlowm3hr() */
```

4.8.3.9 __getMinimumFlowm3hr()

```
double Hydro::__getMinimumFlowm3hr (
            void  )  [private]
```

Helper method to compute and return the minimum required flow for production, based on turbine type.

This helper method assumes that the minimum flow is that which is associated with a power ratio of 0.1. See constructor for initialization of minimum_power_kW.

Ref: Truelove [2023b]

Returns

The minimum required flow [m3/hr] for production.

```
404 {
405     return this->__powerToFlow(this->minimum_power_kW);
406 }   /* __getMinimumFlowm3hr() */
```

4.8.3.10 __initInterpolator()

```
void Hydro::__initInterpolator (
            void  )  [private]
```

Helper method to set up turbine and generator efficiency interpolation.

Ref: Truelove [2023b]

```
131 {
132     //  1. set up generator efficiency interpolation
133     InterpolatorStruct1D generator_interp_struct_1D;
134 
135     generator_interp_struct_1D.n_points = 12;
136 
137     generator_interp_struct_1D.x_vec = {
138         0,   0.1, 0.2,  0.3, 0.4, 0.5,
139         0.6, 0.7, 0.75, 0.8, 0.9, 1
140     };
141 
142     generator_interp_struct_1D.min_x = 0;
143     generator_interp_struct_1D.max_x = 1;
144 
145     generator_interp_struct_1D.y_vec = {
146         0.000, 0.800, 0.900, 0.913,
147         0.925, 0.943, 0.947, 0.950,
148         0.953, 0.954, 0.956, 0.958
149     };
150 
151     this->interpolator.interp_map_1D.insert(
152         std::pair<int, InterpolatorStruct1D>(
153             HydroInterpKeys :: GENERATOR_EFFICIENCY_INTERP_KEY,
154             generator_interp_struct_1D
155         )
156     );
157 
158     //  2. set up turbine efficiency interpolation
159     InterpolatorStruct1D turbine_interp_struct_1D;
160 
161     turbine_interp_struct_1D.n_points = 11;
162 
163     turbine_interp_struct_1D.x_vec = {
164         0,   0.1, 0.2, 0.3, 0.4,
165         0.5, 0.6, 0.7, 0.8, 0.9,
166         1
167     };
168 
169     turbine_interp_struct_1D.min_x = 0;
170     turbine_interp_struct_1D.max_x = 1;
171 
172     std::vector<double> efficiency_vec;
173 
174     switch (this->turbine_type) {
175         case(HydroTurbineType :: HYDRO_TURBINE_PELTON): {
176             efficiency_vec = {
177                 0.000, 0.780, 0.855, 0.875, 0.890,
178                 0.900, 0.908, 0.913, 0.918, 0.908,
179                 0.880
180             };
181 
182             break;
183         }
184 
185         case(HydroTurbineType :: HYDRO_TURBINE_FRANCIS): {
186             efficiency_vec = {
187                 0.000, 0.400, 0.625, 0.745, 0.810,
188                 0.845, 0.880, 0.900, 0.910, 0.900,
189                 0.850
190             };
191 
192             break;
193         }
194 
195         case(HydroTurbineType :: HYDRO_TURBINE_KAPLAN): {
196             efficiency_vec = {
197                 0.000, 0.265, 0.460, 0.550, 0.650,
198                 0.740, 0.805, 0.845, 0.900, 0.880,
199                 0.850
200             };
201 
202             break;
203         }
```

```
204
205         default: {
206             std::string error_str = "ERROR:  Hydro():  turbine type ";
207             error_str += std::to_string(this->turbine_type);
208             error_str += " not recognized";
209
210             #ifdef _WIN32
211                 std::cout << error_str << std::endl;
212             #endif
213
214             throw std::runtime_error(error_str);
215
216             break;
217         }
218     }
219
220     turbine_interp_struct_1D.y_vec = efficiency_vec;
221
222     this->interpolator.interp_map_1D.insert(
223         std::pair<int, InterpolatorStruct1D>(
224             HydroInterpKeys :: TURBINE_EFFICIENCY_INTERP_KEY,
225             turbine_interp_struct_1D
226         )
227     );
228
229     //  3. set up flow to power interpolation
230     InterpolatorStruct1D flow_to_power_interp_struct_1D;
231
232     double power_ratio = 0.1;
233     std::vector<double> power_ratio_vec (91, 0);
234
235     for (size_t i = 0; i < power_ratio_vec.size(); i++) {
236         power_ratio_vec[i] = power_ratio;
237
238         power_ratio += 0.01;
239
240         if (power_ratio < 0) {
241             power_ratio = 0;
242         }
243
244         else if (power_ratio > 1) {
245             power_ratio = 1;
246         }
247     }
248
249     flow_to_power_interp_struct_1D.n_points = power_ratio_vec.size();
250
251     std::vector<double> flow_vec_m3hr;
252     std::vector<double> power_vec_kW;
253     flow_vec_m3hr.resize(power_ratio_vec.size(), 0);
254     power_vec_kW.resize(power_ratio_vec.size(), 0);
255
256     for (size_t i = 0; i < power_ratio_vec.size(); i++) {
257         flow_vec_m3hr[i] = this->__powerToFlow(power_ratio_vec[i] * this->capacity_kW);
258         power_vec_kW[i] = power_ratio_vec[i] * this->capacity_kW;
259         /*
260         std::cout << flow_vec_m3hr[i] << "\t" << power_vec_kW[i] << " (" <<
261             power_ratio_vec[i] << ")" << std::endl;
262         */
263     }
264
265     flow_to_power_interp_struct_1D.x_vec = flow_vec_m3hr;
266
267     flow_to_power_interp_struct_1D.min_x = flow_vec_m3hr[0];
268     flow_to_power_interp_struct_1D.max_x = flow_vec_m3hr[flow_vec_m3hr.size() - 1];
269
270     flow_to_power_interp_struct_1D.y_vec = power_vec_kW;
271
272     this->interpolator.interp_map_1D.insert(
273         std::pair<int, InterpolatorStruct1D>(
274             HydroInterpKeys :: FLOW_TO_POWER_INTERP_KEY,
275             flow_to_power_interp_struct_1D
276         )
277     );
278
279     return;
280 }   /* __initInterpolator() */
```

4.8.3.11 __powerToFlow()

```
double Hydro::__powerToFlow (
            double power_kW )  [private]
```

Helper method to translate a given power output into a corresponding flow.

Ref: Truelove [2023b]

Parameters

power_kW	The power output [kW] of the hydroelectric generator.

Returns

```
486 {
487     //  1. return on zero power
488     if (power_kW <= 0) {
489         return 0;
490     }
491 
492     //  2. get efficiency factor
493     double efficiency_factor = this->__getEfficiencyFactor(power_kW);
494 
495     //  3. compute flow
496     double flow_m3hr = 3600 * 1000 * power_kW;
497     flow_m3hr /= efficiency_factor * this->fluid_density_kgm3 * 9.81 * this->net_head_m;
498 
499     return flow_m3hr;
500 }   /* __powerToFlow() */
```

4.8.3.12 __updateState()

```
void Hydro::__updateState (
             int timestep,
             double dt_hrs,
             double production_kW,
             double hydro_resource_m3hr )  [private]
```

Helper method to update and log flow and reservoir state.

Parameters

timestep	The timestep (i.e., time series index) for the request.
dt_hrs	The interval of time [hrs] associated with the timestep.
production_kW	The production [kW] of the asset in this timestep.
hydro_resource_m3hr	The currently available hydro flow resource [m3/hr].

```
598 {
599     //  1. get turbine flow, log
600     double flow_m3hr = 0;
601 
602     if (production_kW >= this->minimum_power_kW) {
603         flow_m3hr = this->__powerToFlow(production_kW);
604     }
605 
606     double available_flow_m3hr = this->__getAvailableFlow(dt_hrs, hydro_resource_m3hr);
607 
608     if (flow_m3hr > available_flow_m3hr) {
609         flow_m3hr = available_flow_m3hr;
610     }
611 
612     this->turbine_flow_vec_m3hr[timestep] = flow_m3hr;
613 
614     //  3. compute net reservoir flow
```

```
615     double net_flow_m3hr = hydro_resource_m3hr - flow_m3hr;
616
617     //  4. compute flow acceptable by reservoir
618     double acceptable_flow_m3hr = this->__getAcceptableFlow(dt_hrs);
619
620     //  5. compute spill, update net flow (if applicable), log
621     double spill_m3hr = 0;
622
623     if (acceptable_flow_m3hr < net_flow_m3hr) {
624         spill_m3hr = net_flow_m3hr - acceptable_flow_m3hr;
625         net_flow_m3hr = acceptable_flow_m3hr;
626     }
627
628     this->spill_rate_vec_m3hr[timestep] = spill_m3hr;
629
630     //  6. update reservoir state, log
631     this->stored_volume_m3 += net_flow_m3hr * dt_hrs;
632     this->stored_volume_vec_m3[timestep] = this->stored_volume_m3;
633
634     return;
635 }   /* __updateState() */
```

4.8.3.13 __writeSummary()

```
void Hydro::__writeSummary (
            std::string write_path )  [private], [virtual]
```

Helper method to write summary results for Hydro.

Parameters

write_path	A path (either relative or absolute) to the directory location where results are to be written. If already exists, will overwrite.

Reimplemented from Noncombustion.

```
653 {
654     //  1. create filestream
655     write_path += "summary_results.md";
656     std::ofstream ofs;
657     ofs.open(write_path, std::ofstream::out);
658
659     //  2. write to summary results (markdown)
660     ofs « "# ";
661     ofs « std::to_string(int(ceil(this->capacity_kW)));
662     ofs « " kW HYDRO Summary Results\n";
663     ofs « "\n--------\n\n";
664
665     //  2.1. Production attributes
666     ofs « "## Production Attributes\n";
667     ofs « "\n";
668
669     ofs « "Capacity: " « this->capacity_kW « " kW  \n";
670     ofs « "\n";
671
672     ofs « "Production Override: (N = 0 / Y = 1): "
673         « this->normalized_production_series_given « "  \n";
674     if (this->normalized_production_series_given) {
675         ofs « "Path to Normalized Production Time Series: "
676             « this->path_2_normalized_production_time_series « "  \n";
677     }
678     ofs « "\n";
679
680     ofs « "Sunk Cost (N = 0 / Y = 1): " « this->is_sunk « "  \n";
681     ofs « "Capital Cost: " « this->capital_cost « "  \n";
682     ofs « "Operation and Maintenance Cost: " « this->operation_maintenance_cost_kWh
683         « " per kWh produced  \n";
684     ofs « "Nominal Inflation Rate (annual): " « this->nominal_inflation_annual
685         « "  \n";
686     ofs « "Nominal Discount Rate (annual): " « this->nominal_discount_annual
687         « "  \n";
688     ofs « "Real Discount Rate (annual): " « this->real_discount_annual « "  \n";
689     ofs « "\n";
```

```
690
691     ofs « "Replacement Running Hours: " « this->replace_running_hrs « "  \n";
692     ofs « "\n--------\n\n";
693
694     //  2.2. Noncombustion attributes
695     ofs « "## Noncombustion Attributes\n";
696     ofs « "\n";
697
698     //...
699
700     ofs « "\n--------\n\n";
701
702     //  2.3. Hydro attributes
703     ofs « "## Hydro Attributes\n";
704     ofs « "\n";
705
706     ofs « "Fluid Density: " « this->fluid_density_kgm3 « " kg/m3  \n";
707     ofs « "Net Head: " « this->net_head_m « " m  \n";
708     ofs « "\n";
709
710     ofs « "Reservoir Volume: " « this->reservoir_capacity_m3 « " m3  \n";
711     ofs « "Reservoir Initial State: " « this->init_reservoir_state « "  \n";
712     ofs « "\n";
713
714     ofs « "Turbine Type: ";
715     switch(this->turbine_type) {
716         case(HydroTurbineType :: HYDRO_TURBINE_PELTON): {
717             ofs « "PELTON";
718
719             break;
720         }
721
722         case(HydroTurbineType :: HYDRO_TURBINE_FRANCIS): {
723             ofs « "FRANCIS";
724
725             break;
726         }
727
728         case(HydroTurbineType :: HYDRO_TURBINE_KAPLAN): {
729             ofs « "KAPLAN";
730
731             break;
732         }
733
734         default: {
735             // write nothing!
736
737             break;
738         }
739     }
740     ofs « "  \n";
741     ofs « "\n";
742     ofs « "Minimum Flow: " « this->minimum_flow_m3hr « " m3/hr  \n";
743     ofs « "Maximum Flow: " « this->maximum_flow_m3hr « " m3/hr  \n";
744     ofs « "\n";
745     ofs « "Minimum Production: " « this->minimum_power_kW « " kW  \n";
746     ofs « "\n";
747
748     ofs « "\n--------\n\n";
749
750     //  2.4. Hydro Results
751     ofs « "## Results\n";
752     ofs « "\n";
753
754     ofs « "Net Present Cost: " « this->net_present_cost « "  \n";
755     ofs « "\n";
756
757     ofs « "Total Dispatch: " « this->total_dispatch_kWh
758         « " kWh  \n";
759
760     ofs « "Levellized Cost of Energy: " « this->levellized_cost_of_energy_kWh
761         « " per kWh dispatched  \n";
762     ofs « "\n";
763
764     ofs « "Running Hours: " « this->running_hours « "  \n";
765     ofs « "Replacements: " « this->n_replacements « "  \n";
766
767     //...
768
769     ofs « "\n--------\n\n";
770
771     ofs.close();
772     return;
773 }   /* __writeSummary() */
```

4.8.3.14 __writeTimeSeries()

```
void Hydro::__writeTimeSeries (
            std::string write_path,
            std::vector< double > * time_vec_hrs_ptr,
            int max_lines = -1 )  [private], [virtual]
```

Helper method to write time series results for Hydro.

Parameters

write_path	A path (either relative or absolute) to the directory location where results are to be written. If already exists, will overwrite.
time_vec_hrs_ptr	A pointer to the time_vec_hrs attribute of the ElectricalLoad.
max_lines	The maximum number of lines of output to write.

Reimplemented from Noncombustion.

```
803 {
804     //  1. create filestream
805     write_path += "time_series_results.csv";
806     std::ofstream ofs;
807     ofs.open(write_path, std::ofstream::out);
808 
809     //  2. write time series results (comma separated value)
810     ofs « "Time (since start of data) [hrs],";
811     ofs « "Production [kW],";
812     ofs « "Dispatch [kW],";
813     ofs « "Storage [kW],";
814     ofs « "Curtailment [kW],";
815     ofs « "Is Running (N = 0 / Y = 1),";
816     ofs « "Turbine Flow [m3/hr],";
817     ofs « "Spill Rate [m3/hr],";
818     ofs « "Stored Volume [m3],";
819     ofs « "Capital Cost (actual),";
820     ofs « "Operation and Maintenance Cost (actual),";
821     ofs « "\n";
822 
823     for (int i = 0; i < max_lines; i++) {
824         ofs « time_vec_hrs_ptr->at(i) « ",";
825         ofs « this->production_vec_kW[i] « ",";
826         ofs « this->dispatch_vec_kW[i] « ",";
827         ofs « this->storage_vec_kW[i] « ",";
828         ofs « this->curtailment_vec_kW[i] « ",";
829         ofs « this->is_running_vec[i] « ",";
830         ofs « this->turbine_flow_vec_m3hr[i] « ",";
831         ofs « this->spill_rate_vec_m3hr[i] « ",";
832         ofs « this->stored_volume_vec_m3[i] « ",";
833         ofs « this->capital_cost_vec[i] « ",";
834         ofs « this->operation_maintenance_cost_vec[i] « ",";
835         ofs « "\n";
836     }
837 
838     ofs.close();
839     return;
840 }   /* __writeTimeSeries() */
```

4.8.3.15 commit()

```
double Hydro::commit (
            int timestep,
            double dt_hrs,
            double production_kW,
            double load_kW,
            double hydro_resource_m3hr )  [virtual]
```

Method which takes in production and load for the current timestep, computes and records dispatch and curtailment, and then returns remaining load.

Parameters

timestep	The timestep (i.e., time series index) for the request.
dt_hrs	The interval of time [hrs] associated with the timestep.
production_kW	The production [kW] of the asset in this timestep.
load_kW	The load [kW] passed to the asset in this timestep.

Returns

The load [kW] remaining after the dispatch is deducted from it.

Reimplemented from Noncombustion.

```
1092 {
1093     //  1. invoke base class method
1094     load_kW = Noncombustion :: commit(
1095         timestep,
1096         dt_hrs,
1097         production_kW,
1098         load_kW
1099     );
1100
1101     //  2. update state and record
1102     this->__updateState(
1103         timestep,
1104         dt_hrs,
1105         production_kW,
1106         hydro_resource_m3hr
1107     );
1108
1109     return load_kW;
1110 }   /* commit() */
```

4.8.3.16 handleReplacement()

```
void Hydro::handleReplacement (
             int timestep )  [virtual]
```

Method to handle asset replacement and capital cost incursion, if applicable.

Parameters

timestep	The current time step of the Model run.

Reimplemented from Noncombustion.

```
969 {
970     //  1. reset attributes
971     //...
972
973     //  2. invoke base class method
974     Noncombustion :: handleReplacement(timestep);
975
976     return;
977 }   /* __handleReplacement() */
```

4.8.3.17 requestProductionkW()

```
double Hydro::requestProductionkW (
             int timestep,
```

```
            double dt_hrs,
            double request_kW,
            double hydro_resource_m3hr )  [virtual]
```

Method which takes in production request, and then returns what the asset can deliver (subject to operating constraints, etc.).

Parameters

timestep	The timestep (i.e., time series index) for the request.
dt_hrs	The interval of time [hrs] associated with the timestep.
request_kW	The requested production [kW].
hydro_resource_m3hr	The currently available hydro flow resource [m3/hr].

Returns

The production [kW] delivered by the hydro generator.

Reimplemented from Noncombustion.

```
1013 {
1014     //  0. given production time series override
1015     if (this->normalized_production_series_given) {
1016         double production_kW = Production :: getProductionkW(timestep);
1017 
1018         return production_kW;
1019     }
1020 
1021     //  1. return on request of zero
1022     if (request_kW <= 0) {
1023         return 0;
1024     }
1025 
1026     //  2. if request is less than minimum power, set to minimum power
1027     if (request_kW < this->minimum_power_kW) {
1028         request_kW = this->minimum_power_kW;
1029     }
1030 
1031     //  3. check available flow, return if less than minimum flow
1032     double available_flow_m3hr = this->__getAvailableFlow(dt_hrs, hydro_resource_m3hr);
1033 
1034     if (available_flow_m3hr < this->minimum_flow_m3hr) {
1035         return 0;
1036     }
1037 
1038     //  4. init production to request, enforce capacity constraint (which also accounts
1039     //     for maximum flow constraint).
1040     double production_kW = request_kW;
1041 
1042     if (production_kW > this->capacity_kW) {
1043         production_kW = this->capacity_kW;
1044     }
1045 
1046     //  5. map production to flow
1047     double flow_m3hr = this->__powerToFlow(production_kW);
1048 
1049     //  6. if flow is in excess of available, then adjust production accordingly
1050     if (flow_m3hr > available_flow_m3hr) {
1051         production_kW = this->__flowToPower(available_flow_m3hr);
1052     }
1053 
1054     return production_kW;
1055 }   /* requestProductionkW() */
```

4.8.4 Member Data Documentation

4.8.4.1 fluid_density_kgm3

```
double Hydro::fluid_density_kgm3
```

The density [kg/m3] of the hydroelectric working fluid.

4.8.4.2 init_reservoir_state

```
double Hydro::init_reservoir_state
```

The initial state of the reservoir (where state is volume of stored fluid divided by capacity).

4.8.4.3 maximum_flow_m3hr

```
double Hydro::maximum_flow_m3hr
```

The maximum productive flow [m3/hr] that the asset can support.

4.8.4.4 minimum_flow_m3hr

```
double Hydro::minimum_flow_m3hr
```

The minimum required flow [m3/hr] for the asset to produce. Corresponds to minimum power.

4.8.4.5 minimum_power_kW

```
double Hydro::minimum_power_kW
```

The minimum power [kW] that the asset can produce. Corresponds to minimum productive flow.

4.8.4.6 net_head_m

```
double Hydro::net_head_m
```

The net head [m] of the asset.

4.8.4.7 reservoir_capacity_m3

```
double Hydro::reservoir_capacity_m3
```

The capacity [m3] of the hydro reservoir.

4.8.4.8 spill_rate_vec_m3hr

```
std::vector<double> Hydro::spill_rate_vec_m3hr
```

A vector of the spill rate [m3/hr] at each point in the modelling time series.

4.8.4.9 stored_volume_m3

```
double Hydro::stored_volume_m3
```

The volume [m3] of stored fluid.

4.8.4.10 stored_volume_vec_m3

```
std::vector<double> Hydro::stored_volume_vec_m3
```

A vector of the stored volume [m3] in the reservoir at each point in the modelling time series.

4.8.4.11 turbine_flow_vec_m3hr

```
std::vector<double> Hydro::turbine_flow_vec_m3hr
```

A vector of the turbine flow [m3/hr] at each point in the modelling time series.

4.8.4.12 turbine_type

```
HydroTurbineType Hydro::turbine_type
```

The type of hydroelectric turbine model to use.

The documentation for this class was generated from the following files:

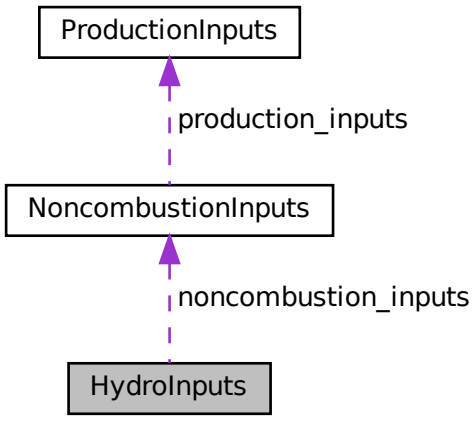
- header/Production/Noncombustion/Hydro.h
- source/Production/Noncombustion/Hydro.cpp

4.9 HydroInputs Struct Reference

A structure which bundles the necessary inputs for the Hydro constructor. Provides default values for every necessary input. Note that this structure encapsulates NoncombustionInputs.

`#include <Hydro.h>`

Collaboration diagram for HydroInputs:



Public Attributes

- NoncombustionInputs noncombustion_inputs

  An encapsulated NoncombustionInputs instance.
- int resource_key = 0

  A key used to index into the Resources object, to associate this asset with the appropriate resource time series.
- double capital_cost = -1

  The capital cost of the asset (undefined currency). -1 is a sentinel value, which triggers a generic cost model on construction (in fact, any negative value here will trigger). Note that the generic cost model is in terms of Canadian dollars [CAD].
- double operation_maintenance_cost_kWh = -1

  The operation and maintenance cost of the asset [1/kWh] (undefined currency). This is a cost incurred per unit of energy produced. -1 is a sentinel value, which triggers a generic cost model on construction (in fact, any negative value here will trigger). Note that the generic cost model is in terms of Canadian dollars [CAD/kWh].
- double fluid_density_kgm3 = 1000

  The density [kg/m3] of the hydroelectric working fluid.
- double net_head_m = 500

  The net head [m] of the asset.
- double reservoir_capacity_m3 = 0

  The capacity [m3] of the hydro reservoir.
- double init_reservoir_state = 0

  The initial state of the reservoir (where state is volume of stored fluid divided by capacity).
- HydroTurbineType turbine_type = HydroTurbineType :: HYDRO_TURBINE_PELTON

  The type of hydroelectric turbine model to use.

4.9.1 Detailed Description

A structure which bundles the necessary inputs for the Hydro constructor. Provides default values for every necessary input. Note that this structure encapsulates NoncombustionInputs.

4.9.2 Member Data Documentation

4.9.2.1 capital_cost

```
double HydroInputs::capital_cost = -1
```

The capital cost of the asset (undefined currency). -1 is a sentinel value, which triggers a generic cost model on construction (in fact, any negative value here will trigger). Note that the generic cost model is in terms of Canadian dollars [CAD].

4.9.2.2 fluid_density_kgm3

```
double HydroInputs::fluid_density_kgm3 = 1000
```

The density [kg/m3] of the hydroelectric working fluid.

4.9.2.3 init_reservoir_state

```
double HydroInputs::init_reservoir_state = 0
```

The initial state of the reservoir (where state is volume of stored fluid divided by capacity).

4.9.2.4 net_head_m

```
double HydroInputs::net_head_m = 500
```

The net head [m] of the asset.

4.9.2.5 noncombustion_inputs

```
NoncombustionInputs HydroInputs::noncombustion_inputs
```

An encapsulated NoncombustionInputs instance.

4.9.2.6 operation_maintenance_cost_kWh

```
double HydroInputs::operation_maintenance_cost_kWh = -1
```

The operation and maintenance cost of the asset [1/kWh] (undefined currency). This is a cost incurred per unit of energy produced. -1 is a sentinel value, which triggers a generic cost model on construction (in fact, any negative value here will trigger). Note that the generic cost model is in terms of Canadian dollars [CAD/kWh].

4.9.2.7 reservoir_capacity_m3

```
double HydroInputs::reservoir_capacity_m3 = 0
```

The capacity [m3] of the hydro reservoir.

4.9.2.8 resource_key

```
int HydroInputs::resource_key = 0
```

A key used to index into the Resources object, to associate this asset with the appropriate resource time series.

4.9.2.9 turbine_type

```
HydroTurbineType HydroInputs::turbine_type = HydroTurbineType ::  HYDRO_TURBINE_PELTON
```

The type of hydroelectric turbine model to use.

The documentation for this struct was generated from the following file:

- header/Production/Noncombustion/Hydro.h

4.10 Interpolator Class Reference

A class which contains interpolation data and functionality. Intended to serve as a component of the Production and Storage hierarchies.

```
#include <Interpolator.h>
```

Public Member Functions

- Interpolator (void)

  Constructor for the Interpolator class.
- void addData1D (int, std::string)

  Method to add 1D interpolation data to the Interpolator.
- void addData2D (int, std::string)

  Method to add 2D interpolation data to the Interpolator.
- double interp1D (int, double)

  Method to perform a 1D interpolation.
- double interp2D (int, double, double)

  Method to perform a 2D interpolation.
- ∼Interpolator (void)

  Destructor for the Interpolator class.

Public Attributes

- std::map< int, InterpolatorStruct1D > interp_map_1D

  A map <int, InterpolatorStruct1D> of given 1D interpolation data.
- std::map< int, std::string > path_map_1D

  A map <int, string> of the paths (either relative or absolute) to the given 1D interpolation data.
- std::map< int, InterpolatorStruct2D > interp_map_2D

  A map <int, InterpolatorStruct2D> of given 2D interpolation data.
- std::map< int, std::string > path_map_2D

  A map <int, string> of the paths (either relative or absolute) to the given 2D interpolation data.

Private Member Functions

- void __checkDataKey1D (int)

  Helper method to check if given data key (1D) is already in use.
- void __checkDataKey2D (int)

  Helper method to check if given data key (2D) is already in use.
- void __checkBounds1D (int, double)

  Helper method to check that the given 1D interpolation value is contained within the given corresponding data domain. Also checks that the data key has been registered.
- void __checkBounds2D (int, double, double)

  Helper method to check that the given 2D interpolation value is contained within the given corresponding data domain. Also checks that the data key has been registered.
- void __throwReadError (std::string, int)

  Helper method to throw a read error whenever non-numeric data is encountered where only numeric data should be.
- bool __isNonNumeric (std::string)

  Helper method to determine if given string is non-numeric (i.e., contains.
- int __getInterpolationIndex (double, std::vector< double > ∗)

  Helper method to get appropriate interpolation index into given vector.
- std::vector< std::string > __splitCommaSeparatedString (std::string, std::string="||")

  Helper method to split a comma-separated string into a vector of substrings.
- std::vector< std::vector< std::string > > __getDataStringMatrix (std::string)
- void __readData1D (int, std::string)

  Helper method to read the given 1D interpolation data into Interpolator.
- void __readData2D (int, std::string)

  Helper method to read the given 2D interpolation data into Interpolator.

4.10.1 Detailed Description

A class which contains interpolation data and functionality. Intended to serve as a component of the Production and Storage hierarchies.

4.10.2 Constructor & Destructor Documentation

4.10.2.1 Interpolator()

```
Interpolator::Interpolator (
            void  )
```

Constructor for the Interpolator class.

```
707 {
708     //...
709
710     return;
711 }   /* Interpolator() */
```

4.10.2.2 ~Interpolator()

```
Interpolator::~Interpolator (
            void  )
```

Destructor for the Interpolator class.

```
893 {
894     //...
895
896     return;
897 }   /* ~Interpolator() */
```

4.10.3 Member Function Documentation

4.10.3.1 __checkBounds1D()

```
void Interpolator::__checkBounds1D (
            int data_key,
            double interp_x )  [private]
```

Helper method to check that the given 1D interpolation value is contained within the given corresponding data domain. Also checks that the data key has been registered.

Parameters

data_key	A key associated with the given interpolation data.
interp↩ _x	The query value to be interpolated.

```
133 {
134     //  1. key error
135     if (this->interp_map_1D.count(data_key) == 0) {
136         std::string error_str = "ERROR:  Interpolator::interp1D()  ";
137         error_str += "data key ";
138         error_str += std::to_string(data_key);
139         error_str += " has not been registered";
140 
141         #ifdef _WIN32
142             std::cout « error_str « std::endl;
143         #endif
144 
145         throw std::invalid_argument(error_str);
146     }
147 
148     //  2. bounds error
149     if (
150         interp_x < this->interp_map_1D[data_key].min_x or
151         interp_x > this->interp_map_1D[data_key].max_x
152     ) {
153         std::string error_str = "ERROR:  Interpolator::interp1D()  ";
154         error_str += "interpolation value ";
155         error_str += std::to_string(interp_x);
156         error_str += " is outside of the given interpolation data domain [";
157         error_str += std::to_string(this->interp_map_1D[data_key].min_x);
158         error_str += " , ";
159         error_str += std::to_string(this->interp_map_1D[data_key].max_x);
160         error_str += "]";
161 
162         #ifdef _WIN32
163             std::cout « error_str « std::endl;
164         #endif
165 
166         throw std::invalid_argument(error_str);
167     }
168 
169     return;
170 }   /* __checkBounds1D() */
```

4.10.3.2 __checkBounds2D()

```
void Interpolator::__checkBounds2D (
            int data_key,
            double interp_x,
            double interp_y )  [private]
```

Helper method to check that the given 2D interpolation value is contained within the given corresponding data domain. Also checks that the data key has been registered.

Parameters

data_key	A key associated with the given interpolation data.
interp_x	The first query value to be interpolated.
interp_y	The second query value to be interpolated.

```
193 {
194     //  1. key error
195     if (this->interp_map_2D.count(data_key) == 0) {
196         std::string error_str = "ERROR:  Interpolator::interp2D()  ";
197         error_str += "data key ";
198         error_str += std::to_string(data_key);
199         error_str += " has not been registered";
200 
201         #ifdef _WIN32
202             std::cout « error_str « std::endl;
203         #endif
204 
205         throw std::invalid_argument(error_str);
206     }
```

```
207
208     //  2. bounds error (x_interp)
209     if (
210         interp_x < this->interp_map_2D[data_key].min_x or
211         interp_x > this->interp_map_2D[data_key].max_x
212     ) {
213         std::string error_str = "ERROR:  Interpolator::interp2D()  ";
214         error_str += "interpolation value interp_x = ";
215         error_str += std::to_string(interp_x);
216         error_str += " is outside of the given interpolation data domain [";
217         error_str += std::to_string(this->interp_map_2D[data_key].min_x);
218         error_str += " , ";
219         error_str += std::to_string(this->interp_map_2D[data_key].max_x);
220         error_str += "]";
221
222         #ifdef _WIN32
223             std::cout « error_str « std::endl;
224         #endif
225
226         throw std::invalid_argument(error_str);
227     }
228
229     //  2. bounds error (y_interp)
230     if (
231         interp_y < this->interp_map_2D[data_key].min_y or
232         interp_y > this->interp_map_2D[data_key].max_y
233     ) {
234         std::string error_str = "ERROR:  Interpolator::interp2D()  ";
235         error_str += "interpolation value interp_y = ";
236         error_str += std::to_string(interp_y);
237         error_str += " is outside of the given interpolation data domain [";
238         error_str += std::to_string(this->interp_map_2D[data_key].min_y);
239         error_str += " , ";
240         error_str += std::to_string(this->interp_map_2D[data_key].max_y);
241         error_str += "]";
242
243         #ifdef _WIN32
244             std::cout « error_str « std::endl;
245         #endif
246
247         throw std::invalid_argument(error_str);
248     }
249
250     return;
251 }   /* __checkBounds2D() */
```

4.10.3.3 __checkDataKey1D()

```
void Interpolator::__checkDataKey1D (
            int data_key )  [private]
```

Helper method to check if given data key (1D) is already in use.

Parameters

data_key	The key associated with the given 1D interpolation data.

```
65 {
66     if (this->interp_map_1D.count(data_key) > 0) {
67         std::string error_str = "ERROR:  Interpolator::addData1D()  ";
68         error_str += "data key (1D) ";
69         error_str += std::to_string(data_key);
70         error_str += " is already in use";
71
72         #ifdef _WIN32
73             std::cout « error_str « std::endl;
74         #endif
75
76         throw std::invalid_argument(error_str);
77     }
78
79     return;
80 }   /* __checkDataKey1D() */
```

4.10.3.4 __checkDataKey2D()

```
void Interpolator::__checkDataKey2D (
            int data_key )  [private]
```

Helper method to check if given data key (2D) is already in use.

Parameters

data_key	The key associated with the given 2D interpolation data.

```
97 {
98     if (this->interp_map_2D.count(data_key) > 0) {
99         std::string error_str = "ERROR:  Interpolator::addData2D()  ";
100         error_str += "data key (2D) ";
101         error_str += std::to_string(data_key);
102         error_str += " is already in use";
103 
104         #ifdef _WIN32
105             std::cout << error_str << std::endl;
106         #endif
107 
108         throw std::invalid_argument(error_str);
109     }
110 
111     return;
112 }   /* __checkDataKey2D() */
```

4.10.3.5 __getDataStringMatrix()

```
std::vector< std::vector< std::string > > Interpolator::__getDataStringMatrix (
            std::string path_2_data )  [private]
```

```
426 {
427     //  1. create input file stream
428     std::ifstream ifs;
429     ifs.open(path_2_data);
430 
431     //  2. check that open() worked
432     if (not ifs.is_open()) {
433         std::string error_str = "ERROR:  Interpolator::__getDataStringMatrix()  ";
434         error_str += " failed to open ";
435         error_str += path_2_data;
436 
437         #ifdef _WIN32
438             std::cout << error_str << std::endl;
439         #endif
440 
441         throw std::invalid_argument(error_str);
442     }
443 
444     //  3. read file line by line
445     bool is_header = true;
446     std::string line;
447     std::vector<std::string> line_split_vec;
448     std::vector<std::vector<std::string>> string_matrix;
449 
450     while (not ifs.eof()) {
451         std::getline(ifs, line);
452 
453         if (is_header) {
454             is_header = false;
455             continue;
456         }
457 
458         line_split_vec = this->__splitCommaSeparatedString(line);
459 
460         if (not line_split_vec.empty()) {
461             string_matrix.push_back(line_split_vec);
462         }
463     }
464 
465     ifs.close();
466     return string_matrix;
467 }   /* __getDataStringMatrix() */
```

4.10.3.6 __getInterpolationIndex()

```
int Interpolator::__getInterpolationIndex (
            double interp_x,
            std::vector< double > * x_vec_ptr )  [private]
```

Helper method to get appropriate interpolation index into given vector.

Parameters

interp_x	The query value to be interpolated.
x_vec_ptr	A pointer to the given vector of interpolation data.

Returns

The appropriate interpolation index into the given vector.

```
343 {
344     int idx = 0;
345     while (
346         not (interp_x >= x_vec_ptr->at(idx) and interp_x <= x_vec_ptr->at(idx + 1))
347     ) {
348         idx++;
349     }
350
351     return idx;
352 }   /* __getInterpolationIndex() */
```

4.10.3.7 __isNonNumeric()

```
bool Interpolator::__isNonNumeric (
            std::string str )  [private]
```

Helper method to determine if given string is non-numeric (i.e., contains.

Parameters

str	The string being tested.

Returns

A boolean indicating if the given string is non-numeric.

```
308 {
309     for (size_t i = 0; i < str.size(); i++) {;
310         if (isalpha(str[i])) {
311             return true;
312         }
313     }
314
315     return false;
316 }   /* __isAlpha() */
```

4.10.3.8 __readData1D()

```
void Interpolator::__readData1D (
            int data_key,
            std::string path_2_data )  [private]
```

Helper method to read the given 1D interpolation data into Interpolator.

Parameters

data_key	A key associated with the given interpolation data.
path_2_data	The path (either relative or absolute) to the given interpolation data.

```
487 {
488     //  1. get string matrix
489     std::vector<std::vector<std::string>> string_matrix =
490         this->__getDataStringMatrix(path_2_data);
491 
492     //  2. read string matrix contents into 1D interpolation struct
493     InterpolatorStruct1D interp_struct_1D;
494 
495     interp_struct_1D.n_points = string_matrix.size();
496     interp_struct_1D.x_vec.resize(interp_struct_1D.n_points, 0);
497     interp_struct_1D.y_vec.resize(interp_struct_1D.n_points, 0);
498 
499     for (int i = 0; i < interp_struct_1D.n_points; i++) {
500         try {
501             interp_struct_1D.x_vec[i] = std::stod(string_matrix[i][0]);
502             interp_struct_1D.y_vec[i] = std::stod(string_matrix[i][1]);
503         }
504 
505         catch (...) {
506             this->__throwReadError(path_2_data, 1);
507         }
508     }
509 
510     interp_struct_1D.min_x = interp_struct_1D.x_vec[0];
511     interp_struct_1D.max_x = interp_struct_1D.x_vec[interp_struct_1D.n_points - 1];
512 
513     //  3. write struct to map
514     this->interp_map_1D.insert(
515         std::pair<int, InterpolatorStruct1D>(data_key, interp_struct_1D)
516     );
517 
518     /*
519     // ==== TEST PRINT ==== //
520     std::cout << std::endl;
521     std::cout << path_2_data << std::endl;
522     std::cout << "--------" << std::endl;
523 
524     std::cout << "n_points: " << this->interp_map_1D[data_key].n_points << std::endl;
525 
526     std::cout << "x_vec: [";
527     for (
528         int i = 0;
529         i < this->interp_map_1D[data_key].n_points;
530         i++
531     ) {
532         std::cout << this->interp_map_1D[data_key].x_vec[i] << ", ";
533     }
534     std::cout << "]" << std::endl;
535 
536     std::cout << "y_vec: [";
537     for (
538         int i = 0;
539         i < this->interp_map_1D[data_key].n_points;
540         i++
541     ) {
542         std::cout << this->interp_map_1D[data_key].y_vec[i] << ", ";
543     }
544     std::cout << "]" << std::endl;
545 
546     std::cout << std::endl;
547     // ==== END TEST PRINT ==== //
548     //*/
549 
550     return;
551 }   /* __readData1D() */
```

4.10.3.9 __readData2D()

```
void Interpolator::__readData2D (
            int data_key,
            std::string path_2_data )  [private]
```

Helper method to read the given 2D interpolation data into Interpolator.

Parameters

data_key	A key associated with the given interpolation data.
path_2_data	The path (either relative or absolute) to the given interpolation data.

```
571 {
572     //  1. get string matrix
573     std::vector<std::vector<std::string>> string_matrix =
574         this->__getDataStringMatrix(path_2_data);
575 
576     //  2. read string matrix contents into 2D interpolation map
577     InterpolatorStruct2D interp_struct_2D;
578 
579     interp_struct_2D.n_rows = string_matrix.size() - 1;
580     interp_struct_2D.n_cols = string_matrix[0].size() - 1;
581 
582     interp_struct_2D.x_vec.resize(interp_struct_2D.n_cols, 0);
583     interp_struct_2D.y_vec.resize(interp_struct_2D.n_rows, 0);
584 
585     interp_struct_2D.z_matrix.resize(interp_struct_2D.n_rows, {});
586 
587     for (int i = 0; i < interp_struct_2D.n_rows; i++) {
588         interp_struct_2D.z_matrix[i].resize(interp_struct_2D.n_cols, 0);
589     }
590 
591     for (size_t i = 1; i < string_matrix[0].size(); i++) {
592         try {
593             interp_struct_2D.x_vec[i - 1] = std::stod(string_matrix[0][i]);
594         }
595 
596         catch (...) {
597             this->__throwReadError(path_2_data, 2);
598         }
599     }
600 
601     interp_struct_2D.min_x = interp_struct_2D.x_vec[0];
602     interp_struct_2D.max_x = interp_struct_2D.x_vec[interp_struct_2D.n_cols - 1];
603 
604     for (size_t i = 1; i < string_matrix.size(); i++) {
605         try {
606             interp_struct_2D.y_vec[i - 1] = std::stod(string_matrix[i][0]);
607         }
608 
609         catch (...) {
610             this->__throwReadError(path_2_data, 2);
611         }
612     }
613 
614     interp_struct_2D.min_y = interp_struct_2D.y_vec[0];
615     interp_struct_2D.max_y = interp_struct_2D.y_vec[interp_struct_2D.n_rows - 1];
616 
617     for (size_t i = 1; i < string_matrix.size(); i++) {
618         for (size_t j = 1; j < string_matrix[0].size(); j++) {
619             try {
620                 interp_struct_2D.z_matrix[i - 1][j - 1] = std::stod(string_matrix[i][j]);
621             }
622 
623             catch (...) {
624                 this->__throwReadError(path_2_data, 2);
625             }
626         }
627     }
628 
629     //  3. write struct to map
630     this->interp_map_2D.insert(
631         std::pair<int, InterpolatorStruct2D>(data_key, interp_struct_2D)
632     );
633 
634     /*
635     // ==== TEST PRINT ==== //
636     std::cout << std::endl;
637     std::cout << path_2_data << std::endl;
```

```
638     std::cout « "--------" « std::endl;
639
640     std::cout « "n_rows: " « this->interp_map_2D[data_key].n_rows « std::endl;
641     std::cout « "n_cols: " « this->interp_map_2D[data_key].n_cols « std::endl;
642
643     std::cout « "x_vec: [";
644     for (
645         int i = 0;
646         i < this->interp_map_2D[data_key].n_cols;
647         i++
648     ) {
649         std::cout « this->interp_map_2D[data_key].x_vec[i] « ", ";
650     }
651     std::cout « "]" « std::endl;
652
653     std::cout « "y_vec: [";
654     for (
655         int i = 0;
656         i < this->interp_map_2D[data_key].n_rows;
657         i++
658     ) {
659         std::cout « this->interp_map_2D[data_key].y_vec[i] « ", ";
660     }
661     std::cout « "]" « std::endl;
662
663     std::cout « "z_matrix:" « std::endl;
664     for (
665         int i = 0;
666         i < this->interp_map_2D[data_key].n_rows;
667         i++
668     ) {
669         std::cout « "\t[";
670
671         for (
672             int j = 0;
673             j < this->interp_map_2D[data_key].n_cols;
674             j++
675         ) {
676             std::cout « this->interp_map_2D[data_key].z_matrix[i][j] « ", ";
677         }
678
679         std::cout « "]" « std::endl;
680     }
681     std::cout « std::endl;
682
683     std::cout « std::endl;
684     // ==== END TEST PRINT ==== //
685     //*/
686
687     return;
688 }   /* __readData2D() */
```

4.10.3.10 __splitCommaSeparatedString()

```
std::vector< std::string > Interpolator::__splitCommaSeparatedString (
            std::string str,
            std::string break_str = "||" )  [private]
```

Helper method to split a comma-separated string into a vector of substrings.

Parameters

str	The string to be split.
break_str	A string which triggers the function to break. What has been split up to the point of the break is then returned.

Returns

A vector of substrings, which follows from splitting the given string in a comma separated manner.

```
381 {
382     std::vector<std::string> str_split_vec;
383 
384     size_t idx = 0;
385     std::string substr;
386 
387     while ((idx = str.find(',')) != std::string::npos) {
388         substr = str.substr(0, idx);
389 
390         if (substr == break_str) {
391             break;
392         }
393 
394         str_split_vec.push_back(substr);
395 
396         str.erase(0, idx + 1);
397     }
398 
399     return str_split_vec;
400 }   /* __splitCommaSeparatedString() */
```

4.10.3.11 __throwReadError()

```
void Interpolator::__throwReadError (
            std::string path_2_data,
            int dimensions )  [private]
```

Helper method to throw a read error whenever non-numeric data is encountered where only numeric data should be.

Parameters

path_2_data	The path (either relative or absolute) to the given interpolation data.
dimensions	The dimensionality of the data being read.

```
272 {
273     std::string error_str = "ERROR:  Interpolator::addData";
274     error_str += std::to_string(dimensions);
275     error_str += "D()  ";
276     error_str += " failed to read ";
277     error_str += path_2_data;
278     error_str += " (this is probably a std::stod() error; is there non-numeric ";
279     error_str += "data where only numeric data should be?)";
280 
281     #ifdef _WIN32
282         std::cout << error_str << std::endl;
283     #endif
284 
285     throw std::runtime_error(error_str);
286 
287     return;
288 }   /* __throwReadError() */
```

4.10.3.12 addData1D()

```
void Interpolator::addData1D (
            int data_key,
            std::string path_2_data )
```

Method to add 1D interpolation data to the Interpolator.

Parameters

data_key	A key used to index into the Interpolator.
path_2_data	A path (either relative or absolute) to the given 1D interpolation data.

```
731 {
732     //  1. check key
733     this->__checkDataKey1D(data_key);
734 
735     //  2. read data into map
736     this->__readData1D(data_key, path_2_data);
737 
738     //  3. record path
739     this->path_map_1D.insert(std::pair<int, std::string>(data_key, path_2_data));
740 
741     return;
742 }   /* addData1D() */
```

4.10.3.13 addData2D()

```
void Interpolator::addData2D (
             int data_key,
             std::string path_2_data )
```

Method to add 2D interpolation data to the Interpolator.

Parameters

data_key	A key used to index into the Interpolator.
path_2_data	A path (either relative or absolute) to the given 2D interpolation data.

```
762 {
763     //  1. check key
764     this->__checkDataKey2D(data_key);
765 
766     //  2. read data into map
767     this->__readData2D(data_key, path_2_data);
768 
769     //  3. record path
770     this->path_map_2D.insert(std::pair<int, std::string>(data_key, path_2_data));
771 
772     return;
773 }   /* addData2D() */
```

4.10.3.14 interp1D()

```
double Interpolator::interp1D (
             int data_key,
             double interp_x )
```

Method to perform a 1D interpolation.

Parameters

data_key	A key used to index into the Interpolator.
interp_x	The query value to be interpolated. If this value is outside the domain of the associated interpolation data, then an error will occur.

Returns

An interpolation of the given query value.

```
795 {
796     //  1. check bounds
797     this->__checkBounds1D(data_key, interp_x);
798 
799     //  2. get interpolation index
800     int idx = this->__getInterpolationIndex(
801         interp_x,
802         &(this->interp_map_1D[data_key].x_vec)
803     );
804 
805     //  3. perform interpolation
806     double x_0 = this->interp_map_1D[data_key].x_vec[idx];
807     double x_1 = this->interp_map_1D[data_key].x_vec[idx + 1];
808 
809     double y_0 = this->interp_map_1D[data_key].y_vec[idx];
810     double y_1 = this->interp_map_1D[data_key].y_vec[idx + 1];
811 
812     double interp_y = ((y_1 - y_0) / (x_1 - x_0)) * (interp_x - x_0) + y_0;
813 
814     return interp_y;
815 }   /* interp1D() */
```

4.10.3.15 interp2D()

```
double Interpolator::interp2D (
            int data_key,
            double interp_x,
            double interp_y )
```

Method to perform a 2D interpolation.

Parameters

data_key	A key used to index into the Interpolator.
interp_x	The first query value to be interpolated. If this value is outside the domain of the associated interpolation data, then an error will occur.
interp_y	The second query value to be interpolated. If this value is outside the domain of the associated interpolation data, then an error will occur.

Returns

An interpolation of the given query values.

```
840 {
841     //  1. check bounds
842     this->__checkBounds2D(data_key, interp_x, interp_y);
843 
844     //  2. get interpolation indices
845     int idx_x = this->__getInterpolationIndex(
846         interp_x,
847         &(this->interp_map_2D[data_key].x_vec)
848     );
849 
850     int idx_y = this->__getInterpolationIndex(
851         interp_y,
852         &(this->interp_map_2D[data_key].y_vec)
853     );
854 
855     //  3. perform first horizontal interpolation
856     double x_0 = this->interp_map_2D[data_key].x_vec[idx_x];
857     double x_1 = this->interp_map_2D[data_key].x_vec[idx_x + 1];
858 
859     double z_0 = this->interp_map_2D[data_key].z_matrix[idx_y][idx_x];
860     double z_1 = this->interp_map_2D[data_key].z_matrix[idx_y][idx_x + 1];
```

```
861
862     double interp_z_0 = ((z_1 - z_0) / (x_1 - x_0)) * (interp_x - x_0) + z_0;
863
864     //  4. perform second horizontal interpolation
865     z_0 = this->interp_map_2D[data_key].z_matrix[idx_y + 1][idx_x];
866     z_1 = this->interp_map_2D[data_key].z_matrix[idx_y + 1][idx_x + 1];
867
868     double interp_z_1 = ((z_1 - z_0) / (x_1 - x_0)) * (interp_x - x_0) + z_0;
869
870     //  5. perform vertical interpolation
871     double y_0 = this->interp_map_2D[data_key].y_vec[idx_y];
872     double y_1 = this->interp_map_2D[data_key].y_vec[idx_y + 1];
873
874     double interp_z =
875         ((interp_z_1 - interp_z_0) / (y_1 - y_0)) * (interp_y - y_0) + interp_z_0;
876
877     return interp_z;
878 }   /* interp2D() */
```

4.10.4 Member Data Documentation

4.10.4.1 interp_map_1D

`std::map<int, InterpolatorStruct1D> Interpolator::interp_map_1D`

A map <int, InterpolatorStruct1D> of given 1D interpolation data.

4.10.4.2 interp_map_2D

`std::map<int, InterpolatorStruct2D> Interpolator::interp_map_2D`

A map <int, InterpolatorStruct2D> of given 2D interpolation data.

4.10.4.3 path_map_1D

`std::map<int, std::string> Interpolator::path_map_1D`

A map <int, string> of the paths (either relative or absolute) to the given 1D interpolation data.

4.10.4.4 path_map_2D

`std::map<int, std::string> Interpolator::path_map_2D`

A map <int, string> of the paths (either relative or absolute) to the given 2D interpolation data.

The documentation for this class was generated from the following files:

- header/Interpolator.h
- source/Interpolator.cpp

4.11 InterpolatorStruct1D Struct Reference

A struct which holds two parallel vectors for use in 1D interpolation.

`#include <Interpolator.h>`

Public Attributes

- int n_points = 0

  The number of data points in each parallel vector.
- std::vector< double > x_vec = {}

  A vector of independent data.
- double min_x = 0

  The minimum (i.e., first) element of x_vec.
- double max_x = 0

  The maximum (i.e., last) element of x_vec.
- std::vector< double > y_vec = {}

  A vector of dependent data.

4.11.1 Detailed Description

A struct which holds two parallel vectors for use in 1D interpolation.

4.11.2 Member Data Documentation

4.11.2.1 max_x

```
double InterpolatorStruct1D::max_x = 0
```

The maximum (i.e., last) element of x_vec.

4.11.2.2 min_x

```
double InterpolatorStruct1D::min_x = 0
```

The minimum (i.e., first) element of x_vec.

4.11.2.3 n_points

```
int InterpolatorStruct1D::n_points = 0
```

The number of data points in each parallel vector.

4.11.2.4 x_vec

```
std::vector<double> InterpolatorStruct1D::x_vec = {}
```

A vector of independent data.

4.11.2.5 y_vec

```
std::vector<double> InterpolatorStruct1D::y_vec = {}
```

A vector of dependent data.

The documentation for this struct was generated from the following file:

- header/Interpolator.h

4.12 InterpolatorStruct2D Struct Reference

A struct which holds two parallel vectors and a matrix for use in 2D interpolation.

```
#include <Interpolator.h>
```

Public Attributes

- int n_rows = 0
  The number of rows in the matrix (also the length of y_vec)
- int n_cols = 0
  The number of cols in the matrix (also the length of x_vec)
- std::vector< double > x_vec = {}
  A vector of independent data (columns).
- double min_x = 0
  The minimum (i.e., first) element of x_vec.
- double max_x = 0
  The maximum (i.e., last) element of x_vec.
- std::vector< double > y_vec = {}
  A vector of independent data (rows).
- double min_y = 0
  The minimum (i.e., first) element of y_vec.
- double max_y = 0
  The maximum (i.e., last) element of y_vec.
- std::vector< std::vector< double > > z_matrix = {}
  A matrix of dependent data.

4.12.1 Detailed Description

A struct which holds two parallel vectors and a matrix for use in 2D interpolation.

4.12.2 Member Data Documentation

4.12.2.1 max_x

```
double InterpolatorStruct2D::max_x = 0
```

The maximum (i.e., last) element of x_vec.

4.12.2.2 max_y

```
double InterpolatorStruct2D::max_y = 0
```

The maximum (i.e., last) element of y_vec.

4.12.2.3 min_x

```
double InterpolatorStruct2D::min_x = 0
```

The minimum (i.e., first) element of x_vec.

4.12.2.4 min_y

```
double InterpolatorStruct2D::min_y = 0
```

The minimum (i.e., first) element of y_vec.

4.12.2.5 n_cols

```
int InterpolatorStruct2D::n_cols = 0
```

The number of cols in the matrix (also the length of x_vec)

4.12.2.6 n_rows

```
int InterpolatorStruct2D::n_rows = 0
```

The number of rows in the matrix (also the length of y_vec)

4.12.2.7 x_vec

```
std::vector<double> InterpolatorStruct2D::x_vec = {}
```

A vector of independent data (columns).

4.12.2.8 y_vec

```
std::vector<double> InterpolatorStruct2D::y_vec = {}
```

A vector of independent data (rows).

4.12.2.9 z_matrix

```
std::vector<std::vector<double> > InterpolatorStruct2D::z_matrix = {}
```

A matrix of dependent data.

The documentation for this struct was generated from the following file:

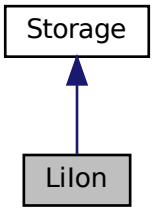
- header/Interpolator.h

4.13 LiIon Class Reference

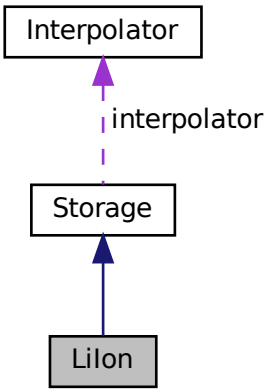
A derived class of Storage which models energy storage by way of lithium-ion batteries.

`#include <LiIon.h>`

Inheritance diagram for LiIon:



Collaboration diagram for LiIon:



Public Member Functions

- LiIon (void)

  Constructor (dummy) for the LiIon class.
- LiIon (int, double, LiIonInputs)

  Constructor (intended) for the LiIon class.
- void handleReplacement (int)

  Method to handle asset replacement and capital cost incursion, if applicable.
- double getAvailablekW (double)

Method to get the discharge power currently available from the asset.

- double getAcceptablekW (double)

  Method to get the charge power currently acceptable by the asset.

- void commitCharge (int, double, double)

  Method which takes in the charging power for the current timestep and records.

- double commitDischarge (int, double, double, double)

  Method which takes in the discharging power for the current timestep and records. Returns the load remaining after discharge.

- ~LiIon (void)

  Destructor for the LiIon class.

Public Attributes

- bool power_degradation_flag

  A flag which indicates whether or not power degradation should be modelled.

- double dynamic_energy_capacity_kWh

  The dynamic (i.e. degrading) energy capacity [kWh] of the asset.

- double dynamic_power_capacity_kW

  The dynamic (i.e. degrading) power capacity [kW] of the asset.

- double SOH

  The state of health of the asset.

- double replace_SOH

  The state of health at which the asset is considered "dead" and must be replaced.

- double degradation_alpha

  A dimensionless acceleration coefficient used in modelling energy capacity degradation.

- double degradation_beta

  A dimensionless acceleration exponent used in modelling energy capacity degradation.

- double degradation_B_hat_cal_0

  A reference (or base) pre-exponential factor [1/sqrt(hrs)] used in modelling energy capacity degradation.

- double degradation_r_cal

  A dimensionless constant used in modelling energy capacity degradation.

- double degradation_Ea_cal_0

  A reference (or base) activation energy [J/mol] used in modelling energy capacity degradation.

- double degradation_a_cal

  A pre-exponential factor [J/mol] used in modelling energy capacity degradation.

- double degradation_s_cal

  A dimensionless constant used in modelling energy capacity degradation.

- double gas_constant_JmolK

  The universal gas constant [J/mol.K].

- double temperature_K

  The absolute environmental temperature [K] of the lithium ion battery energy storage system.

- double init_SOC

  The initial state of charge of the asset.

- double min_SOC

  The minimum state of charge of the asset. Will toggle is_depleted when reached.

- double hysteresis_SOC

  The state of charge the asset must achieve to toggle is_depleted.

- double max_SOC

  The maximum state of charge of the asset.

- double charging_efficiency

The charging efficiency of the asset.

- double discharging_efficiency

  The discharging efficiency of the asset.

- std::vector< double > SOH_vec

  A vector of the state of health of the asset at each point in the modelling time series.

Private Member Functions

- void __checkInputs (LiIonInputs)

  Helper method to check inputs to the Lilon constructor.

- double __getGenericCapitalCost (void)

  Helper method to generate a generic lithium ion battery energy storage system capital cost.

- double __getGenericOpMaintCost (void)

  Helper method to generate a generic lithium ion battery energy storage system operation and maintenance cost. This is a cost incurred per unit energy charged/discharged.

- void __toggleDepleted (void)

  Helper method to toggle the is_depleted attribute of Lilon.

- void __handleDegradation (int, double, double)

  Helper method to apply degradation modelling and update attributes.

- void __modelDegradation (double, double)

  Helper method to model energy capacity degradation as a function of operating state.

- double __getBcal (double)

  Helper method to compute and return the base pre-exponential factor for a given state of charge.

- double __getEacal (double)

  Helper method to compute and return the activation energy value for a given state of charge.

- void __writeSummary (std::string)

  Helper method to write summary results for Lilon.

- void __writeTimeSeries (std::string, std::vector< double > *, int=-1)

  Helper method to write time series results for Lilon.

4.13.1 Detailed Description

A derived class of Storage which models energy storage by way of lithium-ion batteries.

4.13.2 Constructor & Destructor Documentation

4.13.2.1 LiIon() [1/2]

```
LiIon::LiIon (
            void  )
```

Constructor (dummy) for the LiIon class.

```
674 {
675     return;
676 }   /* LiIon() */
```

4.13.2.2 LiIon() [2/2]

```
LiIon::LiIon (
            int n_points,
            double n_years,
            LiIonInputs liion_inputs )
```

Constructor (intended) for the LiIon class.

Parameters

n_points	The number of points in the modelling time series.
n_years	The number of years being modelled.
liion_inputs	A structure of LiIon constructor inputs.

```
704   :
705 Storage(
706     n_points,
707     n_years,
708     liion_inputs.storage_inputs
709 )
710 {
711     //  1. check inputs
712     this->__checkInputs(liion_inputs);
713 
714     //  2. set attributes
715     this->type = StorageType :: LIION;
716     this->type_str = "LIION";
717 
718     this->dynamic_energy_capacity_kWh = this->energy_capacity_kWh;
719     this->dynamic_power_capacity_kW = this->power_capacity_kW;
720 
721     this->SOH = 1;
722     this->power_degradation_flag = liion_inputs.power_degradation_flag;
723     this->replace_SOH = liion_inputs.replace_SOH;
724 
725     this->degradation_alpha = liion_inputs.degradation_alpha;
726     this->degradation_beta = liion_inputs.degradation_beta;
727     this->degradation_B_hat_cal_0 = liion_inputs.degradation_B_hat_cal_0;
728     this->degradation_r_cal = liion_inputs.degradation_r_cal;
729     this->degradation_Ea_cal_0 = liion_inputs.degradation_Ea_cal_0;
730     this->degradation_a_cal = liion_inputs.degradation_a_cal;
731     this->degradation_s_cal = liion_inputs.degradation_s_cal;
732     this->gas_constant_JmolK = liion_inputs.gas_constant_JmolK;
733     this->temperature_K = liion_inputs.temperature_K;
734 
735     this->init_SOC = liion_inputs.init_SOC;
736     this->charge_kWh = this->init_SOC * this->energy_capacity_kWh;
737 
738     this->min_SOC = liion_inputs.min_SOC;
739     this->hysteresis_SOC = liion_inputs.hysteresis_SOC;
740     this->max_SOC = liion_inputs.max_SOC;
741 
742     this->charging_efficiency = liion_inputs.charging_efficiency;
743     this->discharging_efficiency = liion_inputs.discharging_efficiency;
744 
745     if (liion_inputs.capital_cost < 0) {
746         this->capital_cost = this->__getGenericCapitalCost();
747     }
748     else {
749         this->capital_cost = liion_inputs.capital_cost;
750     }
751 
752     if (liion_inputs.operation_maintenance_cost_kWh < 0) {
753         this->operation_maintenance_cost_kWh = this->__getGenericOpMaintCost();
754     }
755     else {
756         this->operation_maintenance_cost_kWh =
757             liion_inputs.operation_maintenance_cost_kWh;
758     }
759 
760     if (not this->is_sunk) {
761         this->capital_cost_vec[0] = this->capital_cost;
762     }
763 
764     this->SOH_vec.resize(this->n_points, 0);
765 
766     //  3. construction print
```

```
767     if (this->print_flag) {
768         std::cout « "LiIon object constructed at " « this « std::endl;
769     }
770
771     return;
772 }   /* LiIon() */
```

4.13.2.3 ~LiIon()

```
LiIon::~LiIon (
            void  )
```

Destructor for the LiIon class.

```
1029 {
1030     //  1. destruction print
1031     if (this->print_flag) {
1032         std::cout « "LiIon object at " « this « " destroyed" « std::endl;
1033     }
1034
1035     return;
1036 }   /* ~LiIon() */
```

4.13.3 Member Function Documentation

4.13.3.1 __checkInputs()

```
void LiIon::__checkInputs (
            LiIonInputs liion_inputs )  [private]
```

Helper method to check inputs to the LiIon constructor.

Parameters

liion_inputs	A structure of LiIon constructor inputs.

```
64 {
65     //  1. check replace_SOH
66     if (liion_inputs.replace_SOH < 0 or liion_inputs.replace_SOH > 1) {
67         std::string error_str = "ERROR:  LiIon():  replace_SOH must be in the closed ";
68         error_str += "interval [0, 1]";
69
70         #ifdef _WIN32
71             std::cout « error_str « std::endl;
72         #endif
73
74         throw std::invalid_argument(error_str);
75     }
76
77     //  2. check init_SOC
78     if (liion_inputs.init_SOC < 0 or liion_inputs.init_SOC > 1) {
79         std::string error_str = "ERROR:  LiIon():  init_SOC must be in the closed ";
80         error_str += "interval [0, 1]";
81
82         #ifdef _WIN32
83             std::cout « error_str « std::endl;
84         #endif
85
86         throw std::invalid_argument(error_str);
87     }
88
89     //  3. check min_SOC
```

```
90      if (liion_inputs.min_SOC < 0 or liion_inputs.min_SOC > 1) {
91          std::string error_str = "ERROR:  LiIon():  min_SOC must be in the closed ";
92          error_str += "interval [0, 1]";
93
94          #ifdef _WIN32
95              std::cout << error_str << std::endl;
96          #endif
97
98          throw std::invalid_argument(error_str);
99      }
100
101     //  4. check hysteresis_SOC
102     if (liion_inputs.hysteresis_SOC < 0 or liion_inputs.hysteresis_SOC > 1) {
103         std::string error_str = "ERROR:  LiIon():  hysteresis_SOC must be in the closed ";
104         error_str += "interval [0, 1]";
105
106         #ifdef _WIN32
107             std::cout << error_str << std::endl;
108         #endif
109
110         throw std::invalid_argument(error_str);
111     }
112
113     //  5. check max_SOC
114     if (liion_inputs.max_SOC < 0 or liion_inputs.max_SOC > 1) {
115         std::string error_str = "ERROR:  LiIon():  max_SOC must be in the closed ";
116         error_str += "interval [0, 1]";
117
118         #ifdef _WIN32
119             std::cout << error_str << std::endl;
120         #endif
121
122         throw std::invalid_argument(error_str);
123     }
124
125     //  6. check charging_efficiency
126     if (liion_inputs.charging_efficiency <= 0 or liion_inputs.charging_efficiency > 1) {
127         std::string error_str = "ERROR:  LiIon():  charging_efficiency must be in the ";
128         error_str += "half-open interval (0, 1]";
129
130         #ifdef _WIN32
131             std::cout << error_str << std::endl;
132         #endif
133
134         throw std::invalid_argument(error_str);
135     }
136
137     //  7. check discharging_efficiency
138     if (
139         liion_inputs.discharging_efficiency <= 0 or
140         liion_inputs.discharging_efficiency > 1
141     ) {
142         std::string error_str = "ERROR:  LiIon():  discharging_efficiency must be in the ";
143         error_str += "half-open interval (0, 1]";
144
145         #ifdef _WIN32
146             std::cout << error_str << std::endl;
147         #endif
148
149         throw std::invalid_argument(error_str);
150     }
151
152     //  8. check degradation_alpha
153     if (liion_inputs.degradation_alpha <= 0) {
154         std::string error_str = "ERROR:  LiIon():  degradation_alpha must be > 0";
155
156         #ifdef _WIN32
157             std::cout << error_str << std::endl;
158         #endif
159
160         throw std::invalid_argument(error_str);
161     }
162
163     //  9. check degradation_beta
164     if (liion_inputs.degradation_beta <= 0) {
165         std::string error_str = "ERROR:  LiIon():  degradation_beta must be > 0";
166
167         #ifdef _WIN32
168             std::cout << error_str << std::endl;
169         #endif
170
171         throw std::invalid_argument(error_str);
172     }
173
174     //  10. check degradation_B_hat_cal_0
175     if (liion_inputs.degradation_B_hat_cal_0 <= 0) {
176         std::string error_str = "ERROR:  LiIon():  degradation_B_hat_cal_0 must be > 0";
```

```
177
178         #ifdef _WIN32
179             std::cout << error_str << std::endl;
180         #endif
181
182         throw std::invalid_argument(error_str);
183     }
184
185     //  11. check degradation_r_cal
186     if (liion_inputs.degradation_r_cal < 0) {
187         std::string error_str = "ERROR:  LiIon():  degradation_r_cal must be >= 0";
188
189         #ifdef _WIN32
190             std::cout << error_str << std::endl;
191         #endif
192
193         throw std::invalid_argument(error_str);
194     }
195
196     //  12. check degradation_Ea_cal_0
197     if (liion_inputs.degradation_Ea_cal_0 <= 0) {
198         std::string error_str = "ERROR:  LiIon():  degradation_Ea_cal_0 must be > 0";
199
200         #ifdef _WIN32
201             std::cout << error_str << std::endl;
202         #endif
203
204         throw std::invalid_argument(error_str);
205     }
206
207     //  13. check degradation_a_cal
208     if (liion_inputs.degradation_a_cal < 0) {
209         std::string error_str = "ERROR:  LiIon():  degradation_a_cal must be >= 0";
210
211         #ifdef _WIN32
212             std::cout << error_str << std::endl;
213         #endif
214
215         throw std::invalid_argument(error_str);
216     }
217
218     //  14. check degradation_s_cal
219     if (liion_inputs.degradation_s_cal < 0) {
220         std::string error_str = "ERROR:  LiIon():  degradation_s_cal must be >= 0";
221
222         #ifdef _WIN32
223             std::cout << error_str << std::endl;
224         #endif
225
226         throw std::invalid_argument(error_str);
227     }
228
229     //  15. check gas_constant_JmolK
230     if (liion_inputs.gas_constant_JmolK <= 0) {
231         std::string error_str = "ERROR:  LiIon():  gas_constant_JmolK must be > 0";
232
233         #ifdef _WIN32
234             std::cout << error_str << std::endl;
235         #endif
236
237         throw std::invalid_argument(error_str);
238     }
239
240     //  16. check temperature_K
241     if (liion_inputs.temperature_K < 0) {
242         std::string error_str = "ERROR:  LiIon():  temperature_K must be >= 0";
243
244         #ifdef _WIN32
245             std::cout << error_str << std::endl;
246         #endif
247
248         throw std::invalid_argument(error_str);
249     }
250
251     return;
252 }   /* __checkInputs() */
```

4.13.3.2 __getBcal()

```
double LiIon::__getBcal (
            double SOC )  [private]
```

Helper method to compute and return the base pre-exponential factor for a given state of charge.

Ref: Truelove [2023a]

Parameters

SOC	The current state of charge of the asset.

Returns

The base pre-exponential factor for the given state of charge.

```
456 {
457     double B_cal = this->degradation_B_hat_cal_0 *
458         exp(this->degradation_r_cal * SOC);
459
460     return B_cal;
461 }   /* __getBcal() */
```

4.13.3.3 __getEacal()

```
double LiIon::__getEacal (
            double SOC )  [private]
```

Helper method to compute and return the activation energy value for a given state of charge.

Ref: Truelove [2023a]

Parameters

SOC	The current state of charge of the asset.

Returns

The activation energy value for the given state of charge.

```
483 {
484     double Ea_cal = this->degradation_Ea_cal_0;
485
486     Ea_cal -= this->degradation_a_cal *
487         (exp(this->degradation_s_cal * SOC) - 1);
488
489     return Ea_cal;
490 }   /* __getEacal( */
```

4.13.3.4 __getGenericCapitalCost()

```
double LiIon::__getGenericCapitalCost (
            void  )  [private]
```

Helper method to generate a generic lithium ion battery energy storage system capital cost.

This model was obtained by way of surveying an assortment of published lithium ion battery energy storage system costs, and then constructing a best fit model. Note that this model expresses cost in terms of Canadian dollars [CAD].

Returns

A generic capital cost for the lithium ion battery energy storage system [CAD].

```
275 {
276     double capital_cost_per_kWh = 250 * pow(this->energy_capacity_kWh, -0.15) + 650;
277 
278     return capital_cost_per_kWh * this->energy_capacity_kWh;
279 }   /* __getGenericCapitalCost() */
```

4.13.3.5 __getGenericOpMaintCost()

```
double LiIon::__getGenericOpMaintCost (
            void  )  [private]
```

Helper method to generate a generic lithium ion battery energy storage system operation and maintenance cost. This is a cost incurred per unit energy charged/discharged.

This model was obtained by way of surveying an assortment of published lithium ion battery energy storage system costs, and then constructing a best fit model. Note that this model expresses cost in terms of Canadian dollars [CAD/kWh].

Returns

A generic operation and maintenance cost, per unit energy charged/discharged, for the lithium ion battery energy storage system [CAD/kWh].

```
303 {
304     return 0.01;
305 }   /* __getGenericOpMaintCost() */
```

4.13.3.6 __handleDegradation()

```
void LiIon::__handleDegradation (
            int timestep,
            double dt_hrs,
            double charging_discharging_kW )  [private]
```

Helper method to apply degradation modelling and update attributes.

Parameters

timestep	The timestep (i.e., time series index) for the request.
dt_hrs	The interval of time [hrs] associated with the timestep.
charging_discharging_kW	The charging/discharging power [kw] being sent to the asset.

```
373 {
374     //  1. model degradation
375     this->__modelDegradation(dt_hrs, charging_discharging_kW);
376 
377     //  2. update and record
378     this->SOH_vec[timestep] = this->SOH;
379     this->dynamic_energy_capacity_kWh = this->SOH * this->energy_capacity_kWh;
380 
381     if (this->power_degradation_flag) {
382         this->dynamic_power_capacity_kW = this->SOH * this->power_capacity_kW;
383     }
```

```
384
385     return;
386 }   /* __handleDegradation() */
```

4.13.3.7 __modelDegradation()

```
void LiIon::__modelDegradation (
              double dt_hrs,
              double charging_discharging_kW )  [private]
```

Helper method to model energy capacity degradation as a function of operating state.

Ref: Truelove [2023a]

Parameters

dt_hrs	The interval of time [hrs] associated with the timestep.
charging_discharging_kW	The charging/discharging power [kw] being sent to the asset.

```
409 {
410     //  1. compute SOC
411     double SOC = this->charge_kWh / this->energy_capacity_kWh;
412
413     //  2. compute C-rate and corresponding acceleration factor
414     double C_rate = charging_discharging_kW / this->power_capacity_kW;
415
416     double C_acceleration_factor =
417         1 + this->degradation_alpha * pow(C_rate, this->degradation_beta);
418
419     //  3. compute dSOH / dt
420     double B_cal = __getBcal(SOC);
421     double Ea_cal = __getEacal(SOC);
422
423     double dSOH_dt = B_cal *
424         exp((-1 * Ea_cal) / (this->gas_constant_JmolK * this->temperature_K));
425
426     dSOH_dt *= dSOH_dt;
427     dSOH_dt *= 1 / (2 * this->SOH);
428     dSOH_dt *= C_acceleration_factor;
429
430     //  4. update state of health
431     this->SOH -= dSOH_dt * dt_hrs;
432
433     return;
434 }   /* __modelDegradation() */
```

4.13.3.8 __toggleDepleted()

```
void LiIon::__toggleDepleted (
              void  )  [private]
```

Helper method to toggle the is_depleted attribute of LiIon.

```
320 {
321     if (this->is_depleted) {
322         double hysteresis_charge_kWh = this->hysteresis_SOC * this->energy_capacity_kWh;
323
324         if (hysteresis_charge_kWh > this->dynamic_energy_capacity_kWh) {
325             hysteresis_charge_kWh = this->dynamic_energy_capacity_kWh;
326         }
327
328         if (this->charge_kWh >= hysteresis_charge_kWh) {
329             this->is_depleted = false;
```

```
330         }
331     }
332
333     else {
334         double min_charge_kWh = this->min_SOC * this->energy_capacity_kWh;
335
336         if (this->charge_kWh <= min_charge_kWh) {
337             this->is_depleted = true;
338         }
339     }
340
341     return;
342 }   /* __toggleDepleted() */
```

4.13.3.9 __writeSummary()

```
void LiIon::__writeSummary (
            std::string write_path )  [private], [virtual]
```

Helper method to write summary results for LiIon.

Parameters

write_path	A path (either relative or absolute) to the directory location where results are to be written. If already exists, will overwrite.

Reimplemented from Storage.

```
508 {
509     //  1. create filestream
510     write_path += "summary_results.md";
511     std::ofstream ofs;
512     ofs.open(write_path, std::ofstream::out);
513
514     //  2. write summary results (markdown)
515     ofs « "# ";
516     ofs « std::to_string(int(ceil(this->power_capacity_kW)));
517     ofs « " kW ";
518     ofs « std::to_string(int(ceil(this->energy_capacity_kWh)));
519     ofs « " kWh LIION Summary Results\n";
520     ofs « "\n--------\n\n";
521
522     //  2.1. Storage attributes
523     ofs « "## Storage Attributes\n";
524     ofs « "\n";
525     ofs « "Power Capacity: " « this->power_capacity_kW « " kW  \n";
526     ofs « "Energy Capacity: " « this->energy_capacity_kWh « " kWh  \n";
527     ofs « "\n";
528
529     ofs « "Sunk Cost (N = 0 / Y = 1): " « this->is_sunk « "  \n";
530     ofs « "Capital Cost: " « this->capital_cost « "  \n";
531     ofs « "Operation and Maintenance Cost: " « this->operation_maintenance_cost_kWh
532         « " per kWh charged/discharged  \n";
533     ofs « "Nominal Inflation Rate (annual): " « this->nominal_inflation_annual
534         « "  \n";
535     ofs « "Nominal Discount Rate (annual): " « this->nominal_discount_annual
536         « "  \n";
537     ofs « "Real Discount Rate (annual): " « this->real_discount_annual « "  \n";
538
539     ofs « "\n--------\n\n";
540
541     //  2.2. LiIon attributes
542     ofs « "## LiIon Attributes\n";
543     ofs « "\n";
544
545     ofs « "Charging Efficiency: " « this->charging_efficiency « "  \n";
546     ofs « "Discharging Efficiency: " « this->discharging_efficiency « "  \n";
547     ofs « "\n";
548
549     ofs « "Initial State of Charge: " « this->init_SOC « "  \n";
550     ofs « "Minimum State of Charge: " « this->min_SOC « "  \n";
551     ofs « "Hyteresis State of Charge: " « this->hysteresis_SOC « "  \n";
552     ofs « "Maximum State of Charge: " « this->max_SOC « "  \n";
```

```
553     ofs << "\n";
554
555     ofs << "Replacement State of Health: " << this->replace_SOH << "  \n";
556     ofs << "\n";
557
558     ofs << "Degradation Acceleration Coeff.: " << this->degradation_alpha << "  \n";
559     ofs << "Degradation Acceleration Exp.: " << this->degradation_beta << "  \n";
560     ofs << "Degradation Base Pre-Exponential Factor: "
561         << this->degradation_B_hat_cal_0 << " 1/sqrt(hrs)  \n";
562     ofs << "Degradation Dimensionless Constant (r_cal): "
563         << this->degradation_r_cal << "  \n";
564     ofs << "Degradation Base Activation Energy: "
565         << this->degradation_Ea_cal_0 << " J/mol  \n";
566     ofs << "Degradation Pre-Exponential Factor: "
567         << this->degradation_a_cal << " J/mol  \n";
568     ofs << "Degradation Dimensionless Constant (s_cal): "
569         << this->degradation_s_cal << "  \n";
570     ofs << "Universal Gas Constant: " << this->gas_constant_JmolK
571         << " J/mol.K  \n";
572     ofs << "Absolute Environmental Temperature: " << this->temperature_K << " K  \n";
573
574     ofs << "\n--------\n\n";
575
576     //  2.3. LiIon Results
577     ofs << "## Results\n";
578     ofs << "\n";
579
580     ofs << "Net Present Cost: " << this->net_present_cost << "  \n";
581     ofs << "\n";
582
583     ofs << "Total Discharge: " << this->total_discharge_kWh
584         << " kWh  \n";
585
586     ofs << "Levellized Cost of Energy: " << this->levellized_cost_of_energy_kWh
587         << " per kWh dispatched  \n";
588     ofs << "\n";
589
590     ofs << "Replacements: " << this->n_replacements << "  \n";
591
592     ofs << "\n--------\n\n";
593     ofs.close();
594     return;
595 }   /* __writeSummary() */
```

4.13.3.10 __writeTimeSeries()

```
void LiIon::__writeTimeSeries (
            std::string write_path,
            std::vector< double > * time_vec_hrs_ptr,
            int max_lines = -1 )  [private], [virtual]
```

Helper method to write time series results for LiIon.

Parameters

write_path	A path (either relative or absolute) to the directory location where results are to be written. If already exists, will overwrite.
time_vec_hrs_ptr	A pointer to the time_vec_hrs attribute of the ElectricalLoad.
max_lines	The maximum number of lines of output to write.

Reimplemented from Storage.

```
626 {
627     //  1. create filestream
628     write_path += "time_series_results.csv";
629     std::ofstream ofs;
630     ofs.open(write_path, std::ofstream::out);
631
632     //  2. write time series results (comma separated value)
633     ofs << "Time (since start of data) [hrs],";
634     ofs << "Charging Power [kW],";
```

```
635     ofs « "Discharging Power [kW],";
636     ofs « "Charge (at end of timestep) [kWh],";
637     ofs « "State of Health (at end of timestep) [ ],";
638     ofs « "Capital Cost (actual),";
639     ofs « "Operation and Maintenance Cost (actual),";
640     ofs « "\n";
641 
642     for (int i = 0; i < max_lines; i++) {
643         ofs « time_vec_hrs_ptr->at(i) « ",";
644         ofs « this->charging_power_vec_kW[i] « ",";
645         ofs « this->discharging_power_vec_kW[i] « ",";
646         ofs « this->charge_vec_kWh[i] « ",";
647         ofs « this->SOH_vec[i] « ",";
648         ofs « this->capital_cost_vec[i] « ",";
649         ofs « this->operation_maintenance_cost_vec[i] « ",";
650         ofs « "\n";
651     }
652 
653     ofs.close();
654     return;
655 }   /* __writeTimeSeries() */
```

4.13.3.11 commitCharge()

```
void LiIon::commitCharge (
            int timestep,
            double dt_hrs,
            double charge_kW )  [virtual]
```

Method which takes in the charging power for the current timestep and records.

Parameters

timestep	The timestep (i.e., time series index) for the request.
dt_hrs	The interval of time [hrs] associated with the timestep.
charging_kW	The charging power [kw] being sent to the asset.

Reimplemented from Storage.

```
920 {
921     //  1. record charging power
922     this->charging_power_vec_kW[timestep] = charging_kW;
923 
924     //  2. update charge and record
925     this->charge_kWh += this->charging_efficiency * charging_kW * dt_hrs;
926     this->charge_vec_kWh[timestep] = this->charge_kWh;
927 
928     //  3. toggle depleted flag (if applicable)
929     this->__toggleDepleted();
930 
931     //  4. model degradation
932     this->__handleDegradation(timestep, dt_hrs, charging_kW);
933 
934     //  5. trigger replacement (if applicable)
935     if (this->SOH <= this->replace_SOH) {
936         this->handleReplacement(timestep);
937     }
938 
939     //  6. capture operation and maintenance costs (if applicable)
940     if (charging_kW > 0) {
941         this->operation_maintenance_cost_vec[timestep] = charging_kW * dt_hrs *
942             this->operation_maintenance_cost_kWh;
943     }
944 
945     this->power_kW= 0;
946     return;
947 }   /* commitCharge() */
```

4.13.3.12 commitDischarge()

```
double LiIon::commitDischarge (
            int timestep,
            double dt_hrs,
            double discharging_kW,
            double load_kW )  [virtual]
```

Method which takes in the discharging power for the current timestep and records. Returns the load remaining after discharge.

Parameters

timestep	The timestep (i.e., time series index) for the request.
dt_hrs	The interval of time [hrs] associated with the timestep.
discharging_kW	The discharging power [kw] being drawn from the asset.
load_kW	The load [kW] passed to the asset in this timestep.

Returns

The load [kW] remaining after the discharge is deducted from it.

Reimplemented from Storage.

```
983 {
984     //  1. record discharging power, update total
985     this->discharging_power_vec_kW[timestep] = discharging_kW;
986     this->total_discharge_kWh += discharging_kW * dt_hrs;
987 
988     //  2. update charge and record
989     this->charge_kWh -= (discharging_kW * dt_hrs) / this->discharging_efficiency;
990     this->charge_vec_kWh[timestep] = this->charge_kWh;
991 
992     //  3. update load
993     load_kW -= discharging_kW;
994 
995     //  4. toggle depleted flag (if applicable)
996     this->__toggleDepleted();
997 
998     //  5. model degradation
999     this->__handleDegradation(timestep, dt_hrs, discharging_kW);
1000 
1001     //  6. trigger replacement (if applicable)
1002     if (this->SOH <= this->replace_SOH) {
1003         this->handleReplacement(timestep);
1004     }
1005 
1006     //  7. capture operation and maintenance costs (if applicable)
1007     if (discharging_kW > 0) {
1008         this->operation_maintenance_cost_vec[timestep] = discharging_kW * dt_hrs *
1009             this->operation_maintenance_cost_kWh;
1010     }
1011 
1012     this->power_kW = 0;
1013     return load_kW;
1014 }   /* commitDischarge() */
```

4.13.3.13 getAcceptablekW()

```
double LiIon::getAcceptablekW (
            double dt_hrs )  [virtual]
```

Method to get the charge power currently acceptable by the asset.

Parameters

dt_hrs	The interval of time [hrs] associated with the timestep.

Returns

The charging power [kW] currently acceptable by the asset.

Reimplemented from Storage.

```
864 {
865     //  1. get max charge
866     double max_charge_kWh = this->max_SOC * this->energy_capacity_kWh;
867 
868     if (max_charge_kWh > this->dynamic_energy_capacity_kWh) {
869         max_charge_kWh = this->dynamic_energy_capacity_kWh;
870     }
871 
872     //  2. compute acceptable power
873     //     (accounting for the power currently being charged/discharged by the asset)
874     double acceptable_kW =
875         (max_charge_kWh - this->charge_kWh) /
876         (this->charging_efficiency * dt_hrs);
877 
878     acceptable_kW -= this->power_kW;
879 
880     if (acceptable_kW <= 0) {
881         return 0;
882     }
883 
884     //  3. apply power constraint
885     if (acceptable_kW > this->dynamic_power_capacity_kW) {
886         acceptable_kW = this->dynamic_power_capacity_kW;
887     }
888 
889     return acceptable_kW;
890 }   /* getAcceptablekW( */
```

4.13.3.14 getAvailablekW()

```
double LiIon::getAvailablekW (
            double dt_hrs )  [virtual]
```

Method to get the discharge power currently available from the asset.

Parameters

dt_hrs	The interval of time [hrs] associated with the timestep.

Returns

The discharging power [kW] currently available from the asset.

Reimplemented from Storage.

```
823 {
824     //  1. get min charge
825     double min_charge_kWh = this->min_SOC * this->energy_capacity_kWh;
826 
827     //  2. compute available power
828     //     (accounting for the power currently being charged/discharged by the asset)
829     double available_kW =
830         ((this->charge_kWh - min_charge_kWh) * this->discharging_efficiency) /
831         dt_hrs;
```

```
832
833     available_kW -= this->power_kW;
834
835     if (available_kW <= 0) {
836         return 0;
837     }
838
839     //  3. apply power constraint
840     if (available_kW > this->dynamic_power_capacity_kW) {
841         available_kW = this->dynamic_power_capacity_kW;
842     }
843
844     return available_kW;
845 }   /* getAvailablekW() */
```

4.13.3.15 handleReplacement()

```
void LiIon::handleReplacement (
             int timestep )  [virtual]
```

Method to handle asset replacement and capital cost incursion, if applicable.

Parameters

timestep	The current time step of the Model run.

Reimplemented from Storage.

```
790 {
791     //  1. reset attributes
792     this->dynamic_energy_capacity_kWh = this->energy_capacity_kWh;
793     this->dynamic_power_capacity_kW = this->power_capacity_kW;
794     this->SOH = 1;
795
796     // 2. invoke base class method
797     Storage::handleReplacement(timestep);
798
799     //  3. correct attributes
800     this->charge_kWh = this->init_SOC * this->energy_capacity_kWh;
801     this->is_depleted = false;
802
803     return;
804 }   /* __handleReplacement() */
```

4.13.4 Member Data Documentation

4.13.4.1 charging_efficiency

```
double LiIon::charging_efficiency
```

The charging efficiency of the asset.

4.13.4.2 degradation_a_cal

```
double LiIon::degradation_a_cal
```

A pre-exponential factor [J/mol] used in modelling energy capacity degradation.

4.13.4.3 degradation_alpha

```
double LiIon::degradation_alpha
```

A dimensionless acceleration coefficient used in modelling energy capacity degradation.

4.13.4.4 degradation_B_hat_cal_0

```
double LiIon::degradation_B_hat_cal_0
```

A reference (or base) pre-exponential factor [1/sqrt(hrs)] used in modelling energy capacity degradation.

4.13.4.5 degradation_beta

```
double LiIon::degradation_beta
```

A dimensionless acceleration exponent used in modelling energy capacity degradation.

4.13.4.6 degradation_Ea_cal_0

```
double LiIon::degradation_Ea_cal_0
```

A reference (or base) activation energy [J/mol] used in modelling energy capacity degradation.

4.13.4.7 degradation_r_cal

```
double LiIon::degradation_r_cal
```

A dimensionless constant used in modelling energy capacity degradation.

4.13.4.8 degradation_s_cal

```
double LiIon::degradation_s_cal
```

A dimensionless constant used in modelling energy capacity degradation.

4.13.4.9 discharging_efficiency

```
double LiIon::discharging_efficiency
```

The discharging efficiency of the asset.

4.13.4.10 dynamic_energy_capacity_kWh

```
double LiIon::dynamic_energy_capacity_kWh
```

The dynamic (i.e. degrading) energy capacity [kWh] of the asset.

4.13.4.11 dynamic_power_capacity_kW

```
double LiIon::dynamic_power_capacity_kW
```

The dynamic (i.e. degrading) power capacity [kW] of the asset.

4.13.4.12 gas_constant_JmolK

```
double LiIon::gas_constant_JmolK
```

The universal gas constant [J/mol.K].

4.13.4.13 hysteresis_SOC

```
double LiIon::hysteresis_SOC
```

The state of charge the asset must achieve to toggle is_depleted.

4.13.4.14 init_SOC

```
double LiIon::init_SOC
```

The initial state of charge of the asset.

4.13.4.15 max_SOC

```
double LiIon::max_SOC
```

The maximum state of charge of the asset.

4.13.4.16 min_SOC

```
double LiIon::min_SOC
```

The minimum state of charge of the asset. Will toggle is_depleted when reached.

4.13.4.17 power_degradation_flag

```
bool LiIon::power_degradation_flag
```

A flag which indicates whether or not power degradation should be modelled.

4.13.4.18 replace_SOH

```
double LiIon::replace_SOH
```

The state of health at which the asset is considered "dead" and must be replaced.

4.13.4.19 SOH

```
double LiIon::SOH
```

The state of health of the asset.

4.13.4.20 SOH_vec

```
std::vector<double> LiIon::SOH_vec
```

A vector of the state of health of the asset at each point in the modelling time series.

4.13.4.21 temperature_K

```
double LiIon::temperature_K
```

The absolute environmental temperature [K] of the lithium ion battery energy storage system.

The documentation for this class was generated from the following files:

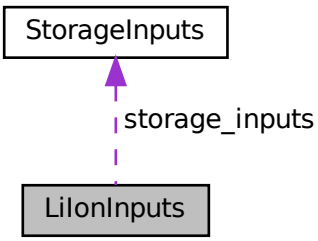
- header/Storage/LiIon.h
- source/Storage/LiIon.cpp

4.14 LiIonInputs Struct Reference

A structure which bundles the necessary inputs for the LiIon constructor. Provides default values for every necessary input. Note that this structure encapsulates StorageInputs.

```
#include <LiIon.h>
```

Collaboration diagram for LiIonInputs:



Public Attributes

- StorageInputs storage_inputs

  An encapsulated StorageInputs instance.
- double capital_cost = -1

  The capital cost of the asset (undefined currency). -1 is a sentinel value, which triggers a generic cost model on construction (in fact, any negative value here will trigger). Note that the generic cost model is in terms of Canadian dollars [CAD].
- double operation_maintenance_cost_kWh = -1

  The operation and maintenance cost of the asset [1/kWh] (undefined currency). This is a cost incurred per unit of energy charged/discharged. -1 is a sentinel value, which triggers a generic cost model on construction (in fact, any negative value here will trigger). Note that the generic cost model is in terms of Canadian dollars [CAD/kWh].
- double init_SOC = 0.5

  The initial state of charge of the asset.
- double min_SOC = 0.15

  The minimum state of charge of the asset. Will toggle is_depleted when reached.
- double hysteresis_SOC = 0.5

  The state of charge the asset must achieve to toggle is_depleted.
- double max_SOC = 0.9

  The maximum state of charge of the asset.
- double charging_efficiency = 0.9

  The charging efficiency of the asset.
- double discharging_efficiency = 0.9

  The discharging efficiency of the asset.
- double replace_SOH = 0.8

  The state of health at which the asset is considered "dead" and must be replaced.
- bool power_degradation_flag = false

  A flag which indicates whether or not power degradation should be modelled.
- double degradation_alpha = 8.935

  A dimensionless acceleration coefficient used in modelling energy capacity degradation.
- double degradation_beta = 1

  A dimensionless acceleration exponent used in modelling energy capacity degradation.
- double degradation_B_hat_cal_0 = 5.22226e6

  A reference (or base) pre-exponential factor [1/sqrt(hrs)] used in modelling energy capacity degradation.
- double degradation_r_cal = 0.4361

  A dimensionless constant used in modelling energy capacity degradation.
- double degradation_Ea_cal_0 = 5.279e4

  A reference (or base) activation energy [J/mol] used in modelling energy capacity degradation.
- double degradation_a_cal = 100

  A pre-exponential factor [J/mol] used in modelling energy capacity degradation.
- double degradation_s_cal = 2

  A dimensionless constant used in modelling energy capacity degradation.
- double gas_constant_JmolK = 8.31446

  The universal gas constant [J/mol.K].
- double temperature_K = 273 + 20

  The absolute environmental temperature [K] of the lithium ion battery energy storage system.

4.14.1 Detailed Description

A structure which bundles the necessary inputs for the LiIon constructor. Provides default values for every necessary input. Note that this structure encapsulates StorageInputs.

Ref: Truelove [2023a]

4.14.2 Member Data Documentation

4.14.2.1 capital_cost

```
double LiIonInputs::capital_cost = -1
```

The capital cost of the asset (undefined currency). -1 is a sentinel value, which triggers a generic cost model on construction (in fact, any negative value here will trigger). Note that the generic cost model is in terms of Canadian dollars [CAD].

4.14.2.2 charging_efficiency

```
double LiIonInputs::charging_efficiency = 0.9
```

The charging efficiency of the asset.

4.14.2.3 degradation_a_cal

```
double LiIonInputs::degradation_a_cal = 100
```

A pre-exponential factor [J/mol] used in modelling energy capacity degradation.

4.14.2.4 degradation_alpha

```
double LiIonInputs::degradation_alpha = 8.935
```

A dimensionless acceleration coefficient used in modelling energy capacity degradation.

4.14.2.5 degradation_B_hat_cal_0

```
double LiIonInputs::degradation_B_hat_cal_0 = 5.22226e6
```

A reference (or base) pre-exponential factor [1/sqrt(hrs)] used in modelling energy capacity degradation.

4.14.2.6 degradation_beta

```
double LiIonInputs::degradation_beta = 1
```

A dimensionless acceleration exponent used in modelling energy capacity degradation.

4.14.2.7 degradation_Ea_cal_0

```
double LiIonInputs::degradation_Ea_cal_0 = 5.279e4
```

A reference (or base) activation energy [J/mol] used in modelling energy capacity degradation.

4.14.2.8 degradation_r_cal

```
double LiIonInputs::degradation_r_cal = 0.4361
```

A dimensionless constant used in modelling energy capacity degradation.

4.14.2.9 degradation_s_cal

```
double LiIonInputs::degradation_s_cal = 2
```

A dimensionless constant used in modelling energy capacity degradation.

4.14.2.10 discharging_efficiency

```
double LiIonInputs::discharging_efficiency = 0.9
```

The discharging efficiency of the asset.

4.14.2.11 gas_constant_JmolK

```
double LiIonInputs::gas_constant_JmolK = 8.31446
```

The universal gas constant [J/mol.K].

4.14.2.12 hysteresis_SOC

```
double LiIonInputs::hysteresis_SOC = 0.5
```

The state of charge the asset must achieve to toggle is_depleted.

4.14.2.13 init_SOC

```
double LiIonInputs::init_SOC = 0.5
```

The initial state of charge of the asset.

4.14.2.14 max_SOC

```
double LiIonInputs::max_SOC = 0.9
```

The maximum state of charge of the asset.

4.14.2.15 min_SOC

```
double LiIonInputs::min_SOC = 0.15
```

The minimum state of charge of the asset. Will toggle is_depleted when reached.

4.14.2.16 operation_maintenance_cost_kWh

```
double LiIonInputs::operation_maintenance_cost_kWh = -1
```

The operation and maintenance cost of the asset [1/kWh] (undefined currency). This is a cost incurred per unit of energy charged/discharged. -1 is a sentinel value, which triggers a generic cost model on construction (in fact, any negative value here will trigger). Note that the generic cost model is in terms of Canadian dollars [CAD/kWh].

4.14.2.17 power_degradation_flag

```
bool LiIonInputs::power_degradation_flag = false
```

A flag which indicates whether or not power degradation should be modelled.

4.14.2.18 replace_SOH

```
double LiIonInputs::replace_SOH = 0.8
```

The state of health at which the asset is considered "dead" and must be replaced.

4.14.2.19 storage_inputs

```
StorageInputs LiIonInputs::storage_inputs
```

An encapsulated StorageInputs instance.

4.14.2.20 temperature_K

```
double LiIonInputs::temperature_K = 273 + 20
```

The absolute environmental temperature [K] of the lithium ion battery energy storage system.

The documentation for this struct was generated from the following file:

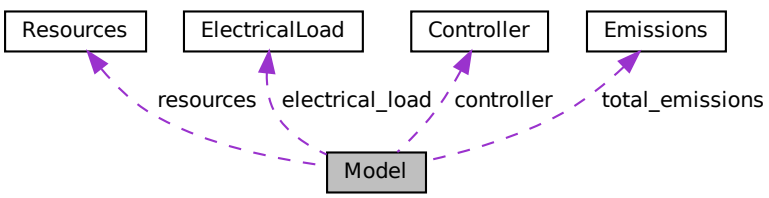
- header/Storage/LiIon.h

4.15 Model Class Reference

A container class which forms the centre of PGMcpp. The Model class is intended to serve as the primary user interface with the functionality of PGMcpp, and as such it contains all other classes.

```
#include <Model.h>
```

Collaboration diagram for Model:



Public Member Functions

- Model (void)

  Constructor (dummy) for the Model class.
- Model (ModelInputs)

  Constructor (intended) for the Model class.
- void addDiesel (DieselInputs)

  Method to add a Diesel asset to the Model.
- void addResource (NoncombustionType, std::string, int)

  A method to add a renewable resource time series to the Model.
- void addResource (RenewableType, std::string, int)

  A method to add a renewable resource time series to the Model.
- void addHydro (HydroInputs)

  Method to add a Hydro asset to the Model.
- void addSolar (SolarInputs)

  Method to add a Solar asset to the Model.
- void addTidal (TidalInputs)

  Method to add a Tidal asset to the Model.
- void addWave (WaveInputs)

  Method to add a Wave asset to the Model.
- void addWind (WindInputs)

  Method to add a Wind asset to the Model.
- void addLiIon (LiIonInputs)

  Method to add a LiIon asset to the Model.
- void run (void)

  A method to run the Model.
- void reset (void)

  Method which resets the model for use in assessing a new candidate microgrid design. This method only clears the asset pointer vectors and resets select Model attribues. It leaves the Controller, ElectricalLoad, and Resources objects of the Model alone.
- void clear (void)

  Method to clear all attributes of the Model object.
- void writeResults (std::string, int=-1)

  Method which writes Model results to an output directory. Also calls out to writeResults() for each contained asset.
- ~Model (void)

  Destructor for the Model class.

Public Attributes

- double total_fuel_consumed_L

  The total fuel consumed [L] over a model run.
- Emissions total_emissions

  An Emissions structure for holding total emissions [kg].
- double net_present_cost

  The net present cost of the Model (undefined currency).
- double total_renewable_dispatch_kWh

  The total energy dispatched [kWh] by all renewable assets over the Model run.
- double total_dispatch_discharge_kWh

  The total energy dispatched/discharged [kWh] over the Model run.
- double levellized_cost_of_energy_kWh

  The levellized cost of energy, per unit energy dispatched/discharged, of the Model [1/kWh] (undefined currency).

- Controller controller

  Controller component of Model.
- ElectricalLoad electrical_load

  ElectricalLoad component of Model.
- Resources resources

  Resources component of Model.
- std::vector< Combustion * > combustion_ptr_vec

  A vector of pointers to the various Combustion assets in the Model.
- std::vector< Noncombustion * > noncombustion_ptr_vec

  A vector of pointers to the various Noncombustion assets in the Model.
- std::vector< Renewable * > renewable_ptr_vec

  A vector of pointers to the various Renewable assets in the Model.
- std::vector< Storage * > storage_ptr_vec

  A vector of pointers to the various Storage assets in the Model.

Private Member Functions

- void __checkInputs (ModelInputs)

  Helper method (private) to check inputs to the Model constructor.
- void __computeFuelAndEmissions (void)

  Helper method to compute the total fuel consumption and emissions over the Model run.
- void __computeNetPresentCost (void)

  Helper method to compute the overall net present cost, for the Model run, from the asset-wise net present costs. Also tallies up total dispatch and discharge.
- void __computeLevellizedCostOfEnergy (void)

  Helper method to compute the overall levellized cost of energy, for the Model run, from the asset-wise levellized costs of energy.
- void __computeEconomics (void)

  Helper method to compute key economic metrics for the Model run.
- void __writeSummary (std::string)

  Helper method to write summary results for Model.
- void __writeTimeSeries (std::string, int=-1)

  Helper method to write time series results for Model.

4.15.1 Detailed Description

A container class which forms the centre of PGMcpp. The Model class is intended to serve as the primary user interface with the functionality of PGMcpp, and as such it contains all other classes.

4.15.2 Constructor & Destructor Documentation

4.15.2.1 Model() [1/2]

```
Model::Model (
              void  )
```

Constructor (dummy) for the Model class.

```
598 {
599     return;
600 }   /* Model() */
```

4.15.2.2 Model() [2/2]

```
Model::Model (
              ModelInputs model_inputs )
```

Constructor (intended) for the Model class.

Parameters

model_inputs	A structure of Model constructor inputs.

```
617 {
618     //  1. check inputs
619     this->__checkInputs(model_inputs);
620 
621     //  2. read in electrical load data
622     this->electrical_load.readLoadData(model_inputs.path_2_electrical_load_time_series);
623 
624     //  3. set control mode
625     this->controller.setControlMode(model_inputs.control_mode);
626 
627     //  4. set public attributes
628     this->total_fuel_consumed_L = 0;
629     this->net_present_cost = 0;
630     this->total_dispatch_discharge_kWh = 0;
631     this->total_renewable_dispatch_kWh = 0;
632     this->levellized_cost_of_energy_kWh = 0;
633 
634     return;
635 }   /* Model() */
```

4.15.2.3 ~Model()

```
Model::~Model (
              void  )
```

Destructor for the Model class.

```
1154 {
1155     this->clear();
1156     return;
1157 }   /* ~Model() */
```

4.15.3 Member Function Documentation

4.15.3.1 __checkInputs()

```
void Model::__checkInputs (
            ModelInputs model_inputs )  [private]
```

Helper method (private) to check inputs to the Model constructor.

Parameters

model_inputs	A structure of Model constructor inputs.

```
65 {
66     //  1. check path_2_electrical_load_time_series
67     if (model_inputs.path_2_electrical_load_time_series.empty()) {
68         std::string error_str = "ERROR:  Model()  path_2_electrical_load_time_series ";
69         error_str += "cannot be empty";
70 
71         #ifdef _WIN32
72             std::cout << error_str << std::endl;
73         #endif
74 
75         throw std::invalid_argument(error_str);
76     }
77 
78     return;
79 }   /* __checkInputs() */
```

4.15.3.2 __computeEconomics()

```
void Model::__computeEconomics (
            void  )  [private]
```

Helper method to compute key economic metrics for the Model run.

```
265 {
266     this->__computeNetPresentCost();
267     this->__computeLevellizedCostOfEnergy();
268 
269     return;
270 }   /* __computeEconomics() */
```

4.15.3.3 __computeFuelAndEmissions()

```
void Model::__computeFuelAndEmissions (
            void  )  [private]
```

Helper method to compute the total fuel consumption and emissions over the Model run.

```
95 {
96     for (size_t i = 0; i < this->combustion_ptr_vec.size(); i++) {
97         this->combustion_ptr_vec[i]->computeFuelAndEmissions();
98 
99         this->total_fuel_consumed_L +=
100             this->combustion_ptr_vec[i]->total_fuel_consumed_L;
101 
102         this->total_emissions.CO2_kg +=
103             this->combustion_ptr_vec[i]->total_emissions.CO2_kg;
104 
105         this->total_emissions.CO_kg +=
106             this->combustion_ptr_vec[i]->total_emissions.CO_kg;
107 
108         this->total_emissions.NOx_kg +=
109             this->combustion_ptr_vec[i]->total_emissions.NOx_kg;
110 
111         this->total_emissions.SOx_kg +=
```

```
112             this->combustion_ptr_vec[i]->total_emissions.SOx_kg;
113
114         this->total_emissions.CH4_kg +=
115             this->combustion_ptr_vec[i]->total_emissions.CH4_kg;
116
117         this->total_emissions.PM_kg +=
118             this->combustion_ptr_vec[i]->total_emissions.PM_kg;
119     }
120
121     return;
122 }   /* __computeFuelAndEmissions() */
```

4.15.3.4 __computeLevellizedCostOfEnergy()

```
void Model::__computeLevellizedCostOfEnergy (
              void  )  [private]
```

Helper method to compute the overall levellized cost of energy, for the Model run, from the asset-wise levellized costs of energy.

```
212 {
213     //  1. account for Combustion economics in levellized cost of energy
214     for (size_t i = 0; i < this->combustion_ptr_vec.size(); i++) {
215         this->levellized_cost_of_energy_kWh +=
216             (
217                 this->combustion_ptr_vec[i]->levellized_cost_of_energy_kWh *
218                 this->combustion_ptr_vec[i]->total_dispatch_kWh
219             ) / this->total_dispatch_discharge_kWh;
220     }
221
222     //  2. account for Noncombustion economics in levellized cost of energy
223     for (size_t i = 0; i < this->noncombustion_ptr_vec.size(); i++) {
224         this->levellized_cost_of_energy_kWh +=
225             (
226                 this->noncombustion_ptr_vec[i]->levellized_cost_of_energy_kWh *
227                 this->noncombustion_ptr_vec[i]->total_dispatch_kWh
228             ) / this->total_dispatch_discharge_kWh;
229     }
230
231     //  3. account for Renewable economics in levellized cost of energy
232     for (size_t i = 0; i < this->renewable_ptr_vec.size(); i++) {
233         this->levellized_cost_of_energy_kWh +=
234             (
235                 this->renewable_ptr_vec[i]->levellized_cost_of_energy_kWh *
236                 this->renewable_ptr_vec[i]->total_dispatch_kWh
237             ) / this->total_dispatch_discharge_kWh;
238     }
239
240     //  4. account for Storage economics in levellized cost of energy
241     for (size_t i = 0; i < this->storage_ptr_vec.size(); i++) {
242         this->levellized_cost_of_energy_kWh +=
243             (
244                 this->storage_ptr_vec[i]->levellized_cost_of_energy_kWh *
245                 this->storage_ptr_vec[i]->total_discharge_kWh
246             ) / this->total_dispatch_discharge_kWh;
247     }
248
249     return;
250 }   /* __computeLevellizedCostOfEnergy() */
```

4.15.3.5 __computeNetPresentCost()

```
void Model::__computeNetPresentCost (
              void  )  [private]
```

Helper method to compute the overall net present cost, for the Model run, from the asset-wise net present costs. Also tallies up total dispatch and discharge.

```
139 {
140     //  1. account for Combustion economics in net present cost
```

```
141     //     increment total dispatch
142     for (size_t i = 0; i < this->combustion_ptr_vec.size(); i++) {
143         this->combustion_ptr_vec[i]->computeEconomics(
144             &(this->electrical_load.time_vec_hrs)
145         );
146 
147         this->net_present_cost += this->combustion_ptr_vec[i]->net_present_cost;
148 
149         this->total_dispatch_discharge_kWh +=
150             this->combustion_ptr_vec[i]->total_dispatch_kWh;
151     }
152 
153     //  2. account for Noncombustion economics in net present cost
154     //     increment total dispatch
155     for (size_t i = 0; i < this->noncombustion_ptr_vec.size(); i++) {
156         this->noncombustion_ptr_vec[i]->computeEconomics(
157             &(this->electrical_load.time_vec_hrs)
158         );
159 
160         this->net_present_cost += this->noncombustion_ptr_vec[i]->net_present_cost;
161 
162         this->total_dispatch_discharge_kWh +=
163             this->noncombustion_ptr_vec[i]->total_dispatch_kWh;
164     }
165 
166     //  3. account for Renewable economics in net present cost,
167     //     increment total dispatch
168     for (size_t i = 0; i < this->renewable_ptr_vec.size(); i++) {
169         this->renewable_ptr_vec[i]->computeEconomics(
170             &(this->electrical_load.time_vec_hrs)
171         );
172 
173         this->net_present_cost += this->renewable_ptr_vec[i]->net_present_cost;
174 
175         this->total_dispatch_discharge_kWh +=
176             this->renewable_ptr_vec[i]->total_dispatch_kWh;
177 
178         this->total_renewable_dispatch_kWh +=
179             this->renewable_ptr_vec[i]->total_dispatch_kWh;
180     }
181 
182     //  4. account for Storage economics in net present cost
183     //     increment total dispatch
184     for (size_t i = 0; i < this->storage_ptr_vec.size(); i++) {
185         this->storage_ptr_vec[i]->computeEconomics(
186             &(this->electrical_load.time_vec_hrs)
187         );
188 
189         this->net_present_cost += this->storage_ptr_vec[i]->net_present_cost;
190 
191         this->total_dispatch_discharge_kWh +=
192             this->storage_ptr_vec[i]->total_discharge_kWh;
193     }
194 
195     return;
196 }   /* __computeNetPresentCost() */
```

4.15.3.6 __writeSummary()

```
void Model::__writeSummary (
            std::string write_path )  [private]
```

Helper method to write summary results for Model.

Parameters

write_path	A path (either relative or absolute) to the directory location where results are to be written. If already exists, will overwrite.

```
288 {
289     //  1. create subdirectory
290     write_path += "Model/";
291     std::filesystem::create_directory(write_path);
292 
```

```
293     //  2. create filestream
294     write_path += "summary_results.md";
295     std::ofstream ofs;
296     ofs.open(write_path, std::ofstream::out);
297 
298     //  3. write summary results (markdown)
299     ofs « "# Model Summary Results\n";
300     ofs « "\n--------\n\n";
301 
302     //  3.1. ElectricalLoad
303     ofs « "## Electrical Load\n";
304     ofs « "\n";
305     ofs « "Path: " «
306         this->electrical_load.path_2_electrical_load_time_series « "  \n";
307     ofs « "Data Points: " « this->electrical_load.n_points « "  \n";
308     ofs « "Years: " « this->electrical_load.n_years « "  \n";
309     ofs « "Min: " « this->electrical_load.min_load_kW « " kW  \n";
310     ofs « "Mean: " « this->electrical_load.mean_load_kW « " kW  \n";
311     ofs « "Max: " « this->electrical_load.max_load_kW « " kW  \n";
312     ofs « "\n--------\n\n";
313 
314     //  3.2. Controller
315     ofs « "## Controller\n";
316     ofs « "\n";
317     ofs « "Control Mode: " « this->controller.control_string « "  \n";
318     ofs « "\n--------\n\n";
319 
320     //  3.3. Resources (1D)
321     ofs « "## 1D Renewable Resources\n";
322     ofs « "\n";
323 
324     std::map<int, std::string>::iterator string_map_1D_iter =
325         this->resources.string_map_1D.begin();
326     std::map<int, std::string>::iterator path_map_1D_iter =
327         this->resources.path_map_1D.begin();
328 
329     while (
330         string_map_1D_iter != this->resources.string_map_1D.end() and
331         path_map_1D_iter != this->resources.path_map_1D.end()
332     ) {
333         ofs « "Resource Key: " « string_map_1D_iter->first « "  \n";
334         ofs « "Type: " « string_map_1D_iter->second « "  \n";
335         ofs « "Path: " « path_map_1D_iter->second « "  \n";
336         ofs « "\n";
337 
338         string_map_1D_iter++;
339         path_map_1D_iter++;
340     }
341 
342     ofs « "\n--------\n\n";
343 
344     //  3.4. Resources (2D)
345     ofs « "## 2D Renewable Resources\n";
346     ofs « "\n";
347 
348     std::map<int, std::string>::iterator string_map_2D_iter =
349         this->resources.string_map_2D.begin();
350     std::map<int, std::string>::iterator path_map_2D_iter =
351         this->resources.path_map_2D.begin();
352 
353     while (
354         string_map_2D_iter != this->resources.string_map_2D.end() and
355         path_map_2D_iter != this->resources.path_map_2D.end()
356     ) {
357         ofs « "Resource Key: " « string_map_2D_iter->first « "  \n";
358         ofs « "Type: " « string_map_2D_iter->second « "  \n";
359         ofs « "Path: " « path_map_2D_iter->second « "  \n";
360         ofs « "\n";
361 
362         string_map_2D_iter++;
363         path_map_2D_iter++;
364     }
365 
366     ofs « "\n--------\n\n";
367 
368     //  3.5. Combustion
369     ofs « "## Combustion Assets\n";
370     ofs « "\n";
371 
372     for (size_t i = 0; i < this->combustion_ptr_vec.size(); i++) {
373         ofs « "Asset Index: " « i « "  \n";
374         ofs « "Type: " « this->combustion_ptr_vec[i]->type_str « "  \n";
375         ofs « "Capacity: " « this->combustion_ptr_vec[i]->capacity_kW « " kW  \n";
376         ofs « "\n";
377     }
378 
379     ofs « "\n--------\n\n";
```

```
380
381     //  3.6. Noncombustion
382     ofs « "## Noncombustion Assets\n";
383     ofs « "\n";
384
385     for (size_t i = 0; i < this->noncombustion_ptr_vec.size(); i++) {
386         ofs « "Asset Index: " « i « "  \n";
387         ofs « "Type: " « this->noncombustion_ptr_vec[i]->type_str « "  \n";
388         ofs « "Capacity: " « this->noncombustion_ptr_vec[i]->capacity_kW « " kW  \n";
389
390         if (this->noncombustion_ptr_vec[i]->type == NoncombustionType :: HYDRO) {
391             ofs « "Reservoir Capacity: " «
392                 ((Hydro*)(this->noncombustion_ptr_vec[i]))->reservoir_capacity_m3 «
393                 " m3  \n";
394         }
395
396         ofs « "\n";
397     }
398
399     ofs « "\n--------\n\n";
400
401     //  3.7. Renewable
402     ofs « "## Renewable Assets\n";
403     ofs « "\n";
404
405     for (size_t i = 0; i < this->renewable_ptr_vec.size(); i++) {
406         ofs « "Asset Index: " « i « "  \n";
407         ofs « "Type: " « this->renewable_ptr_vec[i]->type_str « "  \n";
408         ofs « "Capacity: " « this->renewable_ptr_vec[i]->capacity_kW « " kW  \n";
409         ofs « "\n";
410     }
411
412     ofs « "\n--------\n\n";
413
414     //  3.8. Storage
415     ofs « "## Storage Assets\n";
416     ofs « "\n";
417
418     for (size_t i = 0; i < this->storage_ptr_vec.size(); i++) {
419         ofs « "Asset Index: " « i « "  \n";
420         ofs « "Type: " « this->storage_ptr_vec[i]->type_str « "  \n";
421         ofs « "Power Capacity: " « this->storage_ptr_vec[i]->power_capacity_kW
422             « " kW  \n";
423         ofs « "Energy Capacity: " « this->storage_ptr_vec[i]->energy_capacity_kWh
424             « " kWh  \n";
425         ofs « "\n";
426     }
427
428     ofs « "\n--------\n\n";
429
430     //  3.9. Model Results
431     ofs « "## Results\n";
432     ofs « "\n";
433
434     ofs « "Net Present Cost: " « this->net_present_cost « "  \n";
435     ofs « "\n";
436
437     ofs « "Total Dispatch + Discharge: " « this->total_dispatch_discharge_kWh
438         « " kWh  \n";
439
440     ofs « "Renewable Penetration: "
441         « this->total_renewable_dispatch_kWh / this->total_dispatch_discharge_kWh
442         « "  \n";
443     ofs « "\n";
444
445     ofs « "Levellized Cost of Energy: " « this->levellized_cost_of_energy_kWh
446         « " per kWh dispatched/discharged  \n";
447     ofs « "\n";
448
449     ofs « "Total Fuel Consumed: " « this->total_fuel_consumed_L « " L "
450         « "(Annual Average: " «
451             this->total_fuel_consumed_L / this->electrical_load.n_years
452         « " L/yr)  \n";
453     ofs « "\n";
454
455     ofs « "Total Carbon Dioxide (CO2) Emissions: " «
456         this->total_emissions.CO2_kg « " kg "
457         « "(Annual Average: " «
458             this->total_emissions.CO2_kg / this->electrical_load.n_years
459         « " kg/yr)  \n";
460
461     ofs « "Total Carbon Monoxide (CO) Emissions: " «
462         this->total_emissions.CO_kg « " kg "
463         « "(Annual Average: " «
464             this->total_emissions.CO_kg / this->electrical_load.n_years
465         « " kg/yr)  \n";
466
```

```
467     ofs « "Total Nitrogen Oxides (NOx) Emissions: " «
468         this->total_emissions.NOx_kg « " kg "
469         « "(Annual Average: " «
470             this->total_emissions.NOx_kg / this->electrical_load.n_years
471         « " kg/yr)  \n";
472
473     ofs « "Total Sulfur Oxides (SOx) Emissions: " «
474         this->total_emissions.SOx_kg « " kg "
475         « "(Annual Average: " «
476             this->total_emissions.SOx_kg / this->electrical_load.n_years
477         « " kg/yr)  \n";
478
479     ofs « "Total Methane (CH4) Emissions: " « this->total_emissions.CH4_kg « " kg "
480         « "(Annual Average: " «
481             this->total_emissions.CH4_kg / this->electrical_load.n_years
482         « " kg/yr)  \n";
483
484     ofs « "Total Particulate Matter (PM) Emissions: " «
485         this->total_emissions.PM_kg « " kg "
486         « "(Annual Average: " «
487             this->total_emissions.PM_kg / this->electrical_load.n_years
488         « " kg/yr)  \n";
489
490     ofs « "\n--------\n\n";
491
492     ofs.close();
493     return;
494 }   /* __writeSummary() */
```

4.15.3.7 __writeTimeSeries()

```
void Model::__writeTimeSeries (
              std::string write_path,
              int max_lines = -1 )  [private]
```

Helper method to write time series results for Model.

Parameters

write_path	A path (either relative or absolute) to the directory location where results are to be written. If already exists, will overwrite.
max_lines	The maximum number of lines of output to write.

```
514 {
515     //  1. create filestream
516     write_path += "Model/time_series_results.csv";
517     std::ofstream ofs;
518     ofs.open(write_path, std::ofstream::out);
519
520     //  2. write time series results header (comma separated value)
521     ofs « "Time (since start of data) [hrs],";
522     ofs « "Electrical Load [kW],";
523     ofs « "Net Load [kW],";
524     ofs « "Missed Load [kW],";
525
526     for (size_t i = 0; i < this->renewable_ptr_vec.size(); i++) {
527         ofs « this->renewable_ptr_vec[i]->capacity_kW « " kW "
528             « this->renewable_ptr_vec[i]->type_str « " Dispatch [kW],";
529     }
530
531     for (size_t i = 0; i < this->storage_ptr_vec.size(); i++) {
532         ofs « this->storage_ptr_vec[i]->power_capacity_kW « " kW "
533             « this->storage_ptr_vec[i]->energy_capacity_kWh « " kWh "
534             « this->storage_ptr_vec[i]->type_str « " Discharge [kW],";
535     }
536
537     for (size_t i = 0; i < this->noncombustion_ptr_vec.size(); i++) {
538         ofs « this->noncombustion_ptr_vec[i]->capacity_kW « " kW "
539             « this->noncombustion_ptr_vec[i]->type_str « " Dispatch [kW],";
540     }
541
542     for (size_t i = 0; i < this->combustion_ptr_vec.size(); i++) {
543         ofs « this->combustion_ptr_vec[i]->capacity_kW « " kW "
```

```
544             « this->combustion_ptr_vec[i]->type_str « " Dispatch [kW],";
545     }
546
547     ofs « "\n";
548
549     //  3. write time series results values (comma separated value)
550     for (int i = 0; i < max_lines; i++) {
551         //  3.1. load values
552         ofs « this->electrical_load.time_vec_hrs[i] « ",";
553         ofs « this->electrical_load.load_vec_kW[i] « ",";
554         ofs « this->controller.net_load_vec_kW[i] « ",";
555         ofs « this->controller.missed_load_vec_kW[i] « ",";
556
557         //  3.2. asset-wise dispatch/discharge
558         for (size_t j = 0; j < this->renewable_ptr_vec.size(); j++) {
559             ofs « this->renewable_ptr_vec[j]->dispatch_vec_kW[i] « ",";
560         }
561
562         for (size_t j = 0; j < this->storage_ptr_vec.size(); j++) {
563             ofs « this->storage_ptr_vec[j]->discharging_power_vec_kW[i] « ",";
564         }
565
566         for (size_t j = 0; j < this->noncombustion_ptr_vec.size(); j++) {
567             ofs « this->noncombustion_ptr_vec[j]->dispatch_vec_kW[i] « ",";
568         }
569
570         for (size_t j = 0; j < this->combustion_ptr_vec.size(); j++) {
571             ofs « this->combustion_ptr_vec[j]->dispatch_vec_kW[i] « ",";
572         }
573
574         ofs « "\n";
575     }
576
577     ofs.close();
578     return;
579 }   /* __writeTimeSeries() */
```

4.15.3.8 addDiesel()

```
void Model::addDiesel (
            DieselInputs diesel_inputs )
```

Method to add a Diesel asset to the Model.

Parameters

diesel_inputs	A structure of Diesel constructor inputs.

```
652 {
653     Combustion* diesel_ptr = new Diesel(
654         this->electrical_load.n_points,
655         this->electrical_load.n_years,
656         diesel_inputs,
657         &(this->electrical_load.time_vec_hrs)
658     );
659
660     this->combustion_ptr_vec.push_back(diesel_ptr);
661
662     return;
663 }   /* addDiesel() */
```

4.15.3.9 addHydro()

```
void Model::addHydro (
            HydroInputs hydro_inputs )
```

Method to add a Hydro asset to the Model.

Parameters

hydro_inputs	A structure of Hydro constructor inputs.

```
756 {
757     Noncombustion* hydro_ptr = new Hydro(
758         this->electrical_load.n_points,
759         this->electrical_load.n_years,
760         hydro_inputs,
761         &(this->electrical_load.time_vec_hrs)
762     );
763 
764     this->noncombustion_ptr_vec.push_back(hydro_ptr);
765 
766     return;
767 }   /* addHydro() */
```

4.15.3.10 addLiIon()

```
void Model::addLiIon (
             LiIonInputs liion_inputs )
```

Method to add a LiIon asset to the Model.

Parameters

liion_inputs	A structure of LiIon constructor inputs.

```
896 {
897     Storage* liion_ptr = new LiIon(
898         this->electrical_load.n_points,
899         this->electrical_load.n_years,
900         liion_inputs
901     );
902 
903     this->storage_ptr_vec.push_back(liion_ptr);
904 
905     return;
906 }   /* addLiIon() */
```

4.15.3.11 addResource() [1/2]

```
void Model::addResource (
             NoncombustionType noncombustion_type,
             std::string path_2_resource_data,
             int resource_key )
```

A method to add a renewable resource time series to the Model.

Parameters

noncombustion_type	The type of renewable resource being added to the Model.
path_2_resource_data	A string defining the path (either relative or absolute) to the given resource time series.
resource_key	A key used to index into the Resources object, used to associate Renewable assets with the corresponding resource.

```
692 {
693     resources.addResource(
694         noncombustion_type,
695         path_2_resource_data,
696         resource_key,
697         &(this->electrical_load)
698     );
699 
700     return;
701 }   /* addResource() */
```

4.15.3.12 addResource() [2/2]

```
void Model::addResource (
              RenewableType renewable_type,
              std::string path_2_resource_data,
              int resource_key )
```

A method to add a renewable resource time series to the Model.

Parameters

renewable_type	The type of renewable resource being added to the Model.
path_2_resource_data	A string defining the path (either relative or absolute) to the given resource time series.
resource_key	A key used to index into the Resources object, used to associate Renewable assets with the corresponding resource.

```
730 {
731     resources.addResource(
732         renewable_type,
733         path_2_resource_data,
734         resource_key,
735         &(this->electrical_load)
736     );
737 
738     return;
739 }   /* addResource() */
```

4.15.3.13 addSolar()

```
void Model::addSolar (
              SolarInputs solar_inputs )
```

Method to add a Solar asset to the Model.

Parameters

solar_inputs	A structure of Solar constructor inputs.

```
784 {
785     Renewable* solar_ptr = new Solar(
786         this->electrical_load.n_points,
787         this->electrical_load.n_years,
788         solar_inputs,
789         &(this->electrical_load.time_vec_hrs)
790     );
791 
792     this->renewable_ptr_vec.push_back(solar_ptr);
```

```
793
794     return;
795 }   /* addSolar() */
```

4.15.3.14 addTidal()

```
void Model::addTidal (
            TidalInputs tidal_inputs )
```

Method to add a Tidal asset to the Model.

Parameters

tidal_inputs	A structure of Tidal constructor inputs.

```
812 {
813     Renewable* tidal_ptr = new Tidal(
814         this->electrical_load.n_points,
815         this->electrical_load.n_years,
816         tidal_inputs,
817         &(this->electrical_load.time_vec_hrs)
818     );
819
820     this->renewable_ptr_vec.push_back(tidal_ptr);
821
822     return;
823 }   /* addTidal() */
```

4.15.3.15 addWave()

```
void Model::addWave (
            WaveInputs wave_inputs )
```

Method to add a Wave asset to the Model.

Parameters

wave_inputs	A structure of Wave constructor inputs.

```
840 {
841     Renewable* wave_ptr = new Wave(
842         this->electrical_load.n_points,
843         this->electrical_load.n_years,
844         wave_inputs,
845         &(this->electrical_load.time_vec_hrs)
846     );
847
848     this->renewable_ptr_vec.push_back(wave_ptr);
849
850     return;
851 }   /* addWave() */
```

4.15.3.16 addWind()

```
void Model::addWind (
            WindInputs wind_inputs )
```

Method to add a Wind asset to the Model.

Parameters

wind_inputs	A structure of Wind constructor inputs.

```
868 {
869     Renewable* wind_ptr = new Wind(
870         this->electrical_load.n_points,
871         this->electrical_load.n_years,
872         wind_inputs,
873         &(this->electrical_load.time_vec_hrs)
874     );
875 
876     this->renewable_ptr_vec.push_back(wind_ptr);
877 
878     return;
879 }   /* addWind() */
```

4.15.3.17 clear()

```
void Model::clear (
            void  )
```

Method to clear all attributes of the Model object.

```
1023 {
1024     //  1. reset
1025     this->reset();
1026 
1027     //  2. clear components
1028     controller.clear();
1029     electrical_load.clear();
1030     resources.clear();
1031 
1032     return;
1033 }   /* clear() */
```

4.15.3.18 reset()

```
void Model::reset (
            void  )
```

Method which resets the model for use in assessing a new candidate microgrid design. This method only clears the asset pointer vectors and resets select Model attribues. It leaves the Controller, ElectricalLoad, and Resources objects of the Model alone.

```
965 {
966     //  1. clear combustion_ptr_vec
967     for (size_t i = 0; i < this->combustion_ptr_vec.size(); i++) {
968         delete this->combustion_ptr_vec[i];
969     }
970     this->combustion_ptr_vec.clear();
971 
972     //  2. clear noncombustion_ptr_vec
973     for (size_t i = 0; i < this->noncombustion_ptr_vec.size(); i++) {
974         delete this->noncombustion_ptr_vec[i];
975     }
976     this->noncombustion_ptr_vec.clear();
977 
978     //  3. clear renewable_ptr_vec
979     for (size_t i = 0; i < this->renewable_ptr_vec.size(); i++) {
980         delete this->renewable_ptr_vec[i];
981     }
982     this->renewable_ptr_vec.clear();
983 
984     //  4. clear storage_ptr_vec
```

```
985     for (size_t i = 0; i < this->storage_ptr_vec.size(); i++) {
986         delete this->storage_ptr_vec[i];
987     }
988     this->storage_ptr_vec.clear();
989 
990     //  5. reset components and attributes
991     this->controller.clear();
992 
993     this->total_fuel_consumed_L = 0;
994 
995     this->total_emissions.CO2_kg = 0;
996     this->total_emissions.CO_kg = 0;
997     this->total_emissions.NOx_kg = 0;
998     this->total_emissions.SOx_kg = 0;
999     this->total_emissions.CH4_kg = 0;
1000     this->total_emissions.PM_kg = 0;
1001 
1002     this->net_present_cost = 0;
1003     this->total_dispatch_discharge_kWh = 0;
1004     this->total_renewable_dispatch_kWh = 0;
1005     this->levellized_cost_of_energy_kWh = 0;
1006 
1007     return;
1008 }   /* reset() */
```

4.15.3.19 run()

```
void Model::run (
              void  )
```

A method to run the Model.

```
921 {
922     // 1. init Controller
923     this->controller.init(
924         &(this->electrical_load),
925         &(this->renewable_ptr_vec),
926         &(this->resources),
927         &(this->combustion_ptr_vec)
928     );
929 
930     //  2. apply dispatch control
931     this->controller.applyDispatchControl(
932         &(this->electrical_load),
933         &(this->resources),
934         &(this->combustion_ptr_vec),
935         &(this->noncombustion_ptr_vec),
936         &(this->renewable_ptr_vec),
937         &(this->storage_ptr_vec)
938     );
939 
940     //  3. compute total fuel consumption and emissions
941     this->__computeFuelAndEmissions();
942 
943     //  4. compute key economic metrics
944     this->__computeEconomics();
945 
946     return;
947 }   /* run() */
```

4.15.3.20 writeResults()

```
void Model::writeResults (
              std::string write_path,
              int max_lines = -1 )
```

Method which writes Model results to an output directory. Also calls out to writeResults() for each contained asset.

Parameters

write_path	A path (either relative or absolute) to the directory location where results are to be written. If already exists, will overwrite.
max_lines	The maximum number of lines of output to write. If <0, then all available lines are written. If =0, then only summary results are written.

```
1061 {
1062     //  1. handle sentinel
1063     if (max_lines < 0) {
1064         max_lines = this->electrical_load.n_points;
1065     }
1066
1067     //  2. check for pre-existing, warn (and remove), then create
1068     if (write_path.back() != '/') {
1069         write_path += '/';
1070     }
1071
1072     if (std::filesystem::is_directory(write_path)) {
1073         std::string warning_str = "WARNING:  Model::writeResults():  ";
1074         warning_str += write_path;
1075         warning_str += " already exists, contents will be overwritten!";
1076
1077         std::cout << warning_str << std::endl;
1078
1079         std::filesystem::remove_all(write_path);
1080     }
1081
1082     std::filesystem::create_directory(write_path);
1083
1084     //  3. write summary
1085     this->__writeSummary(write_path);
1086
1087     //  4. write time series
1088     if (max_lines > this->electrical_load.n_points) {
1089         max_lines = this->electrical_load.n_points;
1090     }
1091
1092     if (max_lines > 0) {
1093         this->__writeTimeSeries(write_path, max_lines);
1094     }
1095
1096     //  5. call out to Combustion :: writeResults()
1097     for (size_t i = 0; i < this->combustion_ptr_vec.size(); i++) {
1098         this->combustion_ptr_vec[i]->writeResults(
1099             write_path,
1100             &(this->electrical_load.time_vec_hrs),
1101             i,
1102             max_lines
1103         );
1104     }
1105
1106     //  6. call out to Noncombustion :: writeResults()
1107     for (size_t i = 0; i < this->noncombustion_ptr_vec.size(); i++) {
1108         this->noncombustion_ptr_vec[i]->writeResults(
1109             write_path,
1110             &(this->electrical_load.time_vec_hrs),
1111             i,
1112             max_lines
1113         );
1114     }
1115
1116     //  7. call out to Renewable :: writeResults()
1117     for (size_t i = 0; i < this->renewable_ptr_vec.size(); i++) {
1118         this->renewable_ptr_vec[i]->writeResults(
1119             write_path,
1120             &(this->electrical_load.time_vec_hrs),
1121             &(this->resources.resource_map_1D),
1122             &(this->resources.resource_map_2D),
1123             i,
1124             max_lines
1125         );
1126     }
1127
1128     //  8. call out to Storage :: writeResults()
1129     for (size_t i = 0; i < this->storage_ptr_vec.size(); i++) {
1130         this->storage_ptr_vec[i]->writeResults(
1131             write_path,
1132             &(this->electrical_load.time_vec_hrs),
1133             i,
1134             max_lines
1135         );
1136     }
1137
```

```
1138     return;
1139 }   /* writeResults() */
```

4.15.4 Member Data Documentation

4.15.4.1 combustion_ptr_vec

```
std::vector<Combustion*> Model::combustion_ptr_vec
```

A vector of pointers to the various Combustion assets in the Model.

4.15.4.2 controller

```
Controller Model::controller
```

Controller component of Model.

4.15.4.3 electrical_load

```
ElectricalLoad Model::electrical_load
```

ElectricalLoad component of Model.

4.15.4.4 levellized_cost_of_energy_kWh

```
double Model::levellized_cost_of_energy_kWh
```

The levellized cost of energy, per unit energy dispatched/discharged, of the Model [1/kWh] (undefined currency).

4.15.4.5 net_present_cost

```
double Model::net_present_cost
```

The net present cost of the Model (undefined currency).

4.15.4.6 noncombustion_ptr_vec

```
std::vector<Noncombustion*> Model::noncombustion_ptr_vec
```

A vector of pointers to the various Noncombustion assets in the Model.

4.15.4.7 renewable_ptr_vec

```
std::vector<Renewable*> Model::renewable_ptr_vec
```

A vector of pointers to the various Renewable assets in the Model.

4.15.4.8 resources

```
Resources Model::resources
```

Resources component of Model.

4.15.4.9 storage_ptr_vec

```
std::vector<Storage*> Model::storage_ptr_vec
```

A vector of pointers to the various Storage assets in the Model.

4.15.4.10 total_dispatch_discharge_kWh

```
double Model::total_dispatch_discharge_kWh
```

The total energy dispatched/discharged [kWh] over the Model run.

4.15.4.11 total_emissions

```
Emissions Model::total_emissions
```

An Emissions structure for holding total emissions [kg].

4.15.4.12 total_fuel_consumed_L

```
double Model::total_fuel_consumed_L
```

The total fuel consumed [L] over a model run.

4.15.4.13 total_renewable_dispatch_kWh

```
double Model::total_renewable_dispatch_kWh
```

The total energy dispatched [kWh] by all renewable assets over the Model run.

The documentation for this class was generated from the following files:

- header/Model.h
- source/Model.cpp

4.16 ModelInputs Struct Reference

A structure which bundles the necessary inputs for the Model constructor. Provides default values for every necessary input (except path_2_electrical_load_time_series, for which a valid input must be provided).

```
#include <Model.h>
```

Public Attributes

- std::string path_2_electrical_load_time_series = ""

  A string defining the path (either relative or absolute) to the given electrical load time series.
- ControlMode control_mode = ControlMode :: LOAD_FOLLOWING

  The control mode to be applied by the Controller object.

4.16.1 Detailed Description

A structure which bundles the necessary inputs for the Model constructor. Provides default values for every necessary input (except path_2_electrical_load_time_series, for which a valid input must be provided).

4.16.2 Member Data Documentation

4.16.2.1 control_mode

```
ControlMode ModelInputs::control_mode = ControlMode ::  LOAD_FOLLOWING
```

The control mode to be applied by the Controller object.

4.16.2.2 path_2_electrical_load_time_series

```
std::string ModelInputs::path_2_electrical_load_time_series = ""
```

A string defining the path (either relative or absolute) to the given electrical load time series.

The documentation for this struct was generated from the following file:

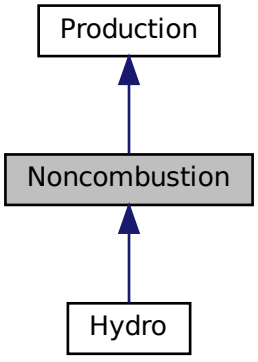
- header/Model.h

4.17 Noncombustion Class Reference

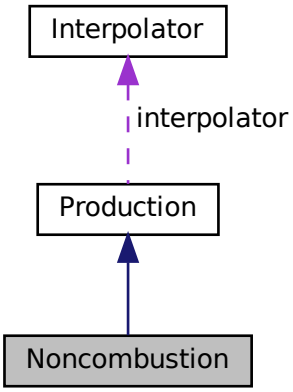
The root of the Noncombustion branch of the Production hierarchy. This branch contains derived classes which model controllable production which is not based on combustion.

```
#include <Noncombustion.h>
```

Inheritance diagram for Noncombustion:



Collaboration diagram for Noncombustion:



Public Member Functions

- Noncombustion (void)

  Constructor (dummy) for the Noncombustion class.
- Noncombustion (int, double, NoncombustionInputs, std::vector< double > *)

  Constructor (intended) for the Noncombustion class.
- virtual void handleReplacement (int)

  Method to handle asset replacement and capital cost incursion, if applicable.
- void computeEconomics (std::vector< double > *)

  Helper method to compute key economic metrics for the Model run.
- virtual double requestProductionkW (int, double, double)
- virtual double requestProductionkW (int, double, double, double)
- virtual double commit (int, double, double, double)

  Method which takes in production and load for the current timestep, computes and records dispatch and curtailment, and then returns remaining load.
- virtual double commit (int, double, double, double, double)
- void writeResults (std::string, std::vector< double > *, int, int=-1)

  Method which writes Noncombustion results to an output directory.
- virtual ~Noncombustion (void)

  Destructor for the Noncombustion class.

Public Attributes

- NoncombustionType type

  The type (NoncombustionType) of the asset.
- int resource_key

  A key used to index into the Resources object, to associate this asset with the appropriate resource time series.

Private Member Functions

- void __checkInputs (NoncombustionInputs)

  Helper method to check inputs to the Noncombustion constructor.
- void __handleStartStop (int, double, double)

  Helper method to handle the starting/stopping of the Noncombustion asset.
- virtual void __writeSummary (std::string)
- virtual void __writeTimeSeries (std::string, std::vector< double > *, int=-1)

4.17.1 Detailed Description

The root of the Noncombustion branch of the Production hierarchy. This branch contains derived classes which model controllable production which is not based on combustion.

4.17.2 Constructor & Destructor Documentation

4.17.2.1 Noncombustion() [1/2]

```
Noncombustion::Noncombustion (
            void  )
```

Constructor (dummy) for the Noncombustion class.

```
127 {
128     return;
129 }   /* Noncombustion() */
```

4.17.2.2 Noncombustion() [2/2]

```
Noncombustion::Noncombustion (
            int n_points,
            double n_years,
            NoncombustionInputs noncombustion_inputs,
            std::vector< double > * time_vec_hrs_ptr )
```

Constructor (intended) for the Noncombustion class.

Parameters

n_points	The number of points in the modelling time series.
n_years	The number of years being modelled.
noncombustion_inputs	A structure of Noncombustion constructor inputs.
time_vec_hrs_ptr	A pointer to the vector containing the modelling time series.

```
161   :
162 Production(
163     n_points,
```

```
164     n_years,
165     noncombustion_inputs.production_inputs,
166     time_vec_hrs_ptr
167 )
168 {
169     //  1. check inputs
170     this->__checkInputs(noncombustion_inputs);
171 
172     //  2. set attributes
173     //...
174 
175     //  3. construction print
176     if (this->print_flag) {
177         std::cout « "Noncombustion object constructed at " « this « std::endl;
178     }
179 
180     return;
181 }   /* Noncombustion() */
```

4.17.2.3 ~Noncombustion()

```
Noncombustion::~Noncombustion (
             void  )  [virtual]
```

Destructor for the Noncombustion class.

```
372 {
373     //  1. destruction print
374     if (this->print_flag) {
375         std::cout « "Noncombustion object at " « this « " destroyed" « std::endl;
376     }
377 
378     return;
379 }   /* ~Noncombustion() */
```

4.17.3 Member Function Documentation

4.17.3.1 __checkInputs()

```
void Noncombustion::__checkInputs (
             NoncombustionInputs noncombustion_inputs )  [private]
```

Helper method to check inputs to the Noncombustion constructor.

Parameters

noncombustion_inputs	A structure of Noncombustion constructor inputs.

```
64 {
65     //...
66 
67     return;
68 }   /* __checkInputs() */
```

4.17.3.2 __handleStartStop()

```
void Noncombustion::__handleStartStop (
```

```
            int timestep,
            double dt_hrs,
            double production_kW )  [private]
```

Helper method to handle the starting/stopping of the Noncombustion asset.

```
91 {
92     if (this->is_running) {
93         // handle stopping
94         if (production_kW <= 0) {
95             this->is_running = false;
96         }
97     }
98 
99     else {
100         // handle starting
101         if (production_kW > 0) {
102             this->is_running = true;
103             this->n_starts++;
104         }
105     }
106 
107     return;
108 }   /* __handleStartStop() */
```

4.17.3.3 __writeSummary()

```
virtual void Noncombustion::__writeSummary (
            std::string  )  [inline], [private], [virtual]
```

Reimplemented in Hydro.

```
95 {return;}
```

4.17.3.4 __writeTimeSeries()

```
virtual void Noncombustion::__writeTimeSeries (
            std::string ,
            std::vector< double > * ,
            int  = -1 )  [inline], [private], [virtual]
```

Reimplemented in Hydro.

```
100         {return;}
```

4.17.3.5 commit() [1/2]

```
double Noncombustion::commit (
            int timestep,
            double dt_hrs,
            double production_kW,
            double load_kW )  [virtual]
```

Method which takes in production and load for the current timestep, computes and records dispatch and curtailment, and then returns remaining load.

Parameters

timestep	The timestep (i.e., time series index) for the request.
dt_hrs	The interval of time [hrs] associated with the timestep.
production_kW	The production [kW] of the asset in this timestep.
load_kW	The load [kW] passed to the asset in this timestep.

Returns

The load [kW] remaining after the dispatch is deducted from it.

Reimplemented from Production.

```
267 {
268     //  1. handle start/stop
269     this->__handleStartStop(timestep, dt_hrs, production_kW);
270 
271     //  2. invoke base class method
272     load_kW = Production :: commit(
273         timestep,
274         dt_hrs,
275         production_kW,
276         load_kW
277     );
278 
279 
280     //...
281 
282     return load_kW;
283 }   /* commit() */
```

4.17.3.6 commit() [2/2]

```
virtual double Noncombustion::commit (
             int ,
             double ,
             double ,
             double ,
             double  )  [inline], [virtual]
```

Reimplemented in Hydro.

```
121 {return 0;}
```

4.17.3.7 computeEconomics()

```
void Noncombustion::computeEconomics (
             std::vector< double > * time_vec_hrs_ptr )  [virtual]
```

Helper method to compute key economic metrics for the Model run.

Ref: HOMER [2023b]

Parameters

time_vec_hrs_ptr	A pointer to the time_vec_hrs attribute of the ElectricalLoad.

Reimplemented from Production.

```
226 {
227     //  1. invoke base class method
228     Production :: computeEconomics(time_vec_hrs_ptr);
229 
230     return;
231 }   /* computeEconomics() */
```

4.17.3.8 handleReplacement()

```
void Noncombustion::handleReplacement (
             int timestep )  [virtual]
```

Method to handle asset replacement and capital cost incursion, if applicable.

Parameters

timestep	The current time step of the Model run.

Reimplemented from Production.

Reimplemented in Hydro.

```
199 {
200     //  1. reset attributes
201     //...
202 
203     //  2. invoke base class method
204     Production :: handleReplacement(timestep);
205 
206     return;
207 }   /* __handleReplacement() */
```

4.17.3.9 requestProductionkW() [1/2]

```
virtual double Noncombustion::requestProductionkW (
             int ,
             double ,
             double  )  [inline], [virtual]
117 {return 0;}
```

4.17.3.10 requestProductionkW() [2/2]

```
virtual double Noncombustion::requestProductionkW (
             int ,
             double ,
             double ,
             double  )  [inline], [virtual]
```

Reimplemented in Hydro.

```
118 {return 0;}
```

4.17.3.11 writeResults()

```
void Noncombustion::writeResults (
            std::string write_path,
            std::vector< double > * time_vec_hrs_ptr,
            int combustion_index,
            int max_lines = -1 )
```

Method which writes Noncombustion results to an output directory.

Parameters

write_path	A path (either relative or absolute) to the directory location where results are to be written. If already exists, will overwrite.
time_vec_hrs_ptr	A pointer to the time_vec_hrs attribute of the ElectricalLoad.
noncombustion_index	An integer which corresponds to the index of the Noncombustion asset in the Model.
max_lines	The maximum number of lines of output to write. If <0, then all available lines are written. If =0, then only summary results are written.

```
319 {
320     //  1. handle sentinel
321     if (max_lines < 0) {
322         max_lines = this->n_points;
323     }
324 
325     //  2. create subdirectories
326     write_path += "Production/";
327     if (not std::filesystem::is_directory(write_path)) {
328         std::filesystem::create_directory(write_path);
329     }
330 
331     write_path += "Noncombustion/";
332     if (not std::filesystem::is_directory(write_path)) {
333         std::filesystem::create_directory(write_path);
334     }
335 
336     write_path += this->type_str;
337     write_path += "_";
338     write_path += std::to_string(int(ceil(this->capacity_kW)));
339     write_path += "kW_idx";
340     write_path += std::to_string(combustion_index);
341     write_path += "/";
342     std::filesystem::create_directory(write_path);
343 
344     //  3. write summary
345     this->__writeSummary(write_path);
346 
347     //  4. write time series
348     if (max_lines > this->n_points) {
349         max_lines = this->n_points;
350     }
351 
352     if (max_lines > 0) {
353         this->__writeTimeSeries(write_path, time_vec_hrs_ptr, max_lines);
354     }
355 
356     return;
357 }   /* writeResults() */
```

4.17.4 Member Data Documentation

4.17.4.1 resource_key

```
int Noncombustion::resource_key
```

A key used to index into the Resources object, to associate this asset with the appropriate resource time series.

4.17.4.2 type

```
NoncombustionType Noncombustion::type
```

The type (NoncombustionType) of the asset.

The documentation for this class was generated from the following files:

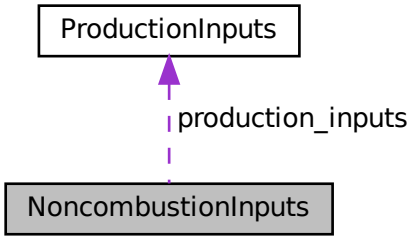
- header/Production/Noncombustion/Noncombustion.h
- source/Production/Noncombustion/Noncombustion.cpp

4.18 NoncombustionInputs Struct Reference

A structure which bundles the necessary inputs for the Noncombustion constructor. Provides default values for every necessary input. Note that this structure encapsulates ProductionInputs.

```
#include <Noncombustion.h>
```

Collaboration diagram for NoncombustionInputs:



Public Attributes

- ProductionInputs production_inputs

  An encapsulated ProductionInputs instance.

4.18.1 Detailed Description

A structure which bundles the necessary inputs for the Noncombustion constructor. Provides default values for every necessary input. Note that this structure encapsulates ProductionInputs.

4.18.2 Member Data Documentation

4.18.2.1 production_inputs

```
ProductionInputs NoncombustionInputs::production_inputs
```

An encapsulated ProductionInputs instance.

The documentation for this struct was generated from the following file:

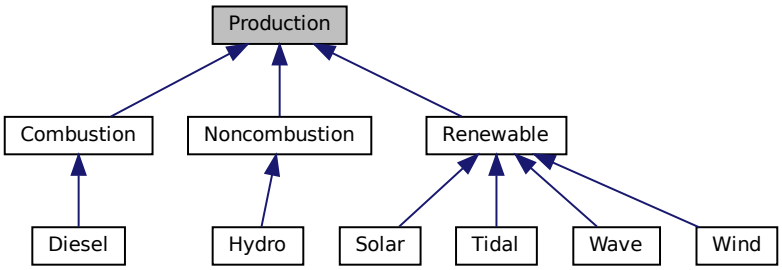
- header/Production/Noncombustion/Noncombustion.h

4.19 Production Class Reference

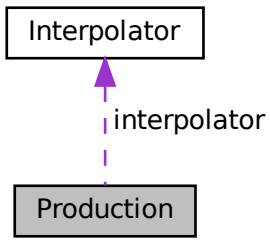
The base class of the Production hierarchy. This hierarchy contains derived classes which model the production of energy, be it renewable or otherwise.

```
#include <Production.h>
```

Inheritance diagram for Production:



Collaboration diagram for Production:



Public Member Functions

- Production (void)

  Constructor (dummy) for the Production class.
- Production (int, double, ProductionInputs, std::vector< double > *)

  Constructor (intended) for the Production class.
- virtual void handleReplacement (int)

  Method to handle asset replacement and capital cost incursion, if applicable.
- double computeRealDiscountAnnual (double, double)

  Method to compute the real, annual discount rate to be used in computing model economics. This enables application of the discount factor approach.
- virtual void computeEconomics (std::vector< double > *)

  Helper method to compute key economic metrics for the Model run.
- double getProductionkW (int)

  A method to simply fetch the normalized production at a particular point in the given normalized production time series, multiply by the rated capacity of the asset, and return.
- virtual double commit (int, double, double, double)

  Method which takes in production and load for the current timestep, computes and records dispatch and curtailment, and then returns remaining load.
- virtual ~Production (void)

  Destructor for the Production class.

Public Attributes

- Interpolator interpolator

  Interpolator component of Production.
- bool print_flag

  A flag which indicates whether or not object construct/destruction should be verbose.
- bool is_running

  A boolean which indicates whether or not the asset is running.
- bool is_sunk

  A boolean which indicates whether or not the asset should be considered a sunk cost (i.e., capital cost incurred at the start of the model, or no).
- bool normalized_production_series_given

  A boolen which indicates whether or not a normalized production time series is given.
- int n_points

  The number of points in the modelling time series.
- int n_starts

  The number of times the asset has been started.
- int n_replacements

  The number of times the asset has been replaced.
- double n_years

  The number of years being modelled.
- double running_hours

  The number of hours for which the assset has been operating.
- double replace_running_hrs

  The number of running hours after which the asset must be replaced.
- double capacity_kW

  The rated production capacity [kW] of the asset.
- double nominal_inflation_annual

  The nominal, annual inflation rate to use in computing model economics.

- double nominal_discount_annual

  The nominal, annual discount rate to use in computing model economics.
- double real_discount_annual

  The real, annual discount rate used in computing model economics. Is computed from the given nominal inflation and discount rates.
- double capital_cost

  The capital cost of the asset (undefined currency).
- double operation_maintenance_cost_kWh

  The operation and maintenance cost of the asset [1/kWh] (undefined currency). This is a cost incurred per unit of energy produced.
- double net_present_cost

  The net present cost of this asset.
- double total_dispatch_kWh

  The total energy dispatched [kWh] over the Model run.
- double levellized_cost_of_energy_kWh

  The levellized cost of energy [1/kWh] (undefined currency) of this asset. This metric considers only dispatch.
- std::string type_str

  A string describing the type of the asset.
- std::string path_2_normalized_production_time_series

  A string defining the path (either relative or absolute) to the given normalized production time series.
- std::vector< bool > is_running_vec

  A boolean vector for tracking if the asset is running at a particular point in time.
- std::vector< double > normalized_production_vec

  A vector of normalizd production [ ] at each point in the modelling time series.
- std::vector< double > production_vec_kW

  A vector of production [kW] at each point in the modelling time series.
- std::vector< double > dispatch_vec_kW

  A vector of dispatch [kW] at each point in the modelling time series. Dispatch is the amount of production that is sent to the grid to satisfy load.
- std::vector< double > storage_vec_kW

  A vector of storage [kW] at each point in the modelling time series. Storage is the amount of production that is sent to storage.
- std::vector< double > curtailment_vec_kW

  A vector of curtailment [kW] at each point in the modelling time series. Curtailment is the amount of production that can be neither dispatched nor stored, and is hence curtailed.
- std::vector< double > capital_cost_vec

  A vector of capital costs (undefined currency) incurred over each modelling time step. These costs are not discounted (i.e., these are actual costs).
- std::vector< double > operation_maintenance_cost_vec

  A vector of operation and maintenance costs (undefined currency) incurred over each modelling time step. These costs are not discounted (i.e., these are actual costs).

Private Member Functions

- void __checkInputs (int, double, ProductionInputs)

  Helper method to check inputs to the Production constructor.
- void __checkTimePoint (double, double)

  Helper method to check received time point against expected time point. The given time series should align point-wise with the previously given electrical load time series.
- void __throwLengthError (void)

  Helper method to throw data length error (if not the same as the given electrical load time series).
- void __checkNormalizedProduction (double)

Helper method to check that given data values are everywhere contained in the closed interval [0, 1]. A normalized production time series is expected, so this must be true everywhere.

- void __readNormalizedProductionData (std::vector< double > *)

  Helper method to read in a given time series of normalized production.

4.19.1 Detailed Description

The base class of the Production hierarchy. This hierarchy contains derived classes which model the production of energy, be it renewable or otherwise.

4.19.2 Constructor & Destructor Documentation

4.19.2.1 Production() [1/2]

```
Production::Production (
            void  )
```

Constructor (dummy) for the Production class.

```
307 {
308     return;
309 }   /* Production() */
```

4.19.2.2 Production() [2/2]

```
Production::Production (
            int n_points,
            double n_years,
            ProductionInputs production_inputs,
            std::vector< double > * time_vec_hrs_ptr )
```

Constructor (intended) for the Production class.

Parameters

n_points	The number of points in the modelling time series.
n_years	The number of years being modelled.
production_inputs	A structure of Production constructor inputs.
time_vec_hrs_ptr	A pointer to the vector containing the modelling time series.

```
342 {
343     //  1. check inputs
344     this->__checkInputs(n_points, n_years, production_inputs);
345 
346     //  2. set attributes
347     this->print_flag = production_inputs.print_flag;
348     this->is_running = false;
349     this->is_sunk = production_inputs.is_sunk;
350     this->normalized_production_series_given = false;
351 
```

```
352     this->n_points = n_points;
353     this->n_starts = 0;
354     this->n_replacements = 0;
355 
356     this->n_years = n_years;
357 
358     this->running_hours = 0;
359     this->replace_running_hrs = production_inputs.replace_running_hrs;
360 
361     this->capacity_kW = production_inputs.capacity_kW;
362 
363     this->nominal_inflation_annual = production_inputs.nominal_inflation_annual;
364     this->nominal_discount_annual = production_inputs.nominal_discount_annual;
365 
366     this->real_discount_annual = this->computeRealDiscountAnnual(
367         production_inputs.nominal_inflation_annual,
368         production_inputs.nominal_discount_annual
369     );
370 
371     this->capital_cost = 0;
372     this->operation_maintenance_cost_kWh = 0;
373     this->net_present_cost = 0;
374     this->total_dispatch_kWh = 0;
375     this->levellized_cost_of_energy_kWh = 0;
376 
377     this->path_2_normalized_production_time_series = "";
378 
379     this->is_running_vec.resize(this->n_points, 0);
380 
381     this->normalized_production_vec.resize(this->n_points, 0);
382     this->production_vec_kW.resize(this->n_points, 0);
383     this->dispatch_vec_kW.resize(this->n_points, 0);
384     this->storage_vec_kW.resize(this->n_points, 0);
385     this->curtailment_vec_kW.resize(this->n_points, 0);
386 
387     this->capital_cost_vec.resize(this->n_points, 0);
388     this->operation_maintenance_cost_vec.resize(this->n_points, 0);
389 
390     //  3. read in normalized production time series (if given)
391     if (not production_inputs.path_2_normalized_production_time_series.empty()) {
392         this->normalized_production_series_given = true;
393 
394         this->path_2_normalized_production_time_series =
395             production_inputs.path_2_normalized_production_time_series;
396 
397         this->__readNormalizedProductionData(time_vec_hrs_ptr);
398     }
399 
400     //  4. construction print
401     if (this->print_flag) {
402         std::cout « "Production object constructed at " « this « std::endl;
403     }
404 
405     return;
406 }   /* Production() */
```

4.19.2.3 ∼Production()

```
Production::∼Production (
            void  )  [virtual]
```

Destructor for the Production class.

```
655 {
656     //  1. destruction print
657     if (this->print_flag) {
658         std::cout « "Production object at " « this « " destroyed" « std::endl;
659     }
660 
661     return;
662 }   /* ~Production() */
```

4.19.3 Member Function Documentation

4.19.3.1 __checkInputs()

```
void Production::__checkInputs (
            int n_points,
            double n_years,
            ProductionInputs production_inputs )  [private]
```

Helper method to check inputs to the Production constructor.

Parameters

n_points	The number of points in the modelling time series.
production_inputs	A structure of Production constructor inputs.

```
70 {
71     //  1. check n_points
72     if (n_points <= 0) {
73         std::string error_str = "ERROR:  Production():  n_points must be > 0";
74 
75         #ifdef _WIN32
76             std::cout << error_str << std::endl;
77         #endif
78 
79         throw std::invalid_argument(error_str);
80     }
81 
82     //  2. check n_years
83     if (n_years <= 0) {
84         std::string error_str = "ERROR:  Production():  n_years must be > 0";
85 
86         #ifdef _WIN32
87             std::cout << error_str << std::endl;
88         #endif
89 
90         throw std::invalid_argument(error_str);
91     }
92 
93     //  3. check capacity_kW
94     if (production_inputs.capacity_kW <= 0) {
95         std::string error_str = "ERROR:  Production():  ";
96         error_str += "ProductionInputs::capacity_kW must be > 0";
97 
98         #ifdef _WIN32
99             std::cout << error_str << std::endl;
100         #endif
101 
102         throw std::invalid_argument(error_str);
103     }
104 
105     //  4. check replace_running_hrs
106     if (production_inputs.replace_running_hrs <= 0) {
107         std::string error_str = "ERROR:  Production():  ";
108         error_str += "ProductionInputs::replace_running_hrs must be > 0";
109 
110         #ifdef _WIN32
111             std::cout << error_str << std::endl;
112         #endif
113 
114         throw std::invalid_argument(error_str);
115     }
116 
117     return;
118 }   /* __checkInputs() */
```

4.19.3.2 __checkNormalizedProduction()

```
void Production::__checkNormalizedProduction (
            double normalized_production )  [private]
```

Helper method to check that given data values are everywhere contained in the closed interval [0, 1]. A normalized production time series is expected, so this must be true everywhere.

Parameters

normalized_production	The normalized production value to check

```
210 {
211     if (normalized_production < 0 or normalized_production > 1) {
212         std::string error_str = "ERROR:  Production():  ";
213         error_str += "the given normalized production time series at ";
214         error_str += this->path_2_normalized_production_time_series;
215         error_str += " contains normalized production values outside the closed ";
216         error_str += "interval [0, 1]";
217 
218         #ifdef _WIN32
219             std::cout « error_str « std::endl;
220         #endif
221 
222         throw std::runtime_error(error_str);
223     }
224 
225     return;
226 }   /* __throwValueError() */
```

4.19.3.3 __checkTimePoint()

```
void Production::__checkTimePoint (
            double time_received_hrs,
            double time_expected_hrs )  [private]
```

Helper method to check received time point against expected time point. The given time series should align point-wise with the previously given electrical load time series.

Parameters

time_received_hrs	The point in time received from the given data.
time_expected_hrs	The point in time expected (this comes from the electrical load time series).

```
146 {
147     if (time_received_hrs != time_expected_hrs) {
148         std::string error_str = "ERROR:  Production():  ";
149         error_str += "the given normalized production time series at ";
150         error_str += this->path_2_normalized_production_time_series;
151         error_str += " does not align with the ";
152         error_str += "previously given electrical load time series";
153 
154         #ifdef _WIN32
155             std::cout « error_str « std::endl;
156         #endif
157 
158         throw std::runtime_error(error_str);
159     }
160 
161     return;
162 }   /* __checkTimePoint() */
```

4.19.3.4 __readNormalizedProductionData()

```
void Production::__readNormalizedProductionData (
            std::vector< double > * time_vec_hrs_ptr )  [private]
```

Helper method to read in a given time series of normalized production.

Parameters

time_vec_hrs_ptr	A pointer to the vector containing the modelling time series.

```
247 {
248     //  1. init CSV reader
249     io::CSVReader<2> CSV(this->path_2_normalized_production_time_series);
250 
251     CSV.read_header(
252         io::ignore_extra_column,
253         "Time (since start of data) [hrs]",
254         "Normalized Production [ ]"
255     );
256 
257     //  2. read in normalized performance data,
258     //     check values and check against time series (point-wise and length)
259     int n_points = 0;
260     double time_hrs = 0;
261     double time_expected_hrs = 0;
262     double normalized_production = 0;
263 
264     while (CSV.read_row(time_hrs, normalized_production)) {
265         //  2.1. check length of data
266         if (n_points > this->n_points) {
267             this->__throwLengthError();
268         }
269 
270         //  2.2. check normalized production value
271         this->__checkNormalizedProduction(normalized_production);
272 
273         //  2.3. check time point
274         time_expected_hrs = time_vec_hrs_ptr->at(n_points);
275         this->__checkTimePoint(time_hrs, time_expected_hrs);
276 
277         //  2.4. write to normalized production vector, increment n_points
278         this->normalized_production_vec[n_points] = normalized_production;
279         n_points++;
280     }
281 
282     //  3. check length of data
283     if (n_points != this->n_points) {
284         this->__throwLengthError();
285     }
286 
287     return;
288 }   /* __readNormalizedProductionData() */
```

4.19.3.5 __throwLengthError()

```
void Production::__throwLengthError (
            void  )  [private]
```

Helper method to throw data length error (if not the same as the given electrical load time series).

```
177 {
178     std::string error_str = "ERROR:  Production():  ";
179     error_str += "the given normalized production time series at ";
180     error_str += this->path_2_normalized_production_time_series;
181     error_str += " is not the same length as the previously given electrical";
182     error_str += " load time series";
183 
184     #ifdef _WIN32
185         std::cout << error_str << std::endl;
186     #endif
187 
188     throw std::runtime_error(error_str);
189 
190     return;
191 }   /* __throwLengthError() */
```

4.19.3.6 commit()

```
double Production::commit (
            int timestep,
            double dt_hrs,
            double production_kW,
            double load_kW )  [virtual]
```

Method which takes in production and load for the current timestep, computes and records dispatch and curtailment, and then returns remaining load.

Parameters

timestep	The timestep (i.e., time series index) for the request.
dt_hrs	The interval of time [hrs] associated with the timestep.
production_kW	The production [kW] of the asset in this timestep.
load_kW	The load [kW] passed to the asset in this timestep.

Returns

The load [kW] remaining after the dispatch is deducted from it.

Reimplemented in Wind, Wave, Tidal, Solar, Renewable, Noncombustion, Diesel, and Combustion.

```
596 {
597     //  1. record production
598     this->production_vec_kW[timestep] = production_kW;
599 
600     //  2. compute and record dispatch and curtailment
601     double dispatch_kW = 0;
602     double curtailment_kW = 0;
603 
604     if (production_kW > load_kW) {
605         dispatch_kW = load_kW;
606         curtailment_kW = production_kW - dispatch_kW;
607     }
608 
609     else {
610         dispatch_kW = production_kW;
611     }
612 
613     this->dispatch_vec_kW[timestep] = dispatch_kW;
614     this->total_dispatch_kWh += dispatch_kW * dt_hrs;
615     this->curtailment_vec_kW[timestep] = curtailment_kW;
616 
617     //  3. update load
618     load_kW -= dispatch_kW;
619 
620     //  4. update and log running attributes
621     if (this->is_running) {
622         //  4.1. log running state, running hours
623         this->is_running_vec[timestep] = this->is_running;
624         this->running_hours += dt_hrs;
625 
626         //  4.2. incur operation and maintenance costs
627         double produced_kWh = production_kW * dt_hrs;
628 
629         double operation_maintenance_cost =
630             this->operation_maintenance_cost_kWh * produced_kWh;
631         this->operation_maintenance_cost_vec[timestep] = operation_maintenance_cost;
632     }
633 
634     //  5. trigger replacement, if applicable
635     if (this->running_hours >= (this->n_replacements + 1) * this->replace_running_hrs) {
636         this->handleReplacement(timestep);
637     }
638 
639     return load_kW;
640 }   /* commit() */
```

4.19.3.7 computeEconomics()

```
void Production::computeEconomics (
            std::vector< double > * time_vec_hrs_ptr )  [virtual]
```

Helper method to compute key economic metrics for the Model run.

Ref: HOMER [2023b]
Ref: HOMER [2023g]
Ref: HOMER [2023i]
Ref: HOMER [2023a]

Parameters

time_vec_hrs_ptr	A pointer to the time_vec_hrs attribute of the ElectricalLoad.

1. compute levellized cost of energy (per unit dispatched)

Reimplemented in Renewable, Noncombustion, and Combustion.

```
494 {
495     //  1. compute net present cost
496     double t_hrs = 0;
497     double real_discount_scalar = 0;
498 
499     for (int i = 0; i < this->n_points; i++) {
500         t_hrs = time_vec_hrs_ptr->at(i);
501 
502         real_discount_scalar = 1.0 / pow(
503             1 + this->real_discount_annual,
504             t_hrs / 8760
505         );
506 
507         this->net_present_cost += real_discount_scalar * this->capital_cost_vec[i];
508 
509         this->net_present_cost +=
510             real_discount_scalar * this->operation_maintenance_cost_vec[i];
511     }
512 
514     //     assuming 8,760 hours per year
515     if (this->total_dispatch_kWh <= 0) {
516         this->levellized_cost_of_energy_kWh = this->net_present_cost;
517     }
518 
519     else {
520         double n_years = time_vec_hrs_ptr->at(this->n_points - 1) / 8760;
521 
522         double capital_recovery_factor =
523             (this->real_discount_annual * pow(1 + this->real_discount_annual, n_years)) /
524             (pow(1 + this->real_discount_annual, n_years) - 1);
525 
526         double total_annualized_cost = capital_recovery_factor *
527             this->net_present_cost;
528 
529         this->levellized_cost_of_energy_kWh =
530             (n_years * total_annualized_cost) /
531             this->total_dispatch_kWh;
532     }
533 
534     return;
535 }   /* computeEconomics() */
```

4.19.3.8 computeRealDiscountAnnual()

```
double Production::computeRealDiscountAnnual (
            double nominal_inflation_annual,
            double nominal_discount_annual )
```

Method to compute the real, annual discount rate to be used in computing model economics. This enables application of the discount factor approach.

Ref: HOMER [2023h]
Ref: HOMER [2023b]

Parameters

nominal_inflation_annual	The nominal, annual inflation rate to use in computing model economics.
nominal_discount_annual	The nominal, annual discount rate to use in computing model economics.

Returns

The real, annual discount rate to use in computing model economics.

```
467 {
468     double real_discount_annual = nominal_discount_annual - nominal_inflation_annual;
469     real_discount_annual /= 1 + nominal_inflation_annual;
470 
471     return real_discount_annual;
472 }   /* __computeRealDiscountAnnual() */
```

4.19.3.9 getProductionkW()

```
double Production::getProductionkW (
            int timestep )
```

A method to simply fetch the normalized production at a particular point in the given normalized production time series, multiply by the rated capacity of the asset, and return.

Returns

The production [kW] for the asset at the given point in time, as defined by the given normalized production time series.

```
555 {
556     double production_kW =
557         this->normalized_production_vec[timestep] * this->capacity_kW;
558 
559     return production_kW;
560 }   /* getProductionkW() */
```

4.19.3.10 handleReplacement()

```
void Production::handleReplacement (
            int timestep )  [virtual]
```

Method to handle asset replacement and capital cost incursion, if applicable.

Parameters

timestep	The current time step of the Model run.

Reimplemented in Wind, Wave, Tidal, Solar, Renewable, Noncombustion, Hydro, Diesel, and Combustion.

```
424 {
425     //  1. reset attributes
426     this->is_running = false;
427 
428     //  2. log replacement
429     this->n_replacements++;
430 
431     //  3. incur capital cost in timestep
432     this->capital_cost_vec[timestep] = this->capital_cost;
433 
434     return;
435 }   /* __handleReplacement() */
```

4.19.4 Member Data Documentation

4.19.4.1 capacity_kW

```
double Production::capacity_kW
```

The rated production capacity [kW] of the asset.

4.19.4.2 capital_cost

```
double Production::capital_cost
```

The capital cost of the asset (undefined currency).

4.19.4.3 capital_cost_vec

```
std::vector<double> Production::capital_cost_vec
```

A vector of capital costs (undefined currency) incurred over each modelling time step. These costs are not discounted (i.e., these are actual costs).

4.19.4.4 curtailment_vec_kW

```
std::vector<double> Production::curtailment_vec_kW
```

A vector of curtailment [kW] at each point in the modelling time series. Curtailment is the amount of production that can be neither dispatched nor stored, and is hence curtailed.

4.19.4.5 dispatch_vec_kW

```
std::vector<double> Production::dispatch_vec_kW
```

A vector of dispatch [kW] at each point in the modelling time series. Dispatch is the amount of production that is sent to the grid to satisfy load.

4.19.4.6 interpolator

```
Interpolator Production::interpolator
```

Interpolator component of Production.

4.19.4.7 is_running

```
bool Production::is_running
```

A boolean which indicates whether or not the asset is running.

4.19.4.8 is_running_vec

```
std::vector<bool> Production::is_running_vec
```

A boolean vector for tracking if the asset is running at a particular point in time.

4.19.4.9 is_sunk

```
bool Production::is_sunk
```

A boolean which indicates whether or not the asset should be considered a sunk cost (i.e., capital cost incurred at the start of the model, or no).

4.19.4.10 levellized_cost_of_energy_kWh

```
double Production::levellized_cost_of_energy_kWh
```

The levellized cost of energy [1/kWh] (undefined currency) of this asset. This metric considers only dispatch.

4.19.4.11 n_points

```
int Production::n_points
```

The number of points in the modelling time series.

4.19.4.12 n_replacements

```
int Production::n_replacements
```

The number of times the asset has been replaced.

4.19.4.13 n_starts

```
int Production::n_starts
```

The number of times the asset has been started.

4.19.4.14 n_years

```
double Production::n_years
```

The number of years being modelled.

4.19.4.15 net_present_cost

```
double Production::net_present_cost
```

The net present cost of this asset.

4.19.4.16 nominal_discount_annual

```
double Production::nominal_discount_annual
```

The nominal, annual discount rate to use in computing model economics.

4.19.4.17 nominal_inflation_annual

```
double Production::nominal_inflation_annual
```

The nominal, annual inflation rate to use in computing model economics.

4.19.4.18 normalized_production_series_given

```
bool Production::normalized_production_series_given
```

A boolen which indicates whether or not a normalized production time series is given.

4.19.4.19 normalized_production_vec

```
std::vector<double> Production::normalized_production_vec
```

A vector of normalizd production [ ] at each point in the modelling time series.

4.19.4.20 operation_maintenance_cost_kWh

```
double Production::operation_maintenance_cost_kWh
```

The operation and maintenance cost of the asset [1/kWh] (undefined currency). This is a cost incurred per unit of energy produced.

4.19.4.21 operation_maintenance_cost_vec

```
std::vector<double> Production::operation_maintenance_cost_vec
```

A vector of operation and maintenance costs (undefined currency) incurred over each modelling time step. These costs are not discounted (i.e., these are actual costs).

4.19.4.22 path_2_normalized_production_time_series

```
std::string Production::path_2_normalized_production_time_series
```

A string defining the path (either relative or absolute) to the given normalized production time series.

4.19.4.23 print_flag

```
bool Production::print_flag
```

A flag which indicates whether or not object construct/destruction should be verbose.

4.19.4.24 production_vec_kW

```
std::vector<double> Production::production_vec_kW
```

A vector of production [kW] at each point in the modelling time series.

4.19.4.25 real_discount_annual

```
double Production::real_discount_annual
```

The real, annual discount rate used in computing model economics. Is computed from the given nominal inflation and discount rates.

4.19.4.26 replace_running_hrs

```
double Production::replace_running_hrs
```

The number of running hours after which the asset must be replaced.

4.19.4.27 running_hours

```
double Production::running_hours
```

The number of hours for which the assset has been operating.

4.19.4.28 storage_vec_kW

```
std::vector<double> Production::storage_vec_kW
```

A vector of storage [kW] at each point in the modelling time series. Storage is the amount of production that is sent to storage.

4.19.4.29 total_dispatch_kWh

```
double Production::total_dispatch_kWh
```

The total energy dispatched [kWh] over the Model run.

4.19.4.30 type_str

```
std::string Production::type_str
```

A string describing the type of the asset.

The documentation for this class was generated from the following files:

- header/Production/Production.h
- source/Production/Production.cpp

4.20 ProductionInputs Struct Reference

A structure which bundles the necessary inputs for the Production constructor. Provides default values for every necessary input.

```
#include <Production.h>
```

Public Attributes

- bool print_flag = false

  A flag which indicates whether or not object construct/destruction should be verbose.
- bool is_sunk = false

  A boolean which indicates whether or not the asset should be considered a sunk cost (i.e., capital cost incurred at the start of the model, or no).
- double capacity_kW = 100

  The rated production capacity [kW] of the asset.
- double nominal_inflation_annual = 0.02

  The nominal, annual inflation rate to use in computing model economics.
- double nominal_discount_annual = 0.04

  The nominal, annual discount rate to use in computing model economics.
- double replace_running_hrs = 90000

  The number of running hours after which the asset must be replaced.
- std::string path_2_normalized_production_time_series = ""

  A string defining the path (either relative or absolute) to the given normalized production time series.

4.20.1 Detailed Description

A structure which bundles the necessary inputs for the Production constructor. Provides default values for every necessary input.

4.20.2 Member Data Documentation

4.20.2.1 capacity_kW

```
double ProductionInputs::capacity_kW = 100
```

The rated production capacity [kW] of the asset.

4.20.2.2 is_sunk

```
bool ProductionInputs::is_sunk = false
```

A boolean which indicates whether or not the asset should be considered a sunk cost (i.e., capital cost incurred at the start of the model, or no).

4.20.2.3 nominal_discount_annual

```
double ProductionInputs::nominal_discount_annual = 0.04
```

The nominal, annual discount rate to use in computing model economics.

4.20.2.4 nominal_inflation_annual

```
double ProductionInputs::nominal_inflation_annual = 0.02
```

The nominal, annual inflation rate to use in computing model economics.

4.20.2.5 path_2_normalized_production_time_series

```
std::string ProductionInputs::path_2_normalized_production_time_series = ""
```

A string defining the path (either relative or absolute) to the given normalized production time series.

4.20.2.6 print_flag

```
bool ProductionInputs::print_flag = false
```

A flag which indicates whether or not object construct/destruction should be verbose.

4.20.2.7 replace_running_hrs

```
double ProductionInputs::replace_running_hrs = 90000
```

The number of running hours after which the asset must be replaced.

The documentation for this struct was generated from the following file:

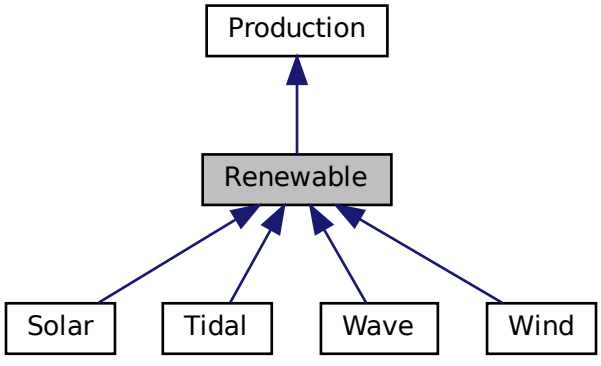
- header/Production/Production.h

4.21 Renewable Class Reference

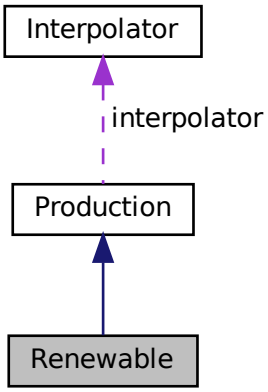
The root of the Renewable branch of the Production hierarchy. This branch contains derived classes which model the renewable production of energy.

```
#include <Renewable.h>
```

Inheritance diagram for Renewable:



Collaboration diagram for Renewable:



Public Member Functions

- Renewable (void)

  Constructor (dummy) for the Renewable class.
- Renewable (int, double, RenewableInputs, std::vector< double > *)

  Constructor (intended) for the Renewable class.
- virtual void handleReplacement (int)

  Method to handle asset replacement and capital cost incursion, if applicable.
- void computeEconomics (std::vector< double > *)

  Helper method to compute key economic metrics for the Model run.
- virtual double computeProductionkW (int, double, double)
- virtual double computeProductionkW (int, double, double, double)
- virtual double commit (int, double, double, double)

  Method which takes in production and load for the current timestep, computes and records dispatch and curtailment, and then returns remaining load.
- void writeResults (std::string, std::vector< double > *, std::map< int, std::vector< double >> *, std::map< int, std::vector< std::vector< double >>> *, int, int=-1)

  Method which writes Renewable results to an output directory.
- virtual ~Renewable (void)

  Destructor for the Renewable class.

Public Attributes

- RenewableType type

  The type (RenewableType) of the asset.
- int resource_key

  A key used to index into the Resources object, to associate this asset with the appropriate resource time series.

Private Member Functions

- void __checkInputs (RenewableInputs)

  Helper method to check inputs to the Renewable constructor.
- void __handleStartStop (int, double, double)

  Helper method to handle the starting/stopping of the renewable asset.
- virtual void __writeSummary (std::string)
- virtual void __writeTimeSeries (std::string, std::vector< double > *, std::map< int, std::vector< double >> *, std::map< int, std::vector< std::vector< double >>> *, int=-1)

4.21.1 Detailed Description

The root of the Renewable branch of the Production hierarchy. This branch contains derived classes which model the renewable production of energy.

4.21.2 Constructor & Destructor Documentation

4.21.2.1 Renewable() [1/2]

```
Renewable::Renewable (
            void  )
```

Constructor (dummy) for the Renewable class.

```
125 {
126     //...
127
128     return;
129 }   /* Renewable() */
```

4.21.2.2 Renewable() [2/2]

```
Renewable::Renewable (
            int n_points,
            double n_years,
            RenewableInputs renewable_inputs,
            std::vector< double > * time_vec_hrs_ptr )
```

Constructor (intended) for the Renewable class.

Parameters

n_points	The number of points in the modelling time series.
n_years	The number of years being modelled.
renewable_inputs	A structure of Renewable constructor inputs.
time_vec_hrs_ptr	A pointer to the vector containing the modelling time series.

```
161   :
162 Production(
163     n_points,
164     n_years,
165     renewable_inputs.production_inputs,
166     time_vec_hrs_ptr
167 )
168 {
169     //  1. check inputs
170     this->__checkInputs(renewable_inputs);
171 
172     //  2. set attributes
173     //...
174 
175     //  3. construction print
176     if (this->print_flag) {
177         std::cout « "Renewable object constructed at " « this « std::endl;
178     }
179 
180     return;
181 }   /* Renewable() */
```

4.21.2.3 ~Renewable()

```
Renewable::~Renewable (
            void  )  [virtual]
```

Destructor for the Renewable class.

```
384 {
385     //  1. destruction print
386     if (this->print_flag) {
387         std::cout « "Renewable object at " « this « " destroyed" « std::endl;
388     }
389 
390     return;
391 }   /* ~Renewable() */
```

4.21.3 Member Function Documentation

4.21.3.1 __checkInputs()

```
void Renewable::__checkInputs (
            RenewableInputs renewable_inputs )  [private]
```

Helper method to check inputs to the Renewable constructor.

```
62 {
63     //...
64 
65     return;
66 }   /* __checkInputs() */
```

4.21.3.2 __handleStartStop()

```
void Renewable::__handleStartStop (
            int timestep,
            double dt_hrs,
            double production_kW )  [private]
```

Helper method to handle the starting/stopping of the renewable asset.

```
89 {
90     if (this->is_running) {
91         // handle stopping
92         if (production_kW <= 0) {
93             this->is_running = false;
94         }
95     }
96
97     else {
98         // handle starting
99         if (production_kW > 0) {
100             this->is_running = true;
101             this->n_starts++;
102         }
103     }
104
105     return;
106 }   /* __handleStartStop() */
```

4.21.3.3 __writeSummary()

```
virtual void Renewable::__writeSummary (
            std::string  )  [inline], [private], [virtual]
```

Reimplemented in Wind, Wave, Tidal, and Solar.

```
97 {return;}
```

4.21.3.4 __writeTimeSeries()

```
virtual void Renewable::__writeTimeSeries (
            std::string ,
            std::vector< double > * ,
            std::map< int, std::vector< double >> * ,
            std::map< int, std::vector< std::vector< double >>> * ,
            int  = -1 )  [inline], [private], [virtual]
```

Reimplemented in Wind, Wave, Tidal, and Solar.

```
104          {return;}
```

4.21.3.5 commit()

```
double Renewable::commit (
            int timestep,
            double dt_hrs,
            double production_kW,
            double load_kW )  [virtual]
```

Method which takes in production and load for the current timestep, computes and records dispatch and curtailment, and then returns remaining load.

Parameters

timestep	The timestep (i.e., time series index) for the request.
dt_hrs	The interval of time [hrs] associated with the timestep.
production_kW	The production [kW] of the asset in this timestep.
load_kW	The load [kW] passed to the asset in this timestep.

Returns

The load [kW] remaining after the dispatch is deducted from it.

Reimplemented from Production.

Reimplemented in Wind, Wave, Tidal, and Solar.

```
265 {
266     //  1. handle start/stop
267     this->__handleStartStop(timestep, dt_hrs, production_kW);
268 
269     //  2. invoke base class method
270     load_kW = Production :: commit(
271         timestep,
272         dt_hrs,
273         production_kW,
274         load_kW
275     );
276 
277 
278     //...
279 
280     return load_kW;
281 }   /* commit() */
```

4.21.3.6 computeEconomics()

```
void Renewable::computeEconomics (
             std::vector< double > * time_vec_hrs_ptr )  [virtual]
```

Helper method to compute key economic metrics for the Model run.

Parameters

time_vec_hrs_ptr	A pointer to the time_vec_hrs attribute of the ElectricalLoad.

Reimplemented from Production.

```
224 {
225     //  1. invoke base class method
226     Production :: computeEconomics(time_vec_hrs_ptr);
227 
228     return;
229 }   /* computeEconomics() */
```

4.21.3.7 computeProductionkW() [1/2]

```
virtual double Renewable::computeProductionkW (
             int ,
```

```
            double ,
            double  )  [inline], [virtual]
```

Reimplemented in Wind, Tidal, and Solar.

```
121 {return 0;}
```

4.21.3.8 computeProductionkW() [2/2]

```
virtual double Renewable::computeProductionkW (
            int ,
            double ,
            double ,
            double  )  [inline], [virtual]
```

Reimplemented in Wave.

```
122 {return 0;}
```

4.21.3.9 handleReplacement()

```
void Renewable::handleReplacement (
            int timestep )  [virtual]
```

Method to handle asset replacement and capital cost incursion, if applicable.

Parameters

timestep	The current time step of the Model run.

Reimplemented from Production.

Reimplemented in Wind, Wave, Tidal, and Solar.

```
199 {
200     //  1. reset attributes
201     //...
202
203     //  2. invoke base class method
204     Production :: handleReplacement(timestep);
205
206     return;
207 }   /* __handleReplacement() */
```

4.21.3.10 writeResults()

```
void Renewable::writeResults (
            std::string write_path,
            std::vector< double > * time_vec_hrs_ptr,
            std::map< int, std::vector< double >> * resource_map_1D_ptr,
            std::map< int, std::vector< std::vector< double >>> * resource_map_2D_ptr,
            int renewable_index,
            int max_lines = -1 )
```

Method which writes Renewable results to an output directory.

Parameters

write_path	A path (either relative or absolute) to the directory location where results are to be written. If already exists, will overwrite.
time_vec_hrs_ptr	A pointer to the time_vec_hrs attribute of the ElectricalLoad.
resource_map_1D_ptr	A pointer to the 1D map of Resources.
resource_map_2D_ptr	A pointer to the 2D map of Resources.
renewable_index	An integer which corresponds to the index of the Renewable asset in the Model.
max_lines	The maximum number of lines of output to write. If <0, then all available lines are written. If =0, then only summary results are written.

```
325 {
326     //  1. handle sentinel
327     if (max_lines < 0) {
328         max_lines = this->n_points;
329     }
330 
331     //  2. create subdirectories
332     write_path += "Production/";
333     if (not std::filesystem::is_directory(write_path)) {
334         std::filesystem::create_directory(write_path);
335     }
336 
337     write_path += "Renewable/";
338     if (not std::filesystem::is_directory(write_path)) {
339         std::filesystem::create_directory(write_path);
340     }
341 
342     write_path += this->type_str;
343     write_path += "_";
344     write_path += std::to_string(int(ceil(this->capacity_kW)));
345     write_path += "kW_idx";
346     write_path += std::to_string(renewable_index);
347     write_path += "/";
348     std::filesystem::create_directory(write_path);
349 
350     //  3. write summary
351     this->__writeSummary(write_path);
352 
353     //  4. write time series
354     if (max_lines > this->n_points) {
355         max_lines = this->n_points;
356     }
357 
358     if (max_lines > 0) {
359         this->__writeTimeSeries(
360             write_path,
361             time_vec_hrs_ptr,
362             resource_map_1D_ptr,
363             resource_map_2D_ptr,
364             max_lines
365         );
366     }
367 
368     return;
369 }   /* writeResults() */
```

4.21.4 Member Data Documentation

4.21.4.1 resource_key

```
int Renewable::resource_key
```

A key used to index into the Resources object, to associate this asset with the appropriate resource time series.

4.21.4.2 type

```
RenewableType Renewable::type
```

The type (RenewableType) of the asset.

The documentation for this class was generated from the following files:

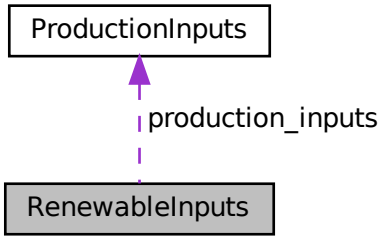
- header/Production/Renewable/Renewable.h
- source/Production/Renewable/Renewable.cpp

4.22 RenewableInputs Struct Reference

A structure which bundles the necessary inputs for the Renewable constructor. Provides default values for every necessary input. Note that this structure encapsulates ProductionInputs.

```
#include <Renewable.h>
```

Collaboration diagram for RenewableInputs:



Public Attributes

- ProductionInputs production_inputs

  An encapsulated ProductionInputs instance.

4.22.1 Detailed Description

A structure which bundles the necessary inputs for the Renewable constructor. Provides default values for every necessary input. Note that this structure encapsulates ProductionInputs.

4.22.2 Member Data Documentation

4.22.2.1 production_inputs

```
ProductionInputs RenewableInputs::production_inputs
```

An encapsulated ProductionInputs instance.

The documentation for this struct was generated from the following file:

- header/Production/Renewable/Renewable.h

4.23 Resources Class Reference

A class which contains renewable resource data. Intended to serve as a component class of Model.

```
#include <Resources.h>
```

Public Member Functions

- Resources (void)

  Constructor for the Resources class.
- void addResource (NoncombustionType, std::string, int, ElectricalLoad *)

  A method to add a renewable resource time series to Resources. Checks if given resource key is already in use. The associated helper methods also check against ElectricalLoad to ensure that all added time series align with the electrical load time series (both in terms of length and which points in time are included).
- void addResource (RenewableType, std::string, int, ElectricalLoad *)

  A method to add a renewable resource time series to Resources. Checks if given resource key is already in use. The associated helper methods also check against ElectricalLoad to ensure that all added time series align with the electrical load time series (both in terms of length and which points in time are included).
- void clear (void)

  Method to clear all attributes of the Resources object.
- ~Resources (void)

  Destructor for the Resources class.

Public Attributes

- std::map< int, std::vector< double > > resource_map_1D

  A map <int, vector<double>> of given 1D renewable resource time series.
- std::map< int, std::string > string_map_1D

  A map <int, string> of descriptors for the type of the given 1D renewable resource time series.
- std::map< int, std::string > path_map_1D

  A map <int, string> of the paths (either relative or absolute) to given 1D renewable resource time series.
- std::map< int, std::vector< std::vector< double > > > resource_map_2D

  A map <int, vector<vector<double>>> of given 2D renewable resource time series.
- std::map< int, std::string > string_map_2D

  A map <int, string> of descriptors for the type of the given 2D renewable resource time series.
- std::map< int, std::string > path_map_2D

  A map <int, string> of the paths (either relative or absolute) to given 2D renewable resource time series.

Private Member Functions

- void __checkResourceKey1D (int, RenewableType)

  Helper method to check if given resource key (1D) is already in use.
- void __checkResourceKey2D (int, RenewableType)

  Helper method to check if given resource key (2D) is already in use.
- void __checkResourceKey1D (int, NoncombustionType)

  Helper method to check if given resource key (1D) is already in use.
- void __checkTimePoint (double, double, std::string, ElectricalLoad *)

  Helper method to check received time point against expected time point. The given time series should align point-wise with the previously given electrical load time series.
- void __throwLengthError (std::string, ElectricalLoad *)

  Helper method to throw data length error (if not the same as the given electrical load time series).
- void __readHydroResource (std::string, int, ElectricalLoad *)

  Helper method to handle reading a hydro resource time series into Resources.
- void __readSolarResource (std::string, int, ElectricalLoad *)

  Helper method to handle reading a solar resource time series into Resources.
- void __readTidalResource (std::string, int, ElectricalLoad *)

  Helper method to handle reading a tidal resource time series into Resources.
- void __readWaveResource (std::string, int, ElectricalLoad *)

  Helper method to handle reading a wave resource time series into Resources.
- void __readWindResource (std::string, int, ElectricalLoad *)

  Helper method to handle reading a wind resource time series into Resources.

4.23.1 Detailed Description

A class which contains renewable resource data. Intended to serve as a component class of Model.

4.23.2 Constructor & Destructor Documentation

4.23.2.1 Resources()

```
Resources::Resources (
            void  )
```

Constructor for the Resources class.

```
755 {
756     return;
757 }   /* Resources() */
```

4.23.2.2 ~Resources()

```
Resources::~Resources (
            void  )
```

Destructor for the Resources class.

```
967 {
968     this->clear();
969     return;
970 }   /* ~Resources() */
```

4.23.3 Member Function Documentation

4.23.3.1 __checkResourceKey1D() [1/2]

```
void Resources::__checkResourceKey1D (
            int resource_key,
            NoncombustionType noncombustion_type )  [private]
```

Helper method to check if given resource key (1D) is already in use.

Parameters

resource_key	The key associated with the given renewable resource.
noncombustion_type	The type of renewable resource being added to Resources.

```
139 {
140     if (this->resource_map_1D.count(resource_key) > 0) {
141         std::string error_str = "ERROR:  Resources::addResource(";
142 
143         switch (noncombustion_type) {
144             case (NoncombustionType :: HYDRO): {
145                 error_str += "HYDRO):  ";
146 
147                 break;
148             }
149 
150             default: {
151                 error_str += "UNDEFINED_TYPE):  ";
152 
153                 break;
154             }
155         }
156 
157         error_str += "resource key (1D) ";
158         error_str += std::to_string(resource_key);
159         error_str += " is already in use";
160 
161         #ifdef _WIN32
162             std::cout « error_str « std::endl;
163         #endif
164 
165         throw std::invalid_argument(error_str);
166     }
167 
168     return;
169 }   /*  __checkResourceKey1D() */
```

4.23.3.2 __checkResourceKey1D() [2/2]

```
void Resources::__checkResourceKey1D (
            int resource_key,
            RenewableType renewable_type )  [private]
```

Helper method to check if given resource key (1D) is already in use.

Parameters

resource_key	The key associated with the given renewable resource.
renewable_type	The type of renewable resource being added to Resources.

```
72 {
73     if (this->resource_map_1D.count(resource_key) > 0) {
74         std::string error_str = "ERROR:  Resources::addResource(";
75 
76         switch (renewable_type) {
77             case (RenewableType :: SOLAR): {
78                 error_str += "SOLAR):  ";
79 
80                 break;
81             }
82 
83             case (RenewableType :: TIDAL): {
84                 error_str += "TIDAL):  ";
85 
86                 break;
87             }
88 
89             case (RenewableType :: WIND): {
90                 error_str += "WIND):  ";
91 
92                 break;
93             }
94 
95             default: {
96                 error_str += "UNDEFINED_TYPE):  ";
97 
98                 break;
99             }
100         }
101 
102         error_str += "resource key (1D) ";
103         error_str += std::to_string(resource_key);
104         error_str += " is already in use";
105 
106         #ifdef _WIN32
107             std::cout « error_str « std::endl;
108         #endif
109 
110         throw std::invalid_argument(error_str);
111     }
112 
113     return;
114 }   /*  __checkResourceKey1D() */
```

4.23.3.3 __checkResourceKey2D()

```
void Resources::__checkResourceKey2D (
            int resource_key,
            RenewableType renewable_type )  [private]
```

Helper method to check if given resource key (2D) is already in use.

Parameters

resource_key	The key associated with the given renewable resource.

```
192 {
193     if (this->resource_map_2D.count(resource_key) > 0) {
194         std::string error_str = "ERROR:  Resources::addResource(";
195 
196         switch (renewable_type) {
197             case (RenewableType :: WAVE): {
198                 error_str += "WAVE):  ";
199 
200                 break;
201             }
202 
203             default: {
204                 error_str += "UNDEFINED_TYPE):  ";
205 
206                 break;
207             }
208         }
209 
```

```
210         error_str += "resource key (2D) ";
211         error_str += std::to_string(resource_key);
212         error_str += " is already in use";
213 
214         #ifdef _WIN32
215             std::cout << error_str << std::endl;
216         #endif
217 
218         throw std::invalid_argument(error_str);
219     }
220 
221     return;
222 }   /*  __checkResourceKey2D() */
```

4.23.3.4 __checkTimePoint()

```
void Resources::__checkTimePoint (
             double time_received_hrs,
             double time_expected_hrs,
             std::string path_2_resource_data,
             ElectricalLoad * electrical_load_ptr )  [private]
```

Helper method to check received time point against expected time point. The given time series should align point-wise with the previously given electrical load time series.

Parameters

time_received_hrs	The point in time received from the given data.
time_expected_hrs	The point in time expected (this comes from the electrical load time series).
path_2_resource_data	The path (either relative or absolute) to the given resource time series.
electrical_load_ptr	A pointer to the Model's ElectricalLoad object.

```
259 {
260     if (time_received_hrs != time_expected_hrs) {
261         std::string error_str = "ERROR:  Resources::addResource():  ";
262         error_str += "the given resource time series at ";
263         error_str += path_2_resource_data;
264         error_str += " does not align with the ";
265         error_str += "previously given electrical load time series at ";
266         error_str += electrical_load_ptr->path_2_electrical_load_time_series;
267 
268         #ifdef _WIN32
269             std::cout << error_str << std::endl;
270         #endif
271 
272         throw std::runtime_error(error_str);
273     }
274 
275     return;
276 }   /* __checkTimePoint() */
```

4.23.3.5 __readHydroResource()

```
void Resources::__readHydroResource (
             std::string path_2_resource_data,
             int resource_key,
             ElectricalLoad * electrical_load_ptr )  [private]
```

Helper method to handle reading a hydro resource time series into Resources.

Parameters

path_2_resource_data	The path (either relative or absolute) to the given resource time series.
resource_key	The key associated with the given renewable resource.
electrical_load_ptr	A pointer to the Model's ElectricalLoad object.

```
348 {
349     //  1. init CSV reader, record path and type
350     io::CSVReader<2> CSV(path_2_resource_data);
351 
352     CSV.read_header(
353         io::ignore_extra_column,
354         "Time (since start of data) [hrs]",
355         "Hydro Inflow [m3/hr]"
356     );
357 
358     this->path_map_1D.insert(
359         std::pair<int, std::string>(resource_key, path_2_resource_data)
360     );
361 
362     this->string_map_1D.insert(std::pair<int, std::string>(resource_key, "HYDRO"));
363 
364     //  2. init map element
365     this->resource_map_1D.insert(
366         std::pair<int, std::vector<double»(resource_key, {})
367     );
368     this->resource_map_1D[resource_key].resize(electrical_load_ptr->n_points, 0);
369 
370 
371     //  3. read in resource data, check against time series (point-wise and length)
372     int n_points = 0;
373     double time_hrs = 0;
374     double time_expected_hrs = 0;
375     double hydro_resource_m3hr = 0;
376 
377     while (CSV.read_row(time_hrs, hydro_resource_m3hr)) {
378         if (n_points > electrical_load_ptr->n_points) {
379             this->__throwLengthError(path_2_resource_data, electrical_load_ptr);
380         }
381 
382         time_expected_hrs = electrical_load_ptr->time_vec_hrs[n_points];
383         this->__checkTimePoint(
384             time_hrs,
385             time_expected_hrs,
386             path_2_resource_data,
387             electrical_load_ptr
388         );
389 
390         this->resource_map_1D[resource_key][n_points] = hydro_resource_m3hr;
391 
392         n_points++;
393     }
394 
395     //  4. check data length
396     if (n_points != electrical_load_ptr->n_points) {
397         this->__throwLengthError(path_2_resource_data, electrical_load_ptr);
398     }
399 
400     return;
401 }   /* __readHydroResource() */
```

4.23.3.6 __readSolarResource()

```
void Resources::__readSolarResource (
            std::string path_2_resource_data,
            int resource_key,
            ElectricalLoad * electrical_load_ptr )  [private]
```

Helper method to handle reading a solar resource time series into Resources.

Parameters

path_2_resource_data	The path (either relative or absolute) to the given resource time series.
resource_key	The key associated with the given renewable resource.
electrical_load_ptr	A pointer to the Model's ElectricalLoad object.

```
431 {
432     //  1. init CSV reader, record path and type
433     io::CSVReader<2> CSV(path_2_resource_data);
434 
435     CSV.read_header(
436         io::ignore_extra_column,
437         "Time (since start of data) [hrs]",
438         "Solar GHI [kW/m2]"
439     );
440 
441     this->path_map_1D.insert(
442         std::pair<int, std::string>(resource_key, path_2_resource_data)
443     );
444 
445     this->string_map_1D.insert(std::pair<int, std::string>(resource_key, "SOLAR"));
446 
447     //  2. init map element
448     this->resource_map_1D.insert(
449         std::pair<int, std::vector<double»(resource_key, {})
450     );
451     this->resource_map_1D[resource_key].resize(electrical_load_ptr->n_points, 0);
452 
453 
454     //  3. read in resource data, check against time series (point-wise and length)
455     int n_points = 0;
456     double time_hrs = 0;
457     double time_expected_hrs = 0;
458     double solar_resource_kWm2 = 0;
459 
460     while (CSV.read_row(time_hrs, solar_resource_kWm2)) {
461         if (n_points > electrical_load_ptr->n_points) {
462             this->__throwLengthError(path_2_resource_data, electrical_load_ptr);
463         }
464 
465         time_expected_hrs = electrical_load_ptr->time_vec_hrs[n_points];
466         this->__checkTimePoint(
467             time_hrs,
468             time_expected_hrs,
469             path_2_resource_data,
470             electrical_load_ptr
471         );
472 
473         this->resource_map_1D[resource_key][n_points] = solar_resource_kWm2;
474 
475         n_points++;
476     }
477 
478     //  4. check data length
479     if (n_points != electrical_load_ptr->n_points) {
480         this->__throwLengthError(path_2_resource_data, electrical_load_ptr);
481     }
482 
483     return;
484 }   /* __readSolarResource() */
```

4.23.3.7 __readTidalResource()

```
void Resources::__readTidalResource (
            std::string path_2_resource_data,
            int resource_key,
            ElectricalLoad * electrical_load_ptr )  [private]
```

Helper method to handle reading a tidal resource time series into Resources.

Parameters

path_2_resource_data	The path (either relative or absolute) to the given resource time series.
resource_key	The key associated with the given renewable resource.
electrical_load_ptr	A pointer to the Model's ElectricalLoad object.

```
514 {
515     //  1. init CSV reader, record path and type
516     io::CSVReader<2> CSV(path_2_resource_data);
517 
518     CSV.read_header(
519         io::ignore_extra_column,
520         "Time (since start of data) [hrs]",
521         "Tidal Speed (hub depth) [m/s]"
522     );
523 
524     this->path_map_1D.insert(
525         std::pair<int, std::string>(resource_key, path_2_resource_data)
526     );
527 
528     this->string_map_1D.insert(std::pair<int, std::string>(resource_key, "TIDAL"));
529 
530     //  2. init map element
531     this->resource_map_1D.insert(
532         std::pair<int, std::vector<double»(resource_key, {})
533     );
534     this->resource_map_1D[resource_key].resize(electrical_load_ptr->n_points, 0);
535 
536 
537     //  3. read in resource data, check against time series (point-wise and length)
538     int n_points = 0;
539     double time_hrs = 0;
540     double time_expected_hrs = 0;
541     double tidal_resource_ms = 0;
542 
543     while (CSV.read_row(time_hrs, tidal_resource_ms)) {
544         if (n_points > electrical_load_ptr->n_points) {
545             this->__throwLengthError(path_2_resource_data, electrical_load_ptr);
546         }
547 
548         time_expected_hrs = electrical_load_ptr->time_vec_hrs[n_points];
549         this->__checkTimePoint(
550             time_hrs,
551             time_expected_hrs,
552             path_2_resource_data,
553             electrical_load_ptr
554         );
555 
556         this->resource_map_1D[resource_key][n_points] = tidal_resource_ms;
557 
558         n_points++;
559     }
560 
561     //  4. check data length
562     if (n_points != electrical_load_ptr->n_points) {
563         this->__throwLengthError(path_2_resource_data, electrical_load_ptr);
564     }
565 
566     return;
567 }   /* __readTidalResource() */
```

4.23.3.8 __readWaveResource()

```
void Resources::__readWaveResource (
            std::string path_2_resource_data,
            int resource_key,
            ElectricalLoad * electrical_load_ptr )  [private]
```

Helper method to handle reading a wave resource time series into Resources.

Parameters

path_2_resource_data	The path (either relative or absolute) to the given resource time series.
resource_key	The key associated with the given renewable resource.
electrical_load_ptr	A pointer to the Model's ElectricalLoad object.

```
597 {
598     //  1. init CSV reader, record path and type
599     io::CSVReader<3> CSV(path_2_resource_data);
600 
601     CSV.read_header(
602         io::ignore_extra_column,
603         "Time (since start of data) [hrs]",
604         "Significant Wave Height [m]",
605         "Energy Period [s]"
606     );
607 
608     this->path_map_2D.insert(
609         std::pair<int, std::string>(resource_key, path_2_resource_data)
610     );
611 
612     this->string_map_2D.insert(std::pair<int, std::string>(resource_key, "WAVE"));
613 
614     //  2. init map element
615     this->resource_map_2D.insert(
616         std::pair<int, std::vector<std::vector<double»>(resource_key, {})
617     );
618     this->resource_map_2D[resource_key].resize(electrical_load_ptr->n_points, {0, 0});
619 
620 
621     //  3. read in resource data, check against time series (point-wise and length)
622     int n_points = 0;
623     double time_hrs = 0;
624     double time_expected_hrs = 0;
625     double significant_wave_height_m = 0;
626     double energy_period_s = 0;
627 
628     while (CSV.read_row(time_hrs, significant_wave_height_m, energy_period_s)) {
629         if (n_points > electrical_load_ptr->n_points) {
630             this->__throwLengthError(path_2_resource_data, electrical_load_ptr);
631         }
632 
633         time_expected_hrs = electrical_load_ptr->time_vec_hrs[n_points];
634         this->__checkTimePoint(
635             time_hrs,
636             time_expected_hrs,
637             path_2_resource_data,
638             electrical_load_ptr
639         );
640 
641         this->resource_map_2D[resource_key][n_points][0] = significant_wave_height_m;
642         this->resource_map_2D[resource_key][n_points][1] = energy_period_s;
643 
644         n_points++;
645     }
646 
647     //  4. check data length
648     if (n_points != electrical_load_ptr->n_points) {
649         this->__throwLengthError(path_2_resource_data, electrical_load_ptr);
650     }
651 
652     return;
653 }   /* __readWaveResource() */
```

4.23.3.9 __readWindResource()

```
void Resources::__readWindResource (
            std::string path_2_resource_data,
            int resource_key,
            ElectricalLoad * electrical_load_ptr )  [private]
```

Helper method to handle reading a wind resource time series into Resources.

Parameters

path_2_resource_data	The path (either relative or absolute) to the given resource time series.
resource_key	The key associated with the given renewable resource.
electrical_load_ptr	A pointer to the Model's ElectricalLoad object.

```
683 {
684     //  1. init CSV reader, record path and type
685     io::CSVReader<2> CSV(path_2_resource_data);
686 
687     CSV.read_header(
688         io::ignore_extra_column,
689         "Time (since start of data) [hrs]",
690         "Wind Speed (hub height) [m/s]"
691     );
692 
693     this->path_map_1D.insert(
694         std::pair<int, std::string>(resource_key, path_2_resource_data)
695     );
696 
697     this->string_map_1D.insert(std::pair<int, std::string>(resource_key, "WIND"));
698 
699     //  2. init map element
700     this->resource_map_1D.insert(
701         std::pair<int, std::vector<double»(resource_key, {})
702     );
703     this->resource_map_1D[resource_key].resize(electrical_load_ptr->n_points, 0);
704 
705 
706     //  3. read in resource data, check against time series (point-wise and length)
707     int n_points = 0;
708     double time_hrs = 0;
709     double time_expected_hrs = 0;
710     double wind_resource_ms = 0;
711 
712     while (CSV.read_row(time_hrs, wind_resource_ms)) {
713         if (n_points > electrical_load_ptr->n_points) {
714             this->__throwLengthError(path_2_resource_data, electrical_load_ptr);
715         }
716 
717         time_expected_hrs = electrical_load_ptr->time_vec_hrs[n_points];
718         this->__checkTimePoint(
719             time_hrs,
720             time_expected_hrs,
721             path_2_resource_data,
722             electrical_load_ptr
723         );
724 
725         this->resource_map_1D[resource_key][n_points] = wind_resource_ms;
726 
727         n_points++;
728     }
729 
730     //  4. check data length
731     if (n_points != electrical_load_ptr->n_points) {
732         this->__throwLengthError(path_2_resource_data, electrical_load_ptr);
733     }
734 
735     return;
736 }   /* __readWindResource() */
```

4.23.3.10 __throwLengthError()

```
void Resources::__throwLengthError (
            std::string path_2_resource_data,
            ElectricalLoad * electrical_load_ptr )  [private]
```

Helper method to throw data length error (if not the same as the given electrical load time series).

Parameters

path_2_resource_data	The path (either relative or absolute) to the given resource time series.
electrical_load_ptr	A pointer to the Model's ElectricalLoad object.

```
303 {
304     std::string error_str = "ERROR:  Resources::addResource():  ";
305     error_str += "the given resource time series at ";
306     error_str += path_2_resource_data;
307     error_str += " is not the same length as the previously given electrical";
308     error_str += " load time series at ";
309     error_str += electrical_load_ptr->path_2_electrical_load_time_series;
310 
311     #ifdef _WIN32
312         std::cout << error_str << std::endl;
313     #endif
314 
315     throw std::runtime_error(error_str);
316 
317     return;
318 }   /* __throwLengthError() */
```

4.23.3.11 addResource() [1/2]

```
void Resources::addResource (
            NoncombustionType noncombustion_type,
            std::string path_2_resource_data,
            int resource_key,
            ElectricalLoad * electrical_load_ptr )
```

A method to add a renewable resource time series to Resources. Checks if given resource key is already in use. The associated helper methods also check against ElectricalLoad to ensure that all added time series align with the electrical load time series (both in terms of length and which points in time are included).

Parameters

noncombustion_type	The type of renewable resource being added to Resources.
path_2_resource_data	A string defining the path (either relative or absolute) to the given resource time series.
resource_key	A key used to index into the Resources object, used to associate Renewable assets with the corresponding resource.
electrical_load_ptr	A pointer to the Model's ElectricalLoad object.

```
794 {
795     switch (noncombustion_type) {
796         case (NoncombustionType :: HYDRO): {
797             this->__checkResourceKey1D(resource_key, noncombustion_type);
798 
799             this->__readHydroResource(
800                 path_2_resource_data,
801                 resource_key,
802                 electrical_load_ptr
803             );
804 
805             break;
806         }
807 
808         default: {
809             std::string error_str = "ERROR:  Resources :: addResource(:  ";
810             error_str += "noncombustion type ";
811             error_str += std::to_string(noncombustion_type);
812             error_str += " has no associated resource";
813 
814             #ifdef _WIN32
815                 std::cout << error_str << std::endl;
816             #endif
817 
818             throw std::runtime_error(error_str);
819 
820             break;
821         }
822     }
823 
824     return;
```

```
825 }   /* addResource() */
```

4.23.3.12 addResource() [2/2]

```
void Resources::addResource (
            RenewableType renewable_type,
            std::string path_2_resource_data,
            int resource_key,
            ElectricalLoad * electrical_load_ptr )
```

A method to add a renewable resource time series to Resources. Checks if given resource key is already in use. The associated helper methods also check against ElectricalLoad to ensure that all added time series align with the electrical load time series (both in terms of length and which points in time are included).

Parameters

renewable_type	The type of renewable resource being added to Resources.
path_2_resource_data	A string defining the path (either relative or absolute) to the given resource time series.
resource_key	A key used to index into the Resources object, used to associate Renewable assets with the corresponding resource.
electrical_load_ptr	A pointer to the Model's ElectricalLoad object.

```
862 {
863     switch (renewable_type) {
864         case (RenewableType :: SOLAR): {
865             this->__checkResourceKey1D(resource_key, renewable_type);
866 
867             this->__readSolarResource(
868                 path_2_resource_data,
869                 resource_key,
870                 electrical_load_ptr
871             );
872 
873             break;
874         }
875 
876         case (RenewableType :: TIDAL): {
877             this->__checkResourceKey1D(resource_key, renewable_type);
878 
879             this->__readTidalResource(
880                 path_2_resource_data,
881                 resource_key,
882                 electrical_load_ptr
883             );
884 
885             break;
886         }
887 
888         case (RenewableType :: WAVE): {
889             this->__checkResourceKey2D(resource_key, renewable_type);
890 
891             this->__readWaveResource(
892                 path_2_resource_data,
893                 resource_key,
894                 electrical_load_ptr
895             );
896 
897             break;
898         }
899 
900         case (RenewableType :: WIND): {
901             this->__checkResourceKey1D(resource_key, renewable_type);
902 
903             this->__readWindResource(
904                 path_2_resource_data,
905                 resource_key,
906                 electrical_load_ptr
907             );
```

```
908
909             break;
910         }
911
912         default: {
913             std::string error_str = "ERROR:  Resources :: addResource(:  ";
914             error_str += "renewable type ";
915             error_str += std::to_string(renewable_type);
916             error_str += " not recognized";
917
918             #ifdef _WIN32
919                 std::cout « error_str « std::endl;
920             #endif
921
922             throw std::runtime_error(error_str);
923
924             break;
925         }
926     }
927
928     return;
929 }   /* addResource() */
```

4.23.3.13 clear()

```
void Resources::clear (
            void  )
```

Method to clear all attributes of the Resources object.

```
943 {
944     this->resource_map_1D.clear();
945     this->string_map_1D.clear();
946     this->path_map_1D.clear();
947
948     this->resource_map_2D.clear();
949     this->string_map_2D.clear();
950     this->path_map_2D.clear();
951
952     return;
953 }   /* clear() */
```

4.23.4 Member Data Documentation

4.23.4.1 path_map_1D

```
std::map<int, std::string> Resources::path_map_1D
```

A map <int, string> of the paths (either relative or absolute) to given 1D renewable resource time series.

4.23.4.2 path_map_2D

```
std::map<int, std::string> Resources::path_map_2D
```

A map <int, string> of the paths (either relative or absolute) to given 2D renewable resource time series.

4.23.4.3 resource_map_1D

```
std::map<int, std::vector<double> > Resources::resource_map_1D
```

A map <int, vector<double>> of given 1D renewable resource time series.

4.23.4.4 resource_map_2D

```
std::map<int, std::vector<std::vector<double> > > Resources::resource_map_2D
```

A map <int, vector<vector<double>>> of given 2D renewable resource time series.

4.23.4.5 string_map_1D

```
std::map<int, std::string> Resources::string_map_1D
```

A map <int, string> of descriptors for the type of the given 1D renewable resource time series.

4.23.4.6 string_map_2D

```
std::map<int, std::string> Resources::string_map_2D
```

A map <int, string> of descriptors for the type of the given 2D renewable resource time series.

The documentation for this class was generated from the following files:

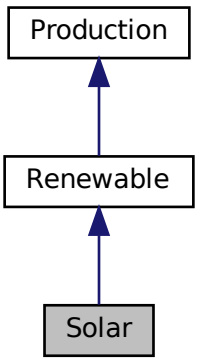
- header/Resources.h
- source/Resources.cpp

4.24 Solar Class Reference

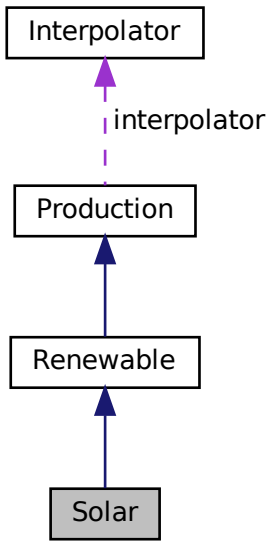
A derived class of the Renewable branch of Production which models solar production.

`#include <Solar.h>`

Inheritance diagram for Solar:



Collaboration diagram for Solar:



Public Member Functions

- Solar (void)

  Constructor (dummy) for the Solar class.
- Solar (int, double, SolarInputs, std::vector< double > *)

  Constructor (intended) for the Solar class.
- void handleReplacement (int)

  Method to handle asset replacement and capital cost incursion, if applicable.
- double computeProductionkW (int, double, double)

  Method which takes in the solar resource at a particular point in time, and then returns the solar PV production at that point in time.
- double commit (int, double, double, double)

  Method which takes in production and load for the current timestep, computes and records dispatch and curtailment, and then returns remaining load.
- ~Solar (void)

  Destructor for the Solar class.

Public Attributes

- double derating

  The derating of the solar PV array (i.e., shadowing, soiling, etc.).
- double julian_day

  The number of days (including partial days) since 12:00 on 1 Jan 2000.
- double latitude_deg

  The latitude of the solar PV array [deg].
- double longitude_deg

  The longitude of the solar PV array [deg].
- double latitude_rad

  The latitude of the solar PV array [rad].
- double longitude_rad

  The longitude of the solar PV array [rad].
- double panel_azimuth_deg

  The azimuth angle of the panels [deg], relative to north.
- double panel_tilt_deg

  The tilt angle of the panels [deg], relative to ground.
- double panel_azimuth_rad

  The azimuth angle of the panels [rad], relative to north.
- double panel_tilt_rad

  The tilt angle of the panels [rad], relative to ground.
- double albedo_ground_reflectance

  The albedo (ground reflectance) to be applied in modelling the solar PV array.
- SolarPowerProductionModel power_model

  The solar power production model to be applied.
- std::string power_model_string

  A string describing the active power production model.

Private Member Functions

- void __checkInputs (SolarInputs)

  Helper method to check inputs to the Solar constructor.
- double __getGenericCapitalCost (void)

  Helper method to generate a generic solar PV array capital cost.
- double __getGenericOpMaintCost (void)

  Helper method to generate a generic solar PV array operation and maintenance cost. This is a cost incurred per unit energy produced.
- double __getMeanLongitudeDeg (void)

  Method to compute and return the mean longitude [deg], bound to the half-open interval [0, 360). From eqn (4.7) of Gilman.
- double __getMeanAnomalyRad (void)

  Method to compute and return the mean anomaly [rad], bound to the half-open interval [0, 2pi). From eqn (4.8) of Gilman.
- double __getEclipticLongitudeRad (double, double)

  Method to compute and return the ecliptic longitude [rad], bound to the half-open interval [0, 2pi). From eqn (4.9) of Gilman.
- double __getObliquityOfEclipticRad (void)

  Method to compute and return the obliquity of the ecliptic [rad], bound to the half-open interval [0, 2pi). From eqn (4.10) of Gilman.
- double __getGreenwichMeanSiderialTimeHrs (void)

  Method to compute the Greenwich mean siderial time [hrs], bound to the half-open interval [0, 24) hrs. From eqn (4.13) of Gilman.
- double __getLocalMeanSiderialTimeHrs (double)

  Method to compute and return the local mean siderial time [hrs], bound to the half-open interval [0, 24) hrs. From eqn (4.14) of Gilman.
- double __getRightAscensionRad (double, double)

  Method to compute and return the right ascension of the sun [rad], bound to the half-open interval [0, 2pi). From eqn (4.11) of Gilman.
- double __getDeclinationRad (double, double)

  Method to compute and return the declination of the sun [rad], bound to the closed interval [-pi/2, pi/2]. From eqn (4.12) of Gilman.
- double __getHourAngleRad (double, double)

  Method to compute and return the hour angle [rad] of the sun, bound to the open interval (-pi, pi). From eqn (4.15) of Gilman.
- double __getSolarAltitudeRad (double, double)

  Method to compute and return the sun altitude [rad], corrected for refraction and bound to the closed interval [0, pi/2]. From eqns (4.16) and (4.17) of Gilman.
- double __getSolarAzimuthRad (double, double)

  Method to copmute and return the solar azimuth [rad], bound to the closed interval [-pi, pi]. From eqns (4.16) and (4.18) of Gilman.
- double __getSolarZenithRad (double, double)

  Method to compute and return the solar zenith [rad], bound to the open interval (-pi/2, pi/2). From eqn (4.19) of Gilman.
- double __getDiffuseHorizontalIrradiancekWm2 (double)

  Method which takes in the solar resource at a particular point in time, and then returns the diffuse horizontal irradiance (DHI) [kW/m2] using a very simple, empirical model (simply DHI is proportional to GHI).
- double __getDirectNormalIrradiancekWm2 (double, double, double)

  Method which takes in the solar resource and DHI at a particular point in time, then the returns the direct normal irradiance (DNI) [kW/m2]. From definition of global horizontal irradiance (GHI).
- double __getAngleOfIncidenceRad (double, double)

  Method to compute and return the angle of incidence [rad] between the solar beam and the panel normal. From eqn (5.1) of Gilman.

- double __getBeamIrradiancekWm2 (double, double)

  Method which computes and returns the beam irradiance normal to the panels [kW/m2]. From eqn (6.1) of Gilman.
- double __getDiffuseIrradiancekWm2 (double)

  Method which computes and returns the (isotropic) diffuse sky irradiance [kW/m2]. From eqn (6.5) of Gilman.
- double __getGroundReflectedIrradiancekWm2 (double)

  Method to compute and return the ground reflected irradiance [kW/m2]. From eqn (6.21) of Gilman.
- double __getPlaneOfArrayIrradiancekWm2 (int, double, double)

  Method which takes in the solar resource at a particular point in time, and then returns the nominal plane of array irradiance. From eqn (7.1) of Gilman.
- double __computeSimpleProductionkW (int, double, double)

  Method which takes in the solar resource at a particular point in time, and then returns the solar PV production at that point in time base on a simple, "HOMER-like" model.
- double __computeDetailedProductionkW (int, double, double)

  Method which takes in the solar resource at a particular point in time, and then returns the solar PV production at that point in time base on a detailed, "PVWatts/SAM-like" model.
- void __writeSummary (std::string)

  Helper method to write summary results for Solar.
- void __writeTimeSeries (std::string, std::vector< double > *, std::map< int, std::vector< double >> *, std::map< int, std::vector< std::vector< double >>> *, int=-1)

  Helper method to write time series results for Solar.

4.24.1 Detailed Description

A derived class of the Renewable branch of Production which models solar production.

4.24.2 Constructor & Destructor Documentation

4.24.2.1 Solar() [1/2]

```
Solar::Solar (
            void  )
```

Constructor (dummy) for the Solar class.

```
1388 {
1389     //...
1390
1391     return;
1392 }   /* Solar() */
```

4.24.2.2 Solar() [2/2]

```
Solar::Solar (
            int n_points,
            double n_years,
            SolarInputs solar_inputs,
            std::vector< double > * time_vec_hrs_ptr )
```

Constructor (intended) for the Solar class.

Parameters

n_points	The number of points in the modelling time series.
n_years	The number of years being modelled.
solar_inputs	A structure of Solar constructor inputs.
time_vec_hrs_ptr	A pointer to the vector containing the modelling time series.

```
1424   :
1425 Renewable(
1426     n_points,
1427     n_years,
1428     solar_inputs.renewable_inputs,
1429     time_vec_hrs_ptr
1430 )
1431 {
1432     //  1. check inputs
1433     this->__checkInputs(solar_inputs);
1434 
1435     //  2. set attributes
1436     this->type = RenewableType :: SOLAR;
1437     this->type_str = "SOLAR";
1438 
1439     this->resource_key = solar_inputs.resource_key;
1440 
1441     this->derating = solar_inputs.derating;
1442 
1443     this->julian_day = solar_inputs.julian_day;
1444 
1445     this->latitude_deg = solar_inputs.latitude_deg;
1446     this->longitude_deg = solar_inputs.longitude_deg;
1447 
1448     this->latitude_rad = (M_PI / 180.0) * this->latitude_deg;
1449     this->longitude_rad = (M_PI / 180.0) * this->longitude_deg;
1450 
1451     this->panel_azimuth_deg = solar_inputs.panel_azimuth_deg;
1452     this->panel_tilt_deg = solar_inputs.panel_tilt_deg;
1453 
1454     this->panel_azimuth_rad = (M_PI / 180.0) * this->panel_azimuth_deg;
1455     this->panel_tilt_rad = (M_PI / 180.0) * this->panel_tilt_deg;
1456 
1457     this->albedo_ground_reflectance = solar_inputs.albedo_ground_reflectance;
1458 
1459     this->power_model = solar_inputs.power_model;
1460 
1461     switch (this->power_model) {
1462         case (SolarPowerProductionModel :: SOLAR_POWER_SIMPLE): {
1463             this->power_model_string = "SIMPLE";
1464 
1465             break;
1466         }
1467 
1468         case (SolarPowerProductionModel :: SOLAR_POWER_DETAILED): {
1469             this->power_model_string = "DETAILED";
1470 
1471             break;
1472         }
1473 
1474         default: {
1475             std::string error_str = "ERROR:  Solar():  ";
1476             error_str += "power production model ";
1477             error_str += std::to_string(this->power_model);
1478             error_str += " not recognized";
1479 
1480             #ifdef _WIN32
1481                 std::cout << error_str << std::endl;
1482             #endif
1483 
1484             throw std::runtime_error(error_str);
1485 
1486             break;
1487         }
1488     }
1489 
1490     if (solar_inputs.capital_cost < 0) {
1491         this->capital_cost = this->__getGenericCapitalCost();
1492     }
1493     else {
1494         this->capital_cost = solar_inputs.capital_cost;
1495     }
1496 
1497     if (solar_inputs.operation_maintenance_cost_kWh < 0) {
1498         this->operation_maintenance_cost_kWh = this->__getGenericOpMaintCost();
1499     }
```

```
1500     else {
1501         this->operation_maintenance_cost_kWh =
1502             solar_inputs.operation_maintenance_cost_kWh;
1503     }
1504 
1505     if (not this->is_sunk) {
1506         this->capital_cost_vec[0] = this->capital_cost;
1507     }
1508 
1509     //  3. construction print
1510     if (this->print_flag) {
1511         std::cout << "Solar object constructed at " << this << std::endl;
1512     }
1513 
1514     return;
1515 }   /* Renewable() */
```

4.24.2.3 ~Solar()

```
Solar::~Solar (
             void  )
```

Destructor for the Solar class.

```
1692 {
1693     //  1. destruction print
1694     if (this->print_flag) {
1695         std::cout << "Solar object at " << this << " destroyed" << std::endl;
1696     }
1697 
1698     return;
1699 }   /* ~Solar() */
```

4.24.3 Member Function Documentation

4.24.3.1 __checkInputs()

```
void Solar::__checkInputs (
             SolarInputs solar_inputs )  [private]
```

Helper method to check inputs to the Solar constructor.

```
62 {
63     //  1. check derating
64     if (
65         solar_inputs.derating < 0 or
66         solar_inputs.derating > 1
67     ) {
68         std::string error_str = "ERROR:  Solar():  ";
69         error_str += "SolarInputs::derating must be in the closed interval [0, 1]";
70 
71         #ifdef _WIN32
72             std::cout << error_str << std::endl;
73         #endif
74 
75         throw std::invalid_argument(error_str);
76     }
77 
78     //  2. check julian day
79     if (solar_inputs.julian_day < 0) {
80         std::string error_str = "ERROR:  Solar():  ";
81         error_str += "SolarInputs::julian_day must be >= 0 days.";
82 
83         #ifdef _WIN32
84             std::cout << error_str << std::endl;
85         #endif
86 
```

```
87          throw std::invalid_argument(error_str);
88      }
89
90      //  3. check latitude
91      if (
92          solar_inputs.latitude_deg < -90 or
93          solar_inputs.latitude_deg > 90
94      ) {
95          std::string error_str = "ERROR:  Solar():  ";
96          error_str += "SolarInputs::latitude_deg must be in the closed interval ";
97          error_str += "[-90, 90] degrees";
98
99          #ifdef _WIN32
100             std::cout « error_str « std::endl;
101         #endif
102
103         throw std::invalid_argument(error_str);
104     }
105
106     //  4. check longitude
107     if (
108         solar_inputs.longitude_deg < -180 or
109         solar_inputs.longitude_deg > 180
110     ) {
111         std::string error_str = "ERROR:  Solar():  ";
112         error_str += "SolarInputs::longitude_deg must be in the closed interval ";
113         error_str += "[-180, 180] degrees";
114
115         #ifdef _WIN32
116             std::cout « error_str « std::endl;
117         #endif
118
119         throw std::invalid_argument(error_str);
120     }
121
122     //  5. check panel tilt angle
123     if (
124         solar_inputs.panel_tilt_deg < 0 or
125         solar_inputs.panel_tilt_deg > 90
126     ) {
127         std::string error_str = "ERROR:  Solar():  ";
128         error_str += "SolarInputs::panel_tilt_deg must be in the closed interval ";
129         error_str += "[0, 90] degrees";
130
131         #ifdef _WIN32
132             std::cout « error_str « std::endl;
133         #endif
134
135         throw std::invalid_argument(error_str);
136     }
137
138     //  6. check albedo ground reflectance
139     if (
140         solar_inputs.albedo_ground_reflectance < 0 or
141         solar_inputs.albedo_ground_reflectance > 1
142     ) {
143         std::string error_str = "ERROR:  Solar():  ";
144         error_str += "SolarInputs::albedo_ground_reflectance must be in the closed ";
145         error_str += "interval [0, 1]";
146
147         #ifdef _WIN32
148             std::cout « error_str « std::endl;
149         #endif
150
151         throw std::invalid_argument(error_str);
152     }
153
154     return;
155 }   /* __checkInputs() */
```

4.24.3.2 __computeDetailedProductionkW()

```
double Solar::__computeDetailedProductionkW (
            int timestep,
            double dt_hrs,
            double solar_resource_kWm2 )  [private]
```

Method which takes in the solar resource at a particular point in time, and then returns the solar PV production at that point in time base on a detailed, "PVWatts/SAM-like" model.

Ref: Gilman et al. [2018]

Parameters

timestep	The timestep (i.e., time series index) for the request.
dt_hrs	The interval of time [hrs] associated with the timestep.
solar_resource_kWm2	Solar resource (i.e. global horizontal irradiance) [kW/m2].

Returns

The production [kW] of the solar PV array.

```
1179 {
1180     // apply detailed production model (POA irradiance -> production)
1181     double plane_of_array_irradiance_kWm2 = this->__getPlaneOfArrayIrradiancekWm2(
1182         timestep,
1183         dt_hrs,
1184         solar_resource_kWm2
1185     );
1186 
1187     double production_kW =
1188         this->derating * plane_of_array_irradiance_kWm2 * this->capacity_kW;
1189 
1190     // cap production at capacity
1191     if (production_kW > this->capacity_kW) {
1192         production_kW = this->capacity_kW;
1193     }
1194 
1195     return production_kW;
1196 }   /* __computeDetailedProductionkW() */
```

4.24.3.3 __computeSimpleProductionkW()

```
double Solar::__computeSimpleProductionkW (
             int timestep,
             double dt_hrs,
             double solar_resource_kWm2 )  [private]
```

Method which takes in the solar resource at a particular point in time, and then returns the solar PV production at that point in time base on a simple, "HOMER-like" model.

Ref: HOMER [2023f]

Parameters

timestep	The timestep (i.e., time series index) for the request.
dt_hrs	The interval of time [hrs] associated with the timestep.
solar_resource_kWm2	Solar resource (i.e. global horizontal irradiance) [kW/m2].

Returns

The production [kW] of the solar PV array.

```
1134 {
1135     // apply simple production model (GHI -> production)
1136     double production_kW = this->derating * solar_resource_kWm2 * this->capacity_kW;
1137 
1138     // cap production at capacity
1139     if (production_kW > this->capacity_kW) {
1140         production_kW = this->capacity_kW;
1141     }
1142 
1143     return production_kW;
1144 }   /* __computeSimpleProductionkW() */
```

4.24.3.4 __getAngleOfIncidenceRad()

```
double Solar::__getAngleOfIncidenceRad (
            double solar_zenith_rad,
            double solar_azimuth_rad )  [private]
```

Method to compute and return the angle of incidence [rad] between the solar beam and the panel normal. From eqn (5.1) of Gilman.

Ref: Gilman et al. [2018]

Parameters

solar_zenith_rad	The solar zenith [rad].
solar_azimuth_rad	The solar azimuth [rad].

Returns

The angle of incidence [rad] between the solar beam and the panel normal.

```
869 {
870     double a =
871         sin(solar_zenith_rad) *
872         cos(solar_azimuth_rad - this->panel_azimuth_rad) *
873         sin(this->panel_tilt_rad) +
874         cos(solar_zenith_rad) *
875         cos(this->panel_tilt_rad);
876 
877     double angle_of_incidence_rad = 0;
878 
879     if (a < -1) {
880         angle_of_incidence_rad = M_PI;
881     }
882 
883     else if (a > 1) {
884         angle_of_incidence_rad = 0;
885     }
886 
887     else {
888         angle_of_incidence_rad = acos(a);
889     }
890 
891     return angle_of_incidence_rad;
892 }   /* __getAngleOfIncidenceRad() */
```

4.24.3.5 __getBeamIrradiancekWm2()

```
double Solar::__getBeamIrradiancekWm2 (
            double direct_normal_irradiance_kWm2,
            double angle_of_incidence_rad )  [private]
```

Method which computes and returns the beam irradiance normal to the panels [kW/m2]. From eqn (6.1) of Gilman.

Ref: Gilman et al. [2018]

Parameters

direct_normal_irradiance_kWm2	The DNI [kW/m2].
angle_of_incidence_rad	The angle of incidence [rad] between the solar beam and the panel normal.

Returns

The beam irradiance normal to the panels [kW/m2].

```
923 {
924     double beam_irradiance_kWm2 = direct_normal_irradiance_kWm2 *
925         cos(angle_of_incidence_rad);
926 
927     return beam_irradiance_kWm2;
928 }   /* __getBeamIrradiancekWm2() */
```

4.24.3.6 __getDeclinationRad()

```
double Solar::__getDeclinationRad (
            double eclong_rad,
            double obleq_rad )  [private]
```

Method to compute and return the declination of the sun [rad], bound to the closed interval [-pi/2, pi/2]. From eqn (4.12) of Gilman.

Ref: Gilman et al. [2018]

Parameters

eclong_rad	The ecliptic longitude [rad], bound to the half-open interval [0, 2pi).
obleq_rad	The obliquity of the ecliptic, bound to the half-open interval [0, 2pi).

Returns

The declination of the sun [rad], bound to the closed interval [-pi/2, pi/2].

```
468 {
469     double declination_rad = asin(sin(obleq_rad) * sin(eclong_rad));
470 
471     return declination_rad;
472 }   /* __getDeclinationRad() */
```

4.24.3.7 __getDiffuseHorizontalIrradiancekWm2()

```
double Solar::__getDiffuseHorizontalIrradiancekWm2 (
            double solar_resource_kWm2 )  [private]
```

Method which takes in the solar resource at a particular point in time, and then returns the diffuse horizontal irradiance (DHI) [kW/m2] using a very simple, empirical model (simply DHI is proportional to GHI).

Ref: Safaripour and Mehrabian [2011]

Parameters

solar_resource_kWm2	Solar resource (i.e. global horizontal irradiance) [kW/m2].

Returns

The diffuse horizontal irradiance [kW/m2].

```
794 {
795     double GHI_2_DHI = 0.32;
796 
797     return GHI_2_DHI * solar_resource_kWm2;
798 }   /* __getDiffuseHorizontalIrradiancekWm2() */
```

4.24.3.8 __getDiffuseIrradiancekWm2()

```
double Solar::__getDiffuseIrradiancekWm2 (
             double diffuse_horizontal_irradiance_kWm2 )  [private]
```

Method which computes and returns the (isotropic) diffuse sky irradiance [kW/m2]. From eqn (6.5) of Gilman.

Ref: Gilman et al. [2018]

Parameters

diffuse_horizontal_irradiance_kWm2	The DHI [kW/m2]

Returns

The (isotropic) diffuse sky irradiance [kW/m2]

```
950 {
951     double diffuse_sky_irradiance_kWm2 = diffuse_horizontal_irradiance_kWm2 *
952         cos(this->panel_tilt_rad);
953 
954     return diffuse_sky_irradiance_kWm2;
955 }   /* __getDiffuseIrradiancekWm2() */
```

4.24.3.9 __getDirectNormalIrradiancekWm2()

```
double Solar::__getDirectNormalIrradiancekWm2 (
             double solar_resource_kWm2,
             double diffuse_horizontal_irradiance_kWm2,
             double solar_zenith_rad )  [private]
```

Method which takes in the solar resource and DHI at a particular point in time, then the returns the direct normal irradiance (DNI) [kW/m2]. From definition of global horizontal irradiance (GHI).

Ref: Gilman et al. [2018]

Parameters

solar_resource_kWm2	Solar resource (i.e. global horizontal irradiance) [kW/m2].
diffuse_horizontal_irradiance_kWm2	The DHI [kW/m2].
solar_zenith_rad	The solar zenith [rad].

Returns

The direct normal irradiance (DNI) [kW/m2].

```
833 {
834     double direct_normal_irradiance_kWm2 =
835         (solar_resource_kWm2 - diffuse_horizontal_irradiance_kWm2) /
836         cos(solar_zenith_rad);
837 
838     return direct_normal_irradiance_kWm2;
839 }   /* __getDirectNormalIrradiancekWm2() */
```

4.24.3.10 __getEclipticLongitudeRad()

```
double Solar::__getEclipticLongitudeRad (
             double mean_longitude_deg,
             double mean_anomaly_rad )  [private]
```

Method to compute and return the ecliptic longitude [rad], bound to the half-open interval [0, 2pi). From eqn (4.9) of Gilman.

Ref: Gilman et al. [2018]

Parameters

mean_longitude_deg	The mean longitude [deg], bound to the half-open interval [0, 360) deg.
mean_anomaly_rad	The mean anomaly [rad], bound to the half-open interval [0, 2pi).

Returns

The ecliptic longitude [rad], bound to the half-open interval [0, 2pi).

```
306 {
307     // compute eclioptic longitude
308     double eclong_deg = mean_longitude_deg +
309         1.915 * sin(mean_anomaly_rad) +
310         0.02 * sin(2 * mean_anomaly_rad);
311 
312     // bound to half-open interval [0, 360) deg
313     int eclong_deg_int = int(eclong_deg);
314     double eclong_deg_frac = eclong_deg - eclong_deg_int;
315 
316     eclong_deg = eclong_deg_int % 360;
317     eclong_deg += eclong_deg_frac;
318 
319     // translate to rads
320     double eclong_rad = (M_PI / 180.0) * eclong_deg;
321 
322     return eclong_rad;
323 }   /* __getEclipticLongitudeRad() */
```

4.24.3.11 __getGenericCapitalCost()

```
double Solar::__getGenericCapitalCost (
            void  )  [private]
```

Helper method to generate a generic solar PV array capital cost.

This model was obtained by way of surveying an assortment of published solar PV costs, and then constructing a best fit model. Note that this model expresses cost in terms of Canadian dollars [CAD].

Returns

A generic capital cost for the solar PV array [CAD].

```
177 {
178     double capital_cost_per_kW = 1000 * pow(this->capacity_kW, -0.15) + 3000;
179 
180     return capital_cost_per_kW * this->capacity_kW;
181 }   /* __getGenericCapitalCost() */
```

4.24.3.12 __getGenericOpMaintCost()

```
double Solar::__getGenericOpMaintCost (
            void  )  [private]
```

Helper method to generate a generic solar PV array operation and maintenance cost. This is a cost incurred per unit energy produced.

This model was obtained by way of surveying an assortment of published solar PV costs, and then constructing a best fit model. Note that this model expresses cost in terms of Canadian dollars [CAD/kWh].

Returns

A generic operation and maintenance cost, per unit energy produced, for the solar PV array [CAD/kWh].

```
204 {
205     return 0.01;
206 }   /* __getGenericOpMaintCost() */
```

4.24.3.13 __getGreenwichMeanSiderialTimeHrs()

```
double Solar::__getGreenwichMeanSiderialTimeHrs (
            void  )  [private]
```

Method to compute the Greenwich mean siderial time [hrs], bound to the half-open interval [0, 24) hrs. From eqn (4.13) of Gilman.

Ref: Gilman et al. [2018]

Returns

Greenwich mean siderial time [hrs], bound to the half-open interval [0, 24) hrs.

```
379 {
380     // compute Greenwich mean siderial time
381     double Greenwich_mean_siderial_time_hrs = 6.697375 +
382         0.0657098242 * this->julian_day -
383         (this->longitude_deg / 15);
384 
385     // bound to the half-open interval [0, 24) hrs
386     int Greenwich_mean_siderial_time_hrs_int = int(Greenwich_mean_siderial_time_hrs);
387     double Greenwich_mean_siderial_time_hrs_frac = Greenwich_mean_siderial_time_hrs -
388         Greenwich_mean_siderial_time_hrs_int;
389 
390     Greenwich_mean_siderial_time_hrs = Greenwich_mean_siderial_time_hrs_int % 24;
391     Greenwich_mean_siderial_time_hrs += Greenwich_mean_siderial_time_hrs_frac;
392 
393     return Greenwich_mean_siderial_time_hrs;
394 }   /* __getGreenwichMeanSiderialTimeHrs() */
```

4.24.3.14 __getGroundReflectedIrradiancekWm2()

```
double Solar::__getGroundReflectedIrradiancekWm2 (
            double solar_resource_kWm2 )  [private]
```

Method to compute and return the ground reflected irradiance [kW/m2]. From eqn (6.21) of Gilman.

Ref: Gilman et al. [2018]

Parameters

solar_resource_kWm2	Solar resource (i.e. global horizontal irradiance) [kW/m2].

Returns

The ground reflected irradiance [kW/m2].

```
977 {
978     double ground_reflected_irradiance_kWm2 =
979         this->albedo_ground_reflectance * solar_resource_kWm2 *
980         ((1 - cos(this->panel_tilt_rad)) / 2);
981 
982     return ground_reflected_irradiance_kWm2;
983 }   /* __getGroundReflectedIrradiancekWm2() */
```

4.24.3.15 __getHourAngleRad()

```
double Solar::__getHourAngleRad (
            double local_mean_siderial_time_hrs,
            double right_ascension_rad )  [private]
```

Method to compute and return the hour angle [rad] of the sun, bound to the open interval (-pi, pi). From eqn (4.15) of Gilman.

Ref: Gilman et al. [2018]

Parameters

local_mean_siderial_time_hrs	The local mean siderial time [hrs], bound to the half-open interval [0, 24) hrs.
right_ascension_rad	The right ascension of the sun [rad], bound to the half-open interval [0, 2pi).

Returns

The hour angle [rad] of the sun, bound to the open interval (-pi, pi).

```
553 {
554     // compute hour angle
555     double b_rad = 15 * (M_PI / 180.0) * local_mean_siderial_time_hrs -
556         right_ascension_rad;
557 
558     double hour_angle_rad = b_rad;
559 
560     // bound to open interval (-pi, pi)
561     if (b_rad < -1 * M_PI) {
562         hour_angle_rad += 2 * M_PI;
```

```
563     }
564
565     else if (b_rad > M_PI) {
566         hour_angle_rad -= 2 * M_PI;
567     }
568
569     return hour_angle_rad;
570 }   /* __getHourAngleRad() */
```

4.24.3.16 __getLocalMeanSiderialTimeHrs()

```
double Solar::__getLocalMeanSiderialTimeHrs (
            double Greenwich_mean_siderial_time_hrs )  [private]
```

Method to compute and return the local mean siderial time [hrs], bound to the half-open interval [0, 24) hrs. From eqn (4.14) of Gilman.

Ref: Gilman et al. [2018]

Parameters

Greenwich_mean_siderial_time_hrs	The Greenwich mean siderial time [hrs], bound to the half-open interval [0, 24) hrs.

Returns

The local mean siderial time [hrs], bound to the half-open interval [0, 24) hrs.

```
422 {
423     // compute local mean siderial time
424     double local_mean_siderial_time_hrs = Greenwich_mean_siderial_time_hrs +
425         (this->longitude_deg / 15);
426
427     // bound to the half-open interval [0, 24) hrs
428     int local_mean_siderial_time_hrs_int = int(local_mean_siderial_time_hrs);
429     double local_mean_siderial_time_hrs_frac = local_mean_siderial_time_hrs -
430         local_mean_siderial_time_hrs_int;
431
432     local_mean_siderial_time_hrs = local_mean_siderial_time_hrs_int % 24;
433     local_mean_siderial_time_hrs += local_mean_siderial_time_hrs_frac;
434
435     return local_mean_siderial_time_hrs;
436 }   /* __getLocalMeanSiderialTimeHrs() */
```

4.24.3.17 __getMeanAnomalyRad()

```
double Solar::__getMeanAnomalyRad (
            void  )  [private]
```

Method to compute and return the mean anomaly [rad], bound to the half-open interval [0, 2pi). From eqn (4.8) of Gilman.

double Solar :: __getMeanAnomalyRad(void)

Ref: Gilman et al. [2018]

Returns

The mean anomaly [rad], bound to the half-open interval [0, 2pi).

```
258 {
259     // compute mean anomaly
260     double mean_anomaly_deg = 357.528 + 0.9856003 * this->julian_day;
261 
262     // bound to the half-open interval [0, 360) deg.
263     int mean_anomaly_deg_int = int(mean_anomaly_deg);
264     double mean_anomaly_deg_frac = mean_anomaly_deg - mean_anomaly_deg_int;
265 
266     mean_anomaly_deg = mean_anomaly_deg_int % 360;
267     mean_anomaly_deg += mean_anomaly_deg_frac;
268 
269     // translate to rads
270     double mean_anomaly_rad = (M_PI / 180.0) * mean_anomaly_deg;
271 
272     return mean_anomaly_rad;
273 }   /* __getMeanAnomalyRad() */
```

4.24.3.18 __getMeanLongitudeDeg()

```
double Solar::__getMeanLongitudeDeg (
            void  )  [private]
```

Method to compute and return the mean longitude [deg], bound to the half-open interval [0, 360). From eqn (4.7) of Gilman.

Ref: Gilman et al. [2018]

Returns

The mean longitude [deg], bound to the half-open interval [0, 360).

```
226 {
227     // compute mean longitude
228     double mean_longitude_deg = 280.46 + 0.9856474 * this->julian_day;
229 
230     // bound to the half-open interval [0, 360) deg
231     int mean_longitude_deg_int = int(mean_longitude_deg);
232     double mean_longitude_deg_frac = mean_longitude_deg - mean_longitude_deg_int;
233 
234     mean_longitude_deg = mean_longitude_deg_int % 360;
235     mean_longitude_deg += mean_longitude_deg_frac;
236 
237     return mean_longitude_deg;
238 }   /* __getMeanLongitudeDeg() */
```

4.24.3.19 __getObliquityOfEclipticRad()

```
double Solar::__getObliquityOfEclipticRad (
            void  )  [private]
```

Method to compute and return the obliquity of the ecliptic [rad], bound to the half-open interval [0, 2pi). From eqn (4.10) of Gilman.

Ref: Gilman et al. [2018]

Returns

The obliquity of the ecliptic [rad], bound to the half-open interval [0, 2pi).

```
343 {
344     // compute obliquity of ecliptic
345     double obleq_deg = 23.439 - 0.0000004 * this->julian_day;
346 
347     // bound to half-open interval [0, 360) deg
348     int obleq_deg_int = int(obleq_deg);
349     double obleq_deg_frac = obleq_deg - obleq_deg_int;
350 
351     obleq_deg = obleq_deg_int % 360;
352     obleq_deg += obleq_deg_frac;
353 
354     // translate to rads
355     double obleq_rad = (M_PI / 180.0) * obleq_deg;
356 
357     return obleq_rad;
358 }   /* __getObliquityOfEclipticRad() */
```

4.24.3.20 __getPlaneOfArrayIrradiancekWm2()

```
double Solar::__getPlaneOfArrayIrradiancekWm2 (
            int timestep,
            double dt_hrs,
            double solar_resource_kWm2 )  [private]
```

Method which takes in the solar resource at a particular point in time, and then returns the nominal plane of array irradiance. From eqn (7.1) of Gilman.

Ref: Gilman et al. [2018]

Parameters

timestep	The timestep (i.e., time series index) for the request.
dt_hrs	The interval of time [hrs] associated with the timestep.
solar_resource_kWm2	Solar resource (i.e. global horizontal irradiance) [kW/m2].

Returns

The nominal plane of array irradiance [kW/m2].

```
1017 {
1018     // get mean longitude and mean anomaly
1019     double mean_longitude_deg = this->__getMeanLongitudeDeg();
1020     double mean_anomaly_rad = this->__getMeanAnomalyRad();
1021 
1022 
1023     // get ecliptic longitude and obliquity of the ecliptic
1024     double eclong_rad = this->__getEclipticLongitudeRad(
1025         mean_longitude_deg,
1026         mean_anomaly_rad
1027     );
1028 
1029     double obleq_rad = this->__getObliquityOfEclipticRad();
1030 
1031 
1032     // get local mean siderial time
1033     double Greenwich_mean_siderial_time_hrs = this->__getGreenwichMeanSiderialTimeHrs();
1034 
1035     double local_mean_siderial_time_hrs = this->__getLocalMeanSiderialTimeHrs(
1036         Greenwich_mean_siderial_time_hrs
1037     );
1038 
1039 
```

```
1040     // get right ascension, declination, and hour angle
1041     double right_ascension_rad = this->__getRightAscensionRad(eclong_rad, obleq_rad);
1042     double declination_rad = this->__getDeclinationRad(eclong_rad, obleq_rad);
1043 
1044     double hour_angle_rad = this->__getHourAngleRad(
1045         local_mean_siderial_time_hrs,
1046         right_ascension_rad
1047     );
1048 
1049 
1050     // get solar azimuth and zenith
1051     double solar_azimuth_rad = this->__getSolarAzimuthRad(
1052         declination_rad,
1053         hour_angle_rad
1054     );
1055 
1056     double solar_zenith_rad = this->__getSolarZenithRad(
1057         declination_rad,
1058         hour_angle_rad
1059     );
1060 
1061 
1062     // get diffuse horizontal irradiance (DHI) and direct normal irradiance (DNI)
1063     double diffuse_horizontal_irradiance_kWm2 = this->__getDiffuseHorizontalIrradiancekWm2(
1064         solar_resource_kWm2
1065     );
1066 
1067     double direct_normal_irradiance_kWm2 = this->__getDirectNormalIrradiancekWm2(
1068         solar_resource_kWm2,
1069         diffuse_horizontal_irradiance_kWm2,
1070         solar_zenith_rad
1071     );
1072 
1073 
1074     // get angle of incidence
1075     double angle_of_incidence_rad = this->__getAngleOfIncidenceRad(
1076         solar_zenith_rad,
1077         solar_azimuth_rad
1078     );
1079 
1080 
1081     // compute plane of array irradiance as superposition of beam, diffuse, and ground
1082     // reflected.
1083     double plane_of_array_irradiance_kWm2 = 0;
1084 
1085     plane_of_array_irradiance_kWm2 += this->__getBeamIrradiancekWm2(
1086         direct_normal_irradiance_kWm2,
1087         angle_of_incidence_rad
1088     );
1089 
1090     plane_of_array_irradiance_kWm2 += this->__getDiffuseIrradiancekWm2(
1091         diffuse_horizontal_irradiance_kWm2
1092     );
1093 
1094     plane_of_array_irradiance_kWm2 += this->__getGroundReflectedIrradiancekWm2(
1095         solar_resource_kWm2
1096     );
1097 
1098     return plane_of_array_irradiance_kWm2;
1099 }   /* __getPlaneOfArrayIrradiance() */
```

4.24.3.21 __getRightAscensionRad()

```
double Solar::__getRightAscensionRad (
            double eclong_rad,
            double obleq_rad )  [private]
```

Method to compute and return the right ascension of the sun [rad], bound to the half-open interval [0, 2pi). From eqn (4.11) of Gilman.

Ref: Gilman et al. [2018]

Parameters

eclong_rad	The ecliptic longitude [rad], bound to the half-open interval [0, 2pi).
obleq_rad	The obliquity of the ecliptic, bound to the half-open interval [0, 2pi).

Returns

The right ascension of the sun [rad], bound to the half-open interval [0, 2pi).

```
505 {
506     // compute right ascension
507     double right_ascension_rad = atan(
508         (cos(obleq_rad) * sin(eclong_rad)) / cos(eclong_rad)
509     );
510 
511     // bound to half-open interval [0, 2pi)
512     if (cos(eclong_rad) < 0) {
513         right_ascension_rad += M_PI;
514     }
515 
516     else if (cos(obleq_rad) * sin(eclong_rad) < 0) {
517         right_ascension_rad += 2 * M_PI;
518     }
519 
520     return right_ascension_rad;
521 }   /* __getRightAscensionRad() */
```

4.24.3.22 __getSolarAltitudeRad()

```
double Solar::__getSolarAltitudeRad (
              double declination_rad,
              double hour_angle_rad )  [private]
```

Method to compute and return the sun altitude [rad], corrected for refraction and bound to the closed interval [0, pi/2]. From eqns (4.16) and (4.17) of Gilman.

Ref: Gilman et al. [2018]

Parameters

declination_rad	The declination of the sun [rad], bound to the closed interval [-pi/2, pi/2].
hour_angle_rad	The hour angle of the sun [rad], bound to the open interval (-pi, pi).

Returns

The sun altitude [rad], corrected for refraction and bound to the closed interval [0, pi/2].

```
603 {
604     // compute un-corrected altitude
605     double a = sin(declination_rad) * sin(this->latitude_rad) +
606         cos(declination_rad) * cos(this->latitude_rad) * cos(hour_angle_rad);
607 
608     double altitude_rad = 0;
609 
610     if (a < -1) {
611         altitude_rad = -1 * M_PI_2;
612     }
613 
614     else if (a > 1) {
615         altitude_rad = M_PI_2;
616     }
```

```
617
618     else {
619         altitude_rad = asin(a);
620     }
621
622     // correct for refraction
623     double altitude_deg = (180.0 / M_PI) * altitude_rad;
624
625     double refraction = 0.56;
626
627     if (altitude_deg > -0.56) {
628         refraction = 3.51567 *
629             (0.1594 + 0.0196 * altitude_deg + 0.00002 * pow(altitude_deg, 2)) *
630             pow(1 + 0.505 * altitude_deg + 0.0845 * pow(altitude_deg, 2), -1);
631     }
632
633     double altitude_corrected_rad = 0;
634
635     if (altitude_deg + refraction > 90) {
636         altitude_corrected_rad = M_PI_2;
637     }
638
639     else {
640         altitude_corrected_rad = (M_PI / 180.0) * (altitude_deg + refraction);
641     }
642
643     return altitude_corrected_rad;
644 }   /* __getSolarAltitudeRad() */
```

4.24.3.23 __getSolarAzimuthRad()

```
double Solar::__getSolarAzimuthRad (
            double declination_rad,
            double hour_angle_rad )  [private]
```

Method to copmute and return the solar azimuth [rad], bound to the closed interval [-pi, pi]. From eqns (4.16) and (4.18) of Gilman.

Ref: Gilman et al. [2018]

Parameters

declination_rad	The declination of the sun [rad], bound to the closed interval [-pi/2, pi/2].
hour_angle_rad	The hour angle of the sun [rad], bound to the open interval (-pi, pi).

Returns

The solar azimuth [rad], bound to the closed interval [-pi, pi].

```
676 {
677     // compute un-corrected altitude
678     double a = sin(declination_rad) * sin(this->latitude_rad) +
679         cos(declination_rad) * cos(this->latitude_rad) * cos(hour_angle_rad);
680
681     double altitude_rad = 0;
682
683     if (a < -1) {
684         altitude_rad = -1 * M_PI_2;
685     }
686
687     else if (a > 1) {
688         altitude_rad = M_PI_2;
689     }
690
691     else {
692         altitude_rad = asin(a);
693     }
```

```
694
695     // compute a term
696     a = (sin(altitude_rad) * sin(this->latitude_rad) - sin(declination_rad)) /
697         (cos(altitude_rad) * cos(this->latitude_rad));
698
699     // compute b term
700     double b_rad = 0;
701
702     if (cos(altitude_rad) == 0 or a < -1) {
703         b_rad = M_PI;
704     }
705
706     else if (a > 1) {
707         b_rad = 0;
708     }
709
710     else {
711         b_rad = acos(a);
712     }
713
714     // compute azimuth
715     double azimuth_rad = 0;
716
717     if (hour_angle_rad < -1 * M_PI) {
718         azimuth_rad = b_rad;
719     }
720
721     else if (
722         (hour_angle_rad >= -1 * M_PI and hour_angle_rad <= 0) or
723         hour_angle_rad > M_PI
724     ) {
725         azimuth_rad = M_PI - b_rad;
726     }
727
728     else {
729         azimuth_rad = M_PI + b_rad;
730     }
731
732     return azimuth_rad;
733 }   /* __getSolarAzimuth() */
```

4.24.3.24 __getSolarZenithRad()

```
double Solar::__getSolarZenithRad (
            double declination_rad,
            double hour_angle_rad )  [private]
```

Method to compute and return the solar zenith [rad], bound to the open interval (-pi/2, pi/2). From eqn (4.19) of Gilman.

Ref: Gilman et al. [2018]

Parameters

declination_rad	The declination of the sun [rad], bound to the closed interval [-pi/2, pi/2].
hour_angle_rad	The hour angle of the sun [rad], bound to the open interval (-pi, pi).

Returns

The solar zenith [rad], bound to the open interval (-pi/2, pi/2).

```
764 {
765     double solar_zenith_rad = M_PI_2 - this->__getSolarAltitudeRad(
766         declination_rad,
767         hour_angle_rad
768     );
769
```

```
770     return solar_zenith_rad;
771 }   /* __getSolarZenith() */
```

4.24.3.25 __writeSummary()

```
void Solar::__writeSummary (
            std::string write_path )  [private], [virtual]
```

Helper method to write summary results for Solar.

Parameters

write_path	A path (either relative or absolute) to the directory location where results are to be written. If already exists, will overwrite.

Reimplemented from Renewable.

```
1214 {
1215     //  1. create filestream
1216     write_path += "summary_results.md";
1217     std::ofstream ofs;
1218     ofs.open(write_path, std::ofstream::out);
1219 
1220     //  2. write summary results (markdown)
1221     ofs « "# ";
1222     ofs « std::to_string(int(ceil(this->capacity_kW)));
1223     ofs « " kW SOLAR Summary Results\n";
1224     ofs « "\n--------\n\n";
1225 
1226     //  2.1. Production attributes
1227     ofs « "## Production Attributes\n";
1228     ofs « "\n";
1229 
1230     ofs « "Capacity: " « this->capacity_kW « " kW  \n";
1231     ofs « "\n";
1232 
1233     ofs « "Production Override: (N = 0 / Y = 1): "
1234         « this->normalized_production_series_given « "  \n";
1235     if (this->normalized_production_series_given) {
1236         ofs « "Path to Normalized Production Time Series: "
1237             « this->path_2_normalized_production_time_series « "  \n";
1238     }
1239     ofs « "\n";
1240 
1241     ofs « "Sunk Cost (N = 0 / Y = 1): " « this->is_sunk « "  \n";
1242     ofs « "Capital Cost: " « this->capital_cost « "  \n";
1243     ofs « "Operation and Maintenance Cost: " « this->operation_maintenance_cost_kWh
1244         « " per kWh produced  \n";
1245     ofs « "Nominal Inflation Rate (annual): " « this->nominal_inflation_annual
1246         « "  \n";
1247     ofs « "Nominal Discount Rate (annual): " « this->nominal_discount_annual
1248         « "  \n";
1249     ofs « "Real Discount Rate (annual): " « this->real_discount_annual « "  \n";
1250     ofs « "\n";
1251 
1252     ofs « "Replacement Running Hours: " « this->replace_running_hrs « "  \n";
1253     ofs « "\n--------\n\n";
1254 
1255     //  2.2. Renewable attributes
1256     ofs « "## Renewable Attributes\n";
1257     ofs « "\n";
1258 
1259     ofs « "Resource Key (1D): " « this->resource_key « "  \n";
1260 
1261     ofs « "\n--------\n\n";
1262 
1263     //  2.3. Solar attributes
1264     ofs « "## Solar Attributes\n";
1265     ofs « "\n";
1266 
1267     ofs « "Derating Factor: " « this->derating « "  \n";
1268 
1269     ofs « "\n--------\n\n";
```

```
1270
1271     //  2.4. Solar Results
1272     ofs « "## Results\n";
1273     ofs « "\n";
1274
1275     ofs « "Net Present Cost: " « this->net_present_cost « "  \n";
1276     ofs « "\n";
1277
1278     ofs « "Total Dispatch: " « this->total_dispatch_kWh
1279         « " kWh  \n";
1280
1281     ofs « "Levellized Cost of Energy: " « this->levellized_cost_of_energy_kWh
1282         « " per kWh dispatched  \n";
1283     ofs « "\n";
1284
1285     ofs « "Running Hours: " « this->running_hours « "  \n";
1286     ofs « "Replacements: " « this->n_replacements « "  \n";
1287
1288     ofs « "\n--------\n\n";
1289
1290     ofs.close();
1291     return;
1292 }   /* __writeSummary() */
```

4.24.3.26 __writeTimeSeries()

```
void Solar::__writeTimeSeries (
              std::string write_path,
              std::vector< double > * time_vec_hrs_ptr,
              std::map< int, std::vector< double >> * resource_map_1D_ptr,
              std::map< int, std::vector< std::vector< double >>> * resource_map_2D_ptr,
              int max_lines = -1 )  [private], [virtual]
```

Helper method to write time series results for Solar.

Parameters

write_path	A path (either relative or absolute) to the directory location where results are to be written. If already exists, will overwrite.
time_vec_hrs_ptr	A pointer to the time_vec_hrs attribute of the ElectricalLoad.
resource_map_1D_ptr	A pointer to the 1D map of Resources.
resource_map_2D_ptr	A pointer to the 2D map of Resources.
max_lines	The maximum number of lines of output to write.

Reimplemented from Renewable.

```
1330 {
1331     //  1. create filestream
1332     write_path += "time_series_results.csv";
1333     std::ofstream ofs;
1334     ofs.open(write_path, std::ofstream::out);
1335
1336     //  2. write time series results (comma separated value)
1337     ofs « "Time (since start of data) [hrs],";
1338     ofs « "Solar Resource [kW/m2],";
1339     ofs « "Production [kW],";
1340     ofs « "Dispatch [kW],";
1341     ofs « "Storage [kW],";
1342     ofs « "Curtailment [kW],";
1343     ofs « "Capital Cost (actual),";
1344     ofs « "Operation and Maintenance Cost (actual),";
1345     ofs « "\n";
1346
1347     for (int i = 0; i < max_lines; i++) {
1348         ofs « time_vec_hrs_ptr->at(i) « ",";
1349
1350         if (not this->normalized_production_series_given) {
1351             ofs « resource_map_1D_ptr->at(this->resource_key)[i] « ",";
```

```
1352         }
1353
1354         else {
1355             ofs « "OVERRIDE" « ",";
1356         }
1357
1358         ofs « this->production_vec_kW[i] « ",";
1359         ofs « this->dispatch_vec_kW[i] « ",";
1360         ofs « this->storage_vec_kW[i] « ",";
1361         ofs « this->curtailment_vec_kW[i] « ",";
1362         ofs « this->capital_cost_vec[i] « ",";
1363         ofs « this->operation_maintenance_cost_vec[i] « ",";
1364         ofs « "\n";
1365     }
1366
1367     ofs.close();
1368     return;
1369 }   /* __writeTimeSeries() */
```

4.24.3.27 commit()

```
double Solar::commit (
            int timestep,
            double dt_hrs,
            double production_kW,
            double load_kW )  [virtual]
```

Method which takes in production and load for the current timestep, computes and records dispatch and curtailment, and then returns remaining load.

Parameters

timestep	The timestep (i.e., time series index) for the request.
dt_hrs	The interval of time [hrs] associated with the timestep.
production_kW	The production [kW] of the asset in this timestep.
load_kW	The load [kW] passed to the asset in this timestep.

Returns

The load [kW] remaining after the dispatch is deducted from it.

Reimplemented from Renewable.

```
1663 {
1664     //  1. invoke base class method
1665     load_kW = Renewable :: commit(
1666         timestep,
1667         dt_hrs,
1668         production_kW,
1669         load_kW
1670     );
1671
1672
1673     //  2. increment julian day
1674     this->julian_day += dt_hrs / 24;
1675
1676     return load_kW;
1677 }   /* commit() */
```

4.24.3.28 computeProductionkW()

```
double Solar::computeProductionkW (
            int timestep,
            double dt_hrs,
            double solar_resource_kWm2 )  [virtual]
```

Method which takes in the solar resource at a particular point in time, and then returns the solar PV production at that point in time.

Parameters

timestep	The timestep (i.e., time series index) for the request.
dt_hrs	The interval of time [hrs] associated with the timestep.
solar_resource_kWm2	Solar resource (i.e. global horizontal irradiance) [kW/m2].

Returns

The production [kW] of the solar PV array.

Reimplemented from Renewable.

```
1573 {
1574     //  given production time series override
1575     if (this->normalized_production_series_given) {
1576         double production_kW = Production :: getProductionkW(timestep);
1577 
1578         return production_kW;
1579     }
1580 
1581     // check if no resource
1582     if (solar_resource_kWm2 <= 0) {
1583         return 0;
1584     }
1585 
1586     // compute production
1587     double production_kW = 0;
1588 
1589     switch (this->power_model) {
1590         case (SolarPowerProductionModel :: SOLAR_POWER_SIMPLE): {
1591             production_kW = this->__computeSimpleProductionkW(
1592                 timestep,
1593                 dt_hrs,
1594                 solar_resource_kWm2
1595             );
1596 
1597             break;
1598         }
1599 
1600         case (SolarPowerProductionModel :: SOLAR_POWER_DETAILED): {
1601             production_kW = this->__computeDetailedProductionkW(
1602                 timestep,
1603                 dt_hrs,
1604                 solar_resource_kWm2
1605             );
1606 
1607             break;
1608         }
1609 
1610         default: {
1611             std::string error_str = "ERROR:  Solar::computeProductionkW():  ";
1612             error_str += "power model ";
1613             error_str += std::to_string(this->power_model);
1614             error_str += " not recognized";
1615 
1616             #ifdef _WIN32
1617                 std::cout « error_str « std::endl;
1618             #endif
1619 
1620             throw std::runtime_error(error_str);
1621 
1622             break;
1623         }
1624     }
```

```
1625
1626     return production_kW;
1627 }   /* computeProductionkW() */
```

4.24.3.29 handleReplacement()

```
void Solar::handleReplacement (
             int timestep )  [virtual]
```

Method to handle asset replacement and capital cost incursion, if applicable.

Parameters

timestep	The current time step of the Model run.

Reimplemented from Renewable.

```
1533 {
1534     //  1. reset attributes
1535     //...
1536
1537     //  2. invoke base class method
1538     Renewable :: handleReplacement(timestep);
1539
1540     return;
1541 }   /* __handleReplacement() */
```

4.24.4 Member Data Documentation

4.24.4.1 albedo_ground_reflectance

```
double Solar::albedo_ground_reflectance
```

The albedo (ground reflectance) to be applied in modelling the solar PV array.

4.24.4.2 derating

```
double Solar::derating
```

The derating of the solar PV array (i.e., shadowing, soiling, etc.).

4.24.4.3 julian_day

```
double Solar::julian_day
```

The number of days (including partial days) since 12:00 on 1 Jan 2000.

4.24.4.4 latitude_deg

```
double Solar::latitude_deg
```

The latitude of the solar PV array [deg].

4.24.4.5 latitude_rad

```
double Solar::latitude_rad
```

The latitude of the solar PV array [rad].

4.24.4.6 longitude_deg

```
double Solar::longitude_deg
```

The longitude of the solar PV array [deg].

4.24.4.7 longitude_rad

```
double Solar::longitude_rad
```

The longitude of the solar PV array [rad].

4.24.4.8 panel_azimuth_deg

```
double Solar::panel_azimuth_deg
```

The azimuth angle of the panels [deg], relative to north.

4.24.4.9 panel_azimuth_rad

```
double Solar::panel_azimuth_rad
```

The azimuth angle of the panels [rad], relative to north.

4.24.4.10 panel_tilt_deg

```
double Solar::panel_tilt_deg
```

The tilt angle of the panels [deg], relative to ground.

4.24.4.11 panel_tilt_rad

```
double Solar::panel_tilt_rad
```

The tilt angle of the panels [rad], relative to ground.

4.24.4.12 power_model

```
SolarPowerProductionModel Solar::power_model
```

The solar power production model to be applied.

4.24.4.13 power_model_string

```
std::string Solar::power_model_string
```

A string describing the active power production model.

The documentation for this class was generated from the following files:

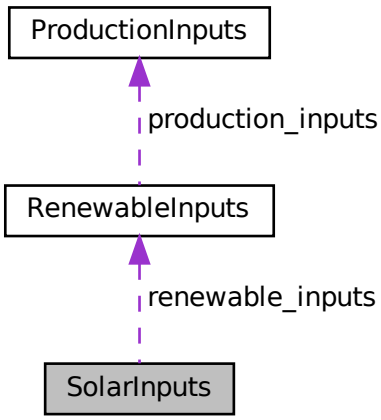
- header/Production/Renewable/Solar.h
- source/Production/Renewable/Solar.cpp

4.25 SolarInputs Struct Reference

A structure which bundles the necessary inputs for the Solar constructor. Provides default values for every necessary input. Note that this structure encapsulates RenewableInputs.

`#include <Solar.h>`

Collaboration diagram for SolarInputs:



Public Attributes

- RenewableInputs renewable_inputs

  An encapsulated RenewableInputs instance.
- int resource_key = 0

  A key used to index into the Resources object, to associate this asset with the appropriate resource time series.
- double capital_cost = -1

  The capital cost of the asset (undefined currency). -1 is a sentinel value, which triggers a generic cost model on construction (in fact, any negative value here will trigger). Note that the generic cost model is in terms of Canadian dollars [CAD].
- double operation_maintenance_cost_kWh = -1

  The operation and maintenance cost of the asset [1/kWh] (undefined currency). This is a cost incurred per unit of energy produced. -1 is a sentinel value, which triggers a generic cost model on construction (in fact, any negative value here will trigger). Note that the generic cost model is in terms of Canadian dollars [CAD/kWh].
- double derating = 0.8

  The derating of the solar PV array (i.e., shadowing, soiling, etc.).
- double julian_day = 0

  The number of days (including partial days) since 12:00 on 1 Jan 2000.
- double latitude_deg = 0

  The latitude of the solar PV array [deg].
- double longitude_deg = 0

  The longitude of the solar PV array [deg].
- double panel_azimuth_deg = 0

The azimuth angle of the panels [deg], relative to north.

- double panel_tilt_deg = 0

  The tilt angle of the panels [deg], relative to ground.

- double albedo_ground_reflectance = 0.5

  The albedo (ground reflectance) to be applied in modelling the solar PV array.

- SolarPowerProductionModel power_model = SolarPowerProductionModel :: SOLAR_POWER_SIMPLE

  The solar power production model to be applied.

4.25.1 Detailed Description

A structure which bundles the necessary inputs for the Solar constructor. Provides default values for every necessary input. Note that this structure encapsulates RenewableInputs.

4.25.2 Member Data Documentation

4.25.2.1 albedo_ground_reflectance

```
double SolarInputs::albedo_ground_reflectance = 0.5
```

The albedo (ground reflectance) to be applied in modelling the solar PV array.

4.25.2.2 capital_cost

```
double SolarInputs::capital_cost = -1
```

The capital cost of the asset (undefined currency). -1 is a sentinel value, which triggers a generic cost model on construction (in fact, any negative value here will trigger). Note that the generic cost model is in terms of Canadian dollars [CAD].

4.25.2.3 derating

```
double SolarInputs::derating = 0.8
```

The derating of the solar PV array (i.e., shadowing, soiling, etc.).

4.25.2.4 julian_day

```
double SolarInputs::julian_day = 0
```

The number of days (including partial days) since 12:00 on 1 Jan 2000.

4.25.2.5 latitude_deg

```
double SolarInputs::latitude_deg = 0
```

The latitude of the solar PV array [deg].

4.25.2.6 longitude_deg

```
double SolarInputs::longitude_deg = 0
```

The longitude of the solar PV array [deg].

4.25.2.7 operation_maintenance_cost_kWh

```
double SolarInputs::operation_maintenance_cost_kWh = -1
```

The operation and maintenance cost of the asset [1/kWh] (undefined currency). This is a cost incurred per unit of energy produced. -1 is a sentinel value, which triggers a generic cost model on construction (in fact, any negative value here will trigger). Note that the generic cost model is in terms of Canadian dollars [CAD/kWh].

4.25.2.8 panel_azimuth_deg

```
double SolarInputs::panel_azimuth_deg = 0
```

The azimuth angle of the panels [deg], relative to north.

4.25.2.9 panel_tilt_deg

```
double SolarInputs::panel_tilt_deg = 0
```

The tilt angle of the panels [deg], relative to ground.

4.25.2.10 power_model

```
SolarPowerProductionModel SolarInputs::power_model = SolarPowerProductionModel ::  SOLAR_POWER_SIMPLE
```

The solar power production model to be applied.

4.25.2.11 renewable_inputs

```
RenewableInputs SolarInputs::renewable_inputs
```

An encapsulated RenewableInputs instance.

4.25.2.12 resource_key

```
int SolarInputs::resource_key = 0
```

A key used to index into the Resources object, to associate this asset with the appropriate resource time series.

The documentation for this struct was generated from the following file:

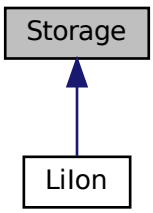
- header/Production/Renewable/Solar.h

4.26 Storage Class Reference

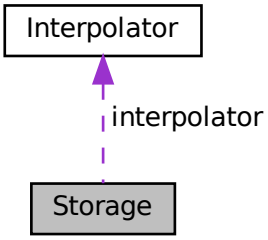
The base class of the Storage hierarchy. This hierarchy contains derived classes which model the storage of energy.

```
#include <Storage.h>
```

Inheritance diagram for Storage:



Collaboration diagram for Storage:



Public Member Functions

- Storage (void)

  Constructor (dummy) for the Storage class.
- Storage (int, double, StorageInputs)

  Constructor (intended) for the Storage class.
- virtual void handleReplacement (int)

  Method to handle asset replacement and capital cost incursion, if applicable.
- void computeEconomics (std::vector< double > *)

  Helper method to compute key economic metrics for the Model run.
- virtual double getAvailablekW (double)
- virtual double getAcceptablekW (double)
- virtual void commitCharge (int, double, double)
- virtual double commitDischarge (int, double, double, double)
- void writeResults (std::string, std::vector< double > *, int, int=-1)

  Method which writes Storage results to an output directory.
- virtual ~Storage (void)

  Destructor for the Storage class.

Public Attributes

- StorageType type

  The type (StorageType) of the asset.
- Interpolator interpolator

  Interpolator component of Storage.
- bool print_flag

  A flag which indicates whether or not object construct/destruction should be verbose.
- bool is_depleted

  A boolean which indicates whether or not the asset is currently considered depleted.
- bool is_sunk

  A boolean which indicates whether or not the asset should be considered a sunk cost (i.e., capital cost incurred at the start of the model, or no).
- int n_points

  The number of points in the modelling time series.

- int n_replacements

  The number of times the asset has been replaced.
- double n_years

  The number of years being modelled.
- double power_capacity_kW

  The rated power capacity [kW] of the asset.
- double energy_capacity_kWh

  The rated energy capacity [kWh] of the asset.
- double charge_kWh

  The energy [kWh] stored in the asset.
- double power_kW

  The power [kW] currently being charged/discharged by the asset.
- double nominal_inflation_annual

  The nominal, annual inflation rate to use in computing model economics.
- double nominal_discount_annual

  The nominal, annual discount rate to use in computing model economics.
- double real_discount_annual

  The real, annual discount rate used in computing model economics. Is computed from the given nominal inflation and discount rates.
- double capital_cost

  The capital cost of the asset (undefined currency).
- double operation_maintenance_cost_kWh

  The operation and maintenance cost of the asset [1/kWh] (undefined currency). This is a cost incurred per unit of energy charged/discharged.
- double net_present_cost

  The net present cost of this asset.
- double total_discharge_kWh

  The total energy discharged [kWh] over the Model run.
- double levellized_cost_of_energy_kWh

  The levellized cost of energy [1/kWh] (undefined currency) of this asset. This metric considers only discharge.
- std::string type_str

  A string describing the type of the asset.
- std::vector< double > charge_vec_kWh

  A vector of the charge state [kWh] at each point in the modelling time series.
- std::vector< double > charging_power_vec_kW

  A vector of the charging power [kW] at each point in the modelling time series.
- std::vector< double > discharging_power_vec_kW

  A vector of the discharging power [kW] at each point in the modelling time series.
- std::vector< double > capital_cost_vec

  A vector of capital costs (undefined currency) incurred over each modelling time step. These costs are not discounted (i.e., these are actual costs).
- std::vector< double > operation_maintenance_cost_vec

  A vector of operation and maintenance costs (undefined currency) incurred over each modelling time step. These costs are not discounted (i.e., these are actual costs).

Private Member Functions

- void __checkInputs (int, double, StorageInputs)

  Helper method to check inputs to the Storage constructor.
- double __computeRealDiscountAnnual (double, double)

  Helper method to compute the real, annual discount rate to be used in computing model economics. This enables application of the discount factor approach.
- virtual void __writeSummary (std::string)
- virtual void __writeTimeSeries (std::string, std::vector< double > *, int=-1)

4.26.1 Detailed Description

The base class of the Storage hierarchy. This hierarchy contains derived classes which model the storage of energy.

4.26.2 Constructor & Destructor Documentation

4.26.2.1 Storage() [1/2]

```
Storage::Storage (
            void  )
```

Constructor (dummy) for the Storage class.

```
176 {
177     return;
178 }   /* Storage() */
```

4.26.2.2 Storage() [2/2]

```
Storage::Storage (
            int n_points,
            double n_years,
            StorageInputs storage_inputs )
```

Constructor (intended) for the Storage class.

Parameters

n_points	The number of points in the modelling time series.
n_years	The number of years being modelled.
storage_inputs	A structure of Storage constructor inputs.

```
207 {
208     //  1. check inputs
209     this->__checkInputs(n_points, n_years, storage_inputs);
210 
211     //  2. set attributes
212     this->print_flag = storage_inputs.print_flag;
213     this->is_depleted = false;
214     this->is_sunk = storage_inputs.is_sunk;
215 
216     this->n_points = n_points;
217     this->n_replacements = 0;
218 
219     this->n_years = n_years;
220 
221     this->power_capacity_kW = storage_inputs.power_capacity_kW;
222     this->energy_capacity_kWh = storage_inputs.energy_capacity_kWh;
223 
224     this->charge_kWh = 0;
225     this->power_kW = 0;
226 
227     this->nominal_inflation_annual = storage_inputs.nominal_inflation_annual;
228     this->nominal_discount_annual = storage_inputs.nominal_discount_annual;
229 
230     this->real_discount_annual = this->__computeRealDiscountAnnual(
231         storage_inputs.nominal_inflation_annual,
```

```
232         storage_inputs.nominal_discount_annual
233     );
234
235     this->capital_cost = 0;
236     this->operation_maintenance_cost_kWh = 0;
237     this->net_present_cost = 0;
238     this->total_discharge_kWh = 0;
239     this->levellized_cost_of_energy_kWh = 0;
240
241     this->charge_vec_kWh.resize(this->n_points, 0);
242     this->charging_power_vec_kW.resize(this->n_points, 0);
243     this->discharging_power_vec_kW.resize(this->n_points, 0);
244
245     this->capital_cost_vec.resize(this->n_points, 0);
246     this->operation_maintenance_cost_vec.resize(this->n_points, 0);
247
248     //  3. construction print
249     if (this->print_flag) {
250         std::cout « "Storage object constructed at " « this « std::endl;
251     }
252
253     return;
254 }   /* Storage() */
```

4.26.2.3 ~Storage()

```
Storage::~Storage (
            void  )  [virtual]
```

Destructor for the Storage class.

```
439 {
440     //  1. destruction print
441     if (this->print_flag) {
442         std::cout « "Storage object at " « this « " destroyed" « std::endl;
443     }
444
445     return;
446 }   /* ~Storage() */
```

4.26.3 Member Function Documentation

4.26.3.1 __checkInputs()

```
void Storage::__checkInputs (
            int n_points,
            double n_years,
            StorageInputs storage_inputs )  [private]
```

Helper method to check inputs to the Storage constructor.

Parameters

n_points	The number of points in the modelling time series.
storage_inputs	A structure of Storage constructor inputs.

```
70 {
71     //  1. check n_points
72     if (n_points <= 0) {
73         std::string error_str = "ERROR:  Storage():  n_points must be > 0";
```

```
74
75          #ifdef _WIN32
76              std::cout « error_str « std::endl;
77          #endif
78
79          throw std::invalid_argument(error_str);
80      }
81
82      //  2. check n_years
83      if (n_years <= 0) {
84          std::string error_str = "ERROR:  Storage():  n_years must be > 0";
85
86          #ifdef _WIN32
87              std::cout « error_str « std::endl;
88          #endif
89
90          throw std::invalid_argument(error_str);
91      }
92
93      //  3. check power_capacity_kW
94      if (storage_inputs.power_capacity_kW <= 0) {
95          std::string error_str = "ERROR:  Storage():  ";
96          error_str += "StorageInputs::power_capacity_kW must be > 0";
97
98          #ifdef _WIN32
99              std::cout « error_str « std::endl;
100          #endif
101
102         throw std::invalid_argument(error_str);
103     }
104
105     //  4. check energy_capacity_kWh
106     if (storage_inputs.energy_capacity_kWh <= 0) {
107         std::string error_str = "ERROR:  Storage():  ";
108         error_str += "StorageInputs::energy_capacity_kWh must be > 0";
109
110         #ifdef _WIN32
111             std::cout « error_str « std::endl;
112         #endif
113
114         throw std::invalid_argument(error_str);
115     }
116
117     return;
118 }   /* __checkInputs() */
```

4.26.3.2 __computeRealDiscountAnnual()

```
double Storage::__computeRealDiscountAnnual (
            double nominal_inflation_annual,
            double nominal_discount_annual )  [private]
```

Helper method to compute the real, annual discount rate to be used in computing model economics. This enables application of the discount factor approach.

Ref: HOMER [2023h]
Ref: HOMER [2023b]

Parameters

nominal_inflation_annual	The nominal, annual inflation rate to use in computing model economics.
nominal_discount_annual	The nominal, annual discount rate to use in computing model economics.

Returns

The real, annual discount rate to use in computing model economics.

```
152 {
153     double real_discount_annual = nominal_discount_annual - nominal_inflation_annual;
154     real_discount_annual /= 1 + nominal_inflation_annual;
155 
156     return real_discount_annual;
157 }   /* __computeRealDiscountAnnual() */
```

4.26.3.3 __writeSummary()

```
virtual void Storage::__writeSummary (
            std::string  )  [inline], [private], [virtual]
```

Reimplemented in Lilon.

```
104 {return;}
```

4.26.3.4 __writeTimeSeries()

```
virtual void Storage::__writeTimeSeries (
            std::string ,
            std::vector< double > * ,
            int  = -1 )  [inline], [private], [virtual]
```

Reimplemented in Lilon.

```
105 {return;}
```

4.26.3.5 commitCharge()

```
virtual void Storage::commitCharge (
            int ,
            double ,
            double  )  [inline], [virtual]
```

Reimplemented in Lilon.

```
159 {return;}
```

4.26.3.6 commitDischarge()

```
virtual double Storage::commitDischarge (
            int ,
            double ,
            double ,
            double  )  [inline], [virtual]
```

Reimplemented in Lilon.

```
160 {return 0;}
```

4.26.3.7 computeEconomics()

```
void Storage::computeEconomics (
            std::vector< double > * time_vec_hrs_ptr )
```

Helper method to compute key economic metrics for the Model run.

Ref: HOMER [2023b]
Ref: HOMER [2023g]
Ref: HOMER [2023i]
Ref: HOMER [2023a]

Parameters

time_vec_hrs_ptr	A pointer to the time_vec_hrs attribute of the ElectricalLoad.

1. compute levellized cost of energy (per unit discharged)

```
307 {
308     //  1. compute net present cost
309     double t_hrs = 0;
310     double real_discount_scalar = 0;
311
312     for (int i = 0; i < this->n_points; i++) {
313         t_hrs = time_vec_hrs_ptr->at(i);
314
315         real_discount_scalar = 1.0 / pow(
316             1 + this->real_discount_annual,
317             t_hrs / 8760
318         );
319
320         this->net_present_cost += real_discount_scalar * this->capital_cost_vec[i];
321
322         this->net_present_cost +=
323             real_discount_scalar * this->operation_maintenance_cost_vec[i];
324     }
325
327     //     assuming 8,760 hours per year
328     if (this->total_discharge_kWh <= 0) {
329         this->levellized_cost_of_energy_kWh = this->net_present_cost;
330     }
331
332     else {
333         double n_years = time_vec_hrs_ptr->at(this->n_points - 1) / 8760;
334
335         double capital_recovery_factor =
336             (this->real_discount_annual * pow(1 + this->real_discount_annual, n_years)) /
337             (pow(1 + this->real_discount_annual, n_years) - 1);
338
339         double total_annualized_cost = capital_recovery_factor *
340             this->net_present_cost;
341
342         this->levellized_cost_of_energy_kWh =
343             (n_years * total_annualized_cost) /
344             this->total_discharge_kWh;
345     }
346
347     return;
348 }   /* computeEconomics() */
```

4.26.3.8 getAcceptablekW()

```
virtual double Storage::getAcceptablekW (
            double  )  [inline], [virtual]
```

Reimplemented in LiIon.

```
157 {return 0;}
```

4.26.3.9 getAvailablekW()

```
virtual double Storage::getAvailablekW (
            double  )  [inline], [virtual]
```

Reimplemented in LiIon.

```
156 {return 0;}
```

4.26.3.10 handleReplacement()

```
void Storage::handleReplacement (
            int timestep )  [virtual]
```

Method to handle asset replacement and capital cost incursion, if applicable.

Parameters

timestep	The current time step of the Model run.

Reimplemented in LiIon.

```
272 {
273     //  1. reset attributes
274     this->charge_kWh = 0;
275     this->power_kW = 0;
276 
277     //  2. log replacement
278     this->n_replacements++;
279 
280     //  3. incur capital cost in timestep
281     this->capital_cost_vec[timestep] = this->capital_cost;
282 
283     return;
284 }   /* __handleReplacement() */
```

4.26.3.11 writeResults()

```
void Storage::writeResults (
            std::string write_path,
            std::vector< double > * time_vec_hrs_ptr,
            int storage_index,
            int max_lines = -1 )
```

Method which writes Storage results to an output directory.

Parameters

write_path	A path (either relative or absolute) to the directory location where results are to be written. If already exists, will overwrite.
time_vec_hrs_ptr	A pointer to the time_vec_hrs attribute of the ElectricalLoad.
storage_index	An integer which corresponds to the index of the Storage asset in the Model.
max_lines	The maximum number of lines of output to write. If <0, then all available lines are written. If =0, then only summary results are written.

```
385 {
386     //  1. handle sentinel
387     if (max_lines < 0) {
388         max_lines = this->n_points;
389     }
390 
391     //  2. create subdirectories
392     write_path += "Storage/";
393     if (not std::filesystem::is_directory(write_path)) {
394         std::filesystem::create_directory(write_path);
395     }
396 
397     write_path += this->type_str;
398     write_path += "_";
399     write_path += std::to_string(int(ceil(this->power_capacity_kW)));
400     write_path += "kW_";
401     write_path += std::to_string(int(ceil(this->energy_capacity_kWh)));
402     write_path += "kWh_idx";
403     write_path += std::to_string(storage_index);
404     write_path += "/";
405     std::filesystem::create_directory(write_path);
406 
407     //  3. write summary
408     this->__writeSummary(write_path);
409 
410     //  4. write time series
411     if (max_lines > this->n_points) {
412         max_lines = this->n_points;
413     }
414 
415     if (max_lines > 0) {
416         this->__writeTimeSeries(
417             write_path,
418             time_vec_hrs_ptr,
419             max_lines
420         );
421     }
422 
423     return;
424 }   /* writeResults() */
```

4.26.4 Member Data Documentation

4.26.4.1 capital_cost

```
double Storage::capital_cost
```

The capital cost of the asset (undefined currency).

4.26.4.2 capital_cost_vec

```
std::vector<double> Storage::capital_cost_vec
```

A vector of capital costs (undefined currency) incurred over each modelling time step. These costs are not discounted (i.e., these are actual costs).

4.26.4.3 charge_kWh

```
double Storage::charge_kWh
```

The energy [kWh] stored in the asset.

4.26.4.4 charge_vec_kWh

```
std::vector<double> Storage::charge_vec_kWh
```

A vector of the charge state [kWh] at each point in the modelling time series.

4.26.4.5 charging_power_vec_kW

```
std::vector<double> Storage::charging_power_vec_kW
```

A vector of the charging power [kW] at each point in the modelling time series.

4.26.4.6 discharging_power_vec_kW

```
std::vector<double> Storage::discharging_power_vec_kW
```

A vector of the discharging power [kW] at each point in the modelling time series.

4.26.4.7 energy_capacity_kWh

```
double Storage::energy_capacity_kWh
```

The rated energy capacity [kWh] of the asset.

4.26.4.8 interpolator

```
Interpolator Storage::interpolator
```

Interpolator component of Storage.

4.26.4.9 is_depleted

```
bool Storage::is_depleted
```

A boolean which indicates whether or not the asset is currently considered depleted.

4.26.4.10 is_sunk

```
bool Storage::is_sunk
```

A boolean which indicates whether or not the asset should be considered a sunk cost (i.e., capital cost incurred at the start of the model, or no).

4.26.4.11 levellized_cost_of_energy_kWh

```
double Storage::levellized_cost_of_energy_kWh
```

The levellized cost of energy [1/kWh] (undefined currency) of this asset. This metric considers only discharge.

4.26.4.12 n_points

```
int Storage::n_points
```

The number of points in the modelling time series.

4.26.4.13 n_replacements

```
int Storage::n_replacements
```

The number of times the asset has been replaced.

4.26.4.14 n_years

```
double Storage::n_years
```

The number of years being modelled.

4.26.4.15 net_present_cost

```
double Storage::net_present_cost
```

The net present cost of this asset.

4.26.4.16 nominal_discount_annual

```
double Storage::nominal_discount_annual
```

The nominal, annual discount rate to use in computing model economics.

4.26.4.17 nominal_inflation_annual

```
double Storage::nominal_inflation_annual
```

The nominal, annual inflation rate to use in computing model economics.

4.26.4.18 operation_maintenance_cost_kWh

```
double Storage::operation_maintenance_cost_kWh
```

The operation and maintenance cost of the asset [1/kWh] (undefined currency). This is a cost incurred per unit of energy charged/discharged.

4.26.4.19 operation_maintenance_cost_vec

```
std::vector<double> Storage::operation_maintenance_cost_vec
```

A vector of operation and maintenance costs (undefined currency) incurred over each modelling time step. These costs are not discounted (i.e., these are actual costs).

4.26.4.20 power_capacity_kW

```
double Storage::power_capacity_kW
```

The rated power capacity [kW] of the asset.

4.26.4.21 power_kW

```
double Storage::power_kW
```

The power [kW] currently being charged/discharged by the asset.

4.26.4.22 print_flag

```
bool Storage::print_flag
```

A flag which indicates whether or not object construct/destruction should be verbose.

4.26.4.23 real_discount_annual

```
double Storage::real_discount_annual
```

The real, annual discount rate used in computing model economics. Is computed from the given nominal inflation and discount rates.

4.26.4.24 total_discharge_kWh

```
double Storage::total_discharge_kWh
```

The total energy discharged [kWh] over the Model run.

4.26.4.25 type

```
StorageType Storage::type
```

The type (StorageType) of the asset.

4.26.4.26 type_str

```
std::string Storage::type_str
```

A string describing the type of the asset.

The documentation for this class was generated from the following files:

- header/Storage/Storage.h
- source/Storage/Storage.cpp

4.27 StorageInputs Struct Reference

A structure which bundles the necessary inputs for the Storage constructor. Provides default values for every necessary input.

`#include <Storage.h>`

Public Attributes

- bool print_flag = false

  A flag which indicates whether or not object construct/destruction should be verbose.
- bool is_sunk = false

  A boolean which indicates whether or not the asset should be considered a sunk cost (i.e., capital cost incurred at the start of the model, or no).
- double power_capacity_kW = 100

  The rated power capacity [kW] of the asset.
- double energy_capacity_kWh = 1000

  The rated energy capacity [kWh] of the asset.
- double nominal_inflation_annual = 0.02

  The nominal, annual inflation rate to use in computing model economics.
- double nominal_discount_annual = 0.04

  The nominal, annual discount rate to use in computing model economics.

4.27.1 Detailed Description

A structure which bundles the necessary inputs for the Storage constructor. Provides default values for every necessary input.

4.27.2 Member Data Documentation

4.27.2.1 energy_capacity_kWh

```
double StorageInputs::energy_capacity_kWh = 1000
```

The rated energy capacity [kWh] of the asset.

4.27.2.2 is_sunk

```
bool StorageInputs::is_sunk = false
```

A boolean which indicates whether or not the asset should be considered a sunk cost (i.e., capital cost incurred at the start of the model, or no).

4.27.2.3 nominal_discount_annual

```
double StorageInputs::nominal_discount_annual = 0.04
```

The nominal, annual discount rate to use in computing model economics.

4.27.2.4 nominal_inflation_annual

```
double StorageInputs::nominal_inflation_annual = 0.02
```

The nominal, annual inflation rate to use in computing model economics.

4.27.2.5 power_capacity_kW

```
double StorageInputs::power_capacity_kW = 100
```

The rated power capacity [kW] of the asset.

4.27.2.6 print_flag

```
bool StorageInputs::print_flag = false
```

A flag which indicates whether or not object construct/destruction should be verbose.

The documentation for this struct was generated from the following file:

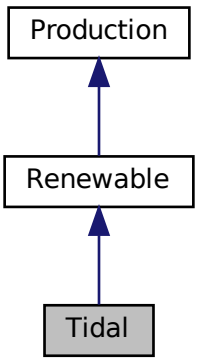
- header/Storage/Storage.h

4.28 Tidal Class Reference

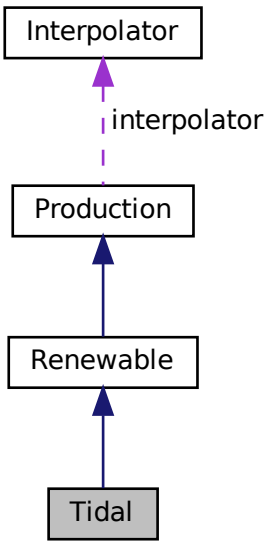
A derived class of the Renewable branch of Production which models tidal production.

`#include <Tidal.h>`

Inheritance diagram for Tidal:



Collaboration diagram for Tidal:



Public Member Functions

- Tidal (void)

  Constructor (dummy) for the Tidal class.
- Tidal (int, double, TidalInputs, std::vector< double > *)

  Constructor (intended) for the Tidal class.
- void handleReplacement (int)

  Method to handle asset replacement and capital cost incursion, if applicable.
- double computeProductionkW (int, double, double)

  Method which takes in the tidal resource at a particular point in time, and then returns the tidal turbine production at that point in time.
- double commit (int, double, double, double)

  Method which takes in production and load for the current timestep, computes and records dispatch and curtailment, and then returns remaining load.
- ~Tidal (void)

  Destructor for the Tidal class.

Public Attributes

- double design_speed_ms

  The tidal stream speed [m/s] at which the tidal turbine achieves its rated capacity.
- TidalPowerProductionModel power_model

  The tidal power production model to be applied.
- std::string power_model_string

  A string describing the active power production model.

Private Member Functions

- void __checkInputs (TidalInputs)

  Helper method to check inputs to the Tidal constructor.
- double __getGenericCapitalCost (void)

  Helper method to generate a generic tidal turbine capital cost.
- double __getGenericOpMaintCost (void)

  Helper method to generate a generic tidal turbine operation and maintenance cost. This is a cost incurred per unit energy produced.
- double __computeCubicProductionkW (int, double, double)

  Helper method to compute tidal turbine production under a cubic production model.
- double __computeExponentialProductionkW (int, double, double)

  Helper method to compute tidal turbine production under an exponential production model.
- double __computeLookupProductionkW (int, double, double)

  Helper method to compute tidal turbine production by way of looking up using given power curve data.
- void __writeSummary (std::string)

  Helper method to write summary results for Tidal.
- void __writeTimeSeries (std::string, std::vector< double > *, std::map< int, std::vector< double >> *, std::map< int, std::vector< std::vector< double >>> *, int=-1)

  Helper method to write time series results for Tidal.

4.28.1 Detailed Description

A derived class of the Renewable branch of Production which models tidal production.

4.28.2 Constructor & Destructor Documentation

4.28.2.1 Tidal() [1/2]

```
Tidal::Tidal (
            void  )
```

Constructor (dummy) for the Tidal class.

```
481 {
482     return;
483 }   /* Tidal() */
```

4.28.2.2 Tidal() [2/2]

```
Tidal::Tidal (
            int n_points,
            double n_years,
            TidalInputs tidal_inputs,
            std::vector< double > * time_vec_hrs_ptr )
```

Constructor (intended) for the Tidal class.

Parameters

n_points	The number of points in the modelling time series.
n_years	The number of years being modelled.
tidal_inputs	A structure of Tidal constructor inputs.
time_vec_hrs_ptr	A pointer to the vector containing the modelling time series.

```
515   :
516 Renewable(
517     n_points,
518     n_years,
519     tidal_inputs.renewable_inputs,
520     time_vec_hrs_ptr
521 )
522 {
523     //  1. check inputs
524     this->__checkInputs(tidal_inputs);
525 
526     //  2. set attributes
527     this->type = RenewableType :: TIDAL;
528     this->type_str = "TIDAL";
529 
530     this->resource_key = tidal_inputs.resource_key;
531 
532     this->design_speed_ms = tidal_inputs.design_speed_ms;
533 
534     this->power_model = tidal_inputs.power_model;
535 
536     switch (this->power_model) {
537         case (TidalPowerProductionModel :: TIDAL_POWER_CUBIC): {
538             this->power_model_string = "CUBIC";
539 
540             break;
541         }
542 
543         case (TidalPowerProductionModel :: TIDAL_POWER_EXPONENTIAL): {
544             this->power_model_string = "EXPONENTIAL";
545 
```

```
546             break;
547         }
548
549         case (TidalPowerProductionModel :: TIDAL_POWER_LOOKUP): {
550             this->power_model_string = "LOOKUP";
551
552             break;
553         }
554
555         default: {
556             std::string error_str = "ERROR:  Tidal():  ";
557             error_str += "power production model ";
558             error_str += std::to_string(this->power_model);
559             error_str += " not recognized";
560
561             #ifdef _WIN32
562                 std::cout << error_str << std::endl;
563             #endif
564
565             throw std::runtime_error(error_str);
566
567             break;
568         }
569     }
570
571     if (tidal_inputs.capital_cost < 0) {
572         this->capital_cost = this->__getGenericCapitalCost();
573     }
574     else {
575         this->capital_cost = tidal_inputs.capital_cost;
576     }
577
578     if (tidal_inputs.operation_maintenance_cost_kWh < 0) {
579         this->operation_maintenance_cost_kWh = this->__getGenericOpMaintCost();
580     }
581     else {
582         this->operation_maintenance_cost_kWh =
583             tidal_inputs.operation_maintenance_cost_kWh;
584     }
585
586     if (not this->is_sunk) {
587         this->capital_cost_vec[0] = this->capital_cost;
588     }
589
590     //  3. construction print
591     if (this->print_flag) {
592         std::cout << "Tidal object constructed at " << this << std::endl;
593     }
594
595     return;
596 }   /* Renewable() */
```

4.28.2.3 ~Tidal()

```
Tidal::~Tidal (
            void  )
```

Destructor for the Tidal class.

```
783 {
784     //  1. destruction print
785     if (this->print_flag) {
786         std::cout << "Tidal object at " << this << " destroyed" << std::endl;
787     }
788
789     return;
790 }   /* ~Tidal() */
```

4.28.3 Member Function Documentation

4.28.3.1 __checkInputs()

```
void Tidal::__checkInputs (
            TidalInputs tidal_inputs )  [private]
```

Helper method to check inputs to the Tidal constructor.

Ref: Bir et al. [2011]
Ref: Lewis et al. [2021]

```
65 {
66     //  1. check design_speed_ms
67     if (tidal_inputs.design_speed_ms <= 0) {
68         std::string error_str = "ERROR:  Tidal():  ";
69         error_str += "TidalInputs::design_speed_ms must be > 0";
70 
71         #ifdef _WIN32
72             std::cout « error_str « std::endl;
73         #endif
74 
75         throw std::invalid_argument(error_str);
76     }
77 
78     else if (tidal_inputs.design_speed_ms < 2) {
79         std::string warning_str = "WARNING:  Tidal():  ";
80         warning_str += "Setting TidalInputs::design_speed_ms to less than 2 m/s may be ";
81         warning_str += "technically unrealistic";
82 
83         std::cout « warning_str « std::endl;
84     }
85 
86     return;
87 }   /* __checkInputs() */
```

4.28.3.2 __computeCubicProductionkW()

```
double Tidal::__computeCubicProductionkW (
            int timestep,
            double dt_hrs,
            double tidal_resource_ms )  [private]
```

Helper method to compute tidal turbine production under a cubic production model.

Ref: Buckham et al. [2023]
Ref: Bir et al. [2011]
Ref: Lewis et al. [2021]
Ref: Whitby and Ugalde-Loo [2013]

Parameters

timestep	The current time step of the Model run.
dt_hrs	The interval of time [hrs] associated with the action.
tidal_resource_ms	The available tidal stream resource [m/s].

Returns

The production [kW] of the tidal turbine, under a cubic model.

```
177 {
```

```
178     double production = 0;
179
180     if (
181         tidal_resource_ms < 0.15 * this->design_speed_ms or
182         tidal_resource_ms > 1.25 * this->design_speed_ms
183     ){
184         production = 0;
185     }
186
187     else if (
188         0.15 * this->design_speed_ms <= tidal_resource_ms and
189         tidal_resource_ms <= this->design_speed_ms
190     ) {
191         production = (1 / pow(this->design_speed_ms, 3)) * pow(tidal_resource_ms, 3);
192     }
193
194     else {
195         production = 1;
196     }
197
198     return production * this->capacity_kW;
199 }   /* __computeCubicProductionkW() */
```

4.28.3.3 __computeExponentialProductionkW()

```
double Tidal::__computeExponentialProductionkW (
              int timestep,
              double dt_hrs,
              double tidal_resource_ms )  [private]
```

Helper method to compute tidal turbine production under an exponential production model.

Ref: Truelove et al. [2019]

Parameters

timestep	The current time step of the Model run.
dt_hrs	The interval of time [hrs] associated with the action.
tidal_resource_ms	The available tidal stream resource [m/s].

Returns

The production [kW] of the tidal turbine, under an exponential model.

```
233 {
234     double production = 0;
235
236     double turbine_speed =
237         (tidal_resource_ms - this->design_speed_ms) / this->design_speed_ms;
238
239     if (turbine_speed < -0.71 or turbine_speed > 0.65) {
240         production = 0;
241     }
242
243     else if (turbine_speed >= -0.71 and turbine_speed <= 0) {
244         production = 1.69215 * exp(1.25909 * turbine_speed) - 0.69215;
245     }
246
247     else {
248         production = 1;
249     }
250
251     return production * this->capacity_kW;
252 }   /* __computeExponentialProductionkW() */
```

4.28.3.4 __computeLookupProductionkW()

```
double Tidal::__computeLookupProductionkW (
            int timestep,
            double dt_hrs,
            double tidal_resource_ms )  [private]
```

Helper method to compute tidal turbine production by way of looking up using given power curve data.

Parameters

timestep	The current time step of the Model run.
dt_hrs	The interval of time [hrs] associated with the action.
tidal_resource_ms	The available tidal stream resource [m/s].

Returns

The interpolated production [kW] of the tidal tubrine.

```
284 {
285     // *** WORK IN PROGRESS *** //
286
287     return 0;
288 }   /* __computeLookupProductionkW() */
```

4.28.3.5 __getGenericCapitalCost()

```
double Tidal::__getGenericCapitalCost (
            void  )  [private]
```

Helper method to generate a generic tidal turbine capital cost.

Note that this model expresses cost in terms of Canadian dollars [CAD].

Ref: MacDougall [2019]

Returns

A generic capital cost for the tidal turbine [CAD].

```
109 {
110     double capital_cost_per_kW = 2000 * pow(this->capacity_kW, -0.15) + 4000;
111
112     return capital_cost_per_kW * this->capacity_kW;
113 }   /* __getGenericCapitalCost() */
```

4.28.3.6 __getGenericOpMaintCost()

```
double Tidal::__getGenericOpMaintCost (
            void  )  [private]
```

Helper method to generate a generic tidal turbine operation and maintenance cost. This is a cost incurred per unit energy produced.

Note that this model expresses cost in terms of Canadian dollars [CAD/kWh].

Ref: MacDougall [2019]

Returns

A generic operation and maintenance cost, per unit energy produced, for the tidal turbine [CAD/kWh].

```
136 {
137     double operation_maintenance_cost_kWh = 0.05 * pow(this->capacity_kW, -0.2) + 0.05;
138 
139     return operation_maintenance_cost_kWh;
140 }   /* __getGenericOpMaintCost() */
```

4.28.3.7 __writeSummary()

```
void Tidal::__writeSummary (
            std::string write_path )  [private], [virtual]
```

Helper method to write summary results for Tidal.

Parameters

write_path	A path (either relative or absolute) to the directory location where results are to be written. If already exists, will overwrite.

Reimplemented from Renewable.

```
306 {
307     //  1. create filestream
308     write_path += "summary_results.md";
309     std::ofstream ofs;
310     ofs.open(write_path, std::ofstream::out);
311 
312     //  2. write summary results (markdown)
313     ofs « "# ";
314     ofs « std::to_string(int(ceil(this->capacity_kW)));
315     ofs « " kW TIDAL Summary Results\n";
316     ofs « "\n--------\n\n";
317 
318     //  2.1. Production attributes
319     ofs « "## Production Attributes\n";
320     ofs « "\n";
321 
322     ofs « "Capacity: " « this->capacity_kW « " kW  \n";
323     ofs « "\n";
324 
325     ofs « "Production Override: (N = 0 / Y = 1): "
326         « this->normalized_production_series_given « "  \n";
327     if (this->normalized_production_series_given) {
328         ofs « "Path to Normalized Production Time Series: "
329             « this->path_2_normalized_production_time_series « "  \n";
330     }
331     ofs « "\n";
332 
```

```
333     ofs « "Sunk Cost (N = 0 / Y = 1): " « this->is_sunk « "  \n";
334     ofs « "Capital Cost: " « this->capital_cost « "  \n";
335     ofs « "Operation and Maintenance Cost: " « this->operation_maintenance_cost_kWh
336         « " per kWh produced  \n";
337     ofs « "Nominal Inflation Rate (annual): " « this->nominal_inflation_annual
338         « "  \n";
339     ofs « "Nominal Discount Rate (annual): " « this->nominal_discount_annual
340         « "  \n";
341     ofs « "Real Discount Rate (annual): " « this->real_discount_annual « "  \n";
342     ofs « "\n";
343
344     ofs « "Replacement Running Hours: " « this->replace_running_hrs « "  \n";
345     ofs « "\n--------\n\n";
346
347     //  2.2. Renewable attributes
348     ofs « "## Renewable Attributes\n";
349     ofs « "\n";
350
351     ofs « "Resource Key (1D): " « this->resource_key « "  \n";
352
353     ofs « "\n--------\n\n";
354
355     //  2.3. Tidal attributes
356     ofs « "## Tidal Attributes\n";
357     ofs « "\n";
358
359     ofs « "Power Production Model: " « this->power_model_string « "  \n";
360     ofs « "Design Speed: " « this->design_speed_ms « " m/s  \n";
361
362     ofs « "\n--------\n\n";
363
364     //  2.4. Tidal Results
365     ofs « "## Results\n";
366     ofs « "\n";
367
368     ofs « "Net Present Cost: " « this->net_present_cost « "  \n";
369     ofs « "\n";
370
371     ofs « "Total Dispatch: " « this->total_dispatch_kWh
372         « " kWh  \n";
373
374     ofs « "Levellized Cost of Energy: " « this->levellized_cost_of_energy_kWh
375         « " per kWh dispatched  \n";
376     ofs « "\n";
377
378     ofs « "Running Hours: " « this->running_hours « "  \n";
379     ofs « "Replacements: " « this->n_replacements « "  \n";
380
381     ofs « "\n--------\n\n";
382
383     ofs.close();
384
385     return;
386 }   /* __writeSummary() */
```

4.28.3.8 __writeTimeSeries()

```
void Tidal::__writeTimeSeries (
              std::string write_path,
              std::vector< double > * time_vec_hrs_ptr,
              std::map< int, std::vector< double >> * resource_map_1D_ptr,
              std::map< int, std::vector< std::vector< double >>> * resource_map_2D_ptr,
              int max_lines = -1 )  [private], [virtual]
```

Helper method to write time series results for Tidal.

Parameters

write_path	A path (either relative or absolute) to the directory location where results are to be written. If already exists, will overwrite.
time_vec_hrs_ptr	A pointer to the time_vec_hrs attribute of the ElectricalLoad.
resource_map_1D_ptr	A pointer to the 1D map of Resources.
resource_map_2D_ptr	A pointer to the 2D map of Resources.
max_lines	The maximum number of lines of output to write.

Reimplemented from Renewable.

```
424 {
425     //  1. create filestream
426     write_path += "time_series_results.csv";
427     std::ofstream ofs;
428     ofs.open(write_path, std::ofstream::out);
429 
430     //  2. write time series results (comma separated value)
431     ofs « "Time (since start of data) [hrs],";
432     ofs « "Tidal Resource [m/s],";
433     ofs « "Production [kW],";
434     ofs « "Dispatch [kW],";
435     ofs « "Storage [kW],";
436     ofs « "Curtailment [kW],";
437     ofs « "Capital Cost (actual),";
438     ofs « "Operation and Maintenance Cost (actual),";
439     ofs « "\n";
440 
441     for (int i = 0; i < max_lines; i++) {
442         ofs « time_vec_hrs_ptr->at(i) « ",";
443 
444         if (not this->normalized_production_series_given) {
445             ofs « resource_map_1D_ptr->at(this->resource_key)[i] « ",";
446         }
447 
448         else {
449             ofs « "OVERRIDE" « ",";
450         }
451 
452         ofs « this->production_vec_kW[i] « ",";
453         ofs « this->dispatch_vec_kW[i] « ",";
454         ofs « this->storage_vec_kW[i] « ",";
455         ofs « this->curtailment_vec_kW[i] « ",";
456         ofs « this->capital_cost_vec[i] « ",";
457         ofs « this->operation_maintenance_cost_vec[i] « ",";
458         ofs « "\n";
459     }
460 
461     return;
462 }   /* __writeTimeSeries() */
```

4.28.3.9 commit()

```
double Tidal::commit (
              int timestep,
              double dt_hrs,
              double production_kW,
              double load_kW )  [virtual]
```

Method which takes in production and load for the current timestep, computes and records dispatch and curtailment, and then returns remaining load.

Parameters

timestep	The timestep (i.e., time series index) for the request.
dt_hrs	The interval of time [hrs] associated with the timestep.
production_kW	The production [kW] of the asset in this timestep.
load_kW	The load [kW] passed to the asset in this timestep.

Returns

The load [kW] remaining after the dispatch is deducted from it.

Reimplemented from Renewable.

```
755 {
```

```
756     //  1. invoke base class method
757     load_kW = Renewable :: commit(
758         timestep,
759         dt_hrs,
760         production_kW,
761         load_kW
762     );
763 
764 
765     //...
766 
767     return load_kW;
768 }   /* commit() */
```

4.28.3.10 computeProductionkW()

```
double Tidal::computeProductionkW (
              int timestep,
              double dt_hrs,
              double tidal_resource_ms )  [virtual]
```

Method which takes in the tidal resource at a particular point in time, and then returns the tidal turbine production at that point in time.

Parameters

timestep	The timestep (i.e., time series index) for the request.
dt_hrs	The interval of time [hrs] associated with the timestep.
tidal_resource_ms	Tidal resource (i.e. tidal stream speed) [m/s].

Returns

The production [kW] of the tidal turbine.

Reimplemented from Renewable.

```
654 {
655     //  given production time series override
656     if (this->normalized_production_series_given) {
657         double production_kW = Production :: getProductionkW(timestep);
658 
659         return production_kW;
660     }
661 
662     // check if no resource
663     if (tidal_resource_ms <= 0) {
664         return 0;
665     }
666 
667     // compute production
668     double production_kW = 0;
669 
670     switch (this->power_model) {
671         case (TidalPowerProductionModel :: TIDAL_POWER_CUBIC): {
672             production_kW = this->__computeCubicProductionkW(
673                 timestep,
674                 dt_hrs,
675                 tidal_resource_ms
676             );
677 
678             break;
679         }
680 
681 
682         case (TidalPowerProductionModel :: TIDAL_POWER_EXPONENTIAL): {
683             production_kW = this->__computeExponentialProductionkW(
684                 timestep,
```

```
685                 dt_hrs,
686                 tidal_resource_ms
687             );
688 
689             break;
690         }
691 
692         case (TidalPowerProductionModel :: TIDAL_POWER_LOOKUP): {
693             production_kW = this->__computeLookupProductionkW(
694                 timestep,
695                 dt_hrs,
696                 tidal_resource_ms
697             );
698 
699             break;
700         }
701 
702         default: {
703             std::string error_str = "ERROR:  Tidal::computeProductionkW():  ";
704             error_str += "power model ";
705             error_str += std::to_string(this->power_model);
706             error_str += " not recognized";
707 
708             #ifdef _WIN32
709                 std::cout « error_str « std::endl;
710             #endif
711 
712             throw std::runtime_error(error_str);
713 
714             break;
715         }
716     }
717 
718     return production_kW;
719 }   /* computeProductionkW() */
```

4.28.3.11 handleReplacement()

```
void Tidal::handleReplacement (
              int timestep )  [virtual]
```

Method to handle asset replacement and capital cost incursion, if applicable.

Parameters

timestep	The current time step of the Model run.

Reimplemented from Renewable.

```
614 {
615     //  1. reset attributes
616     //...
617 
618     //  2. invoke base class method
619     Renewable :: handleReplacement(timestep);
620 
621     return;
622 }   /* __handleReplacement() */
```

4.28.4 Member Data Documentation

4.28.4.1 design_speed_ms

```
double Tidal::design_speed_ms
```

The tidal stream speed [m/s] at which the tidal turbine achieves its rated capacity.

4.28.4.2 power_model

```
TidalPowerProductionModel Tidal::power_model
```

The tidal power production model to be applied.

4.28.4.3 power_model_string

```
std::string Tidal::power_model_string
```

A string describing the active power production model.

The documentation for this class was generated from the following files:

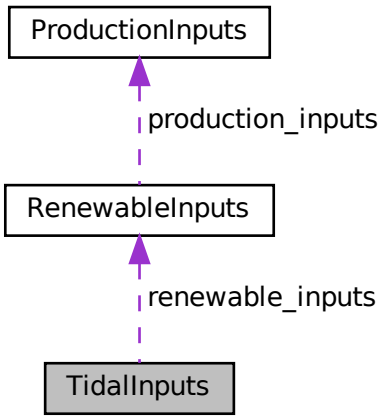
- header/Production/Renewable/Tidal.h
- source/Production/Renewable/Tidal.cpp

4.29 TidalInputs Struct Reference

A structure which bundles the necessary inputs for the Tidal constructor. Provides default values for every necessary input. Note that this structure encapsulates RenewableInputs.

```
#include <Tidal.h>
```

Collaboration diagram for TidalInputs:



Public Attributes

- RenewableInputs renewable_inputs

  An encapsulated RenewableInputs instance.
- int resource_key = 0

  A key used to index into the Resources object, to associate this asset with the appropriate resource time series.
- double capital_cost = -1

  The capital cost of the asset (undefined currency). -1 is a sentinel value, which triggers a generic cost model on construction (in fact, any negative value here will trigger). Note that the generic cost model is in terms of Canadian dollars [CAD].
- double operation_maintenance_cost_kWh = -1

  The operation and maintenance cost of the asset [1/kWh] (undefined currency). This is a cost incurred per unit of energy produced. -1 is a sentinel value, which triggers a generic cost model on construction (in fact, any negative value here will trigger). Note that the generic cost model is in terms of Canadian dollars [CAD/kWh].
- double design_speed_ms = 3

  The tidal stream speed [m/s] at which the tidal turbine achieves its rated capacity.
- TidalPowerProductionModel power_model = TidalPowerProductionModel :: TIDAL_POWER_CUBIC

  The tidal power production model to be applied.

4.29.1 Detailed Description

A structure which bundles the necessary inputs for the Tidal constructor. Provides default values for every necessary input. Note that this structure encapsulates RenewableInputs.

4.29.2 Member Data Documentation

4.29.2.1 capital_cost

```
double TidalInputs::capital_cost = -1
```

The capital cost of the asset (undefined currency). -1 is a sentinel value, which triggers a generic cost model on construction (in fact, any negative value here will trigger). Note that the generic cost model is in terms of Canadian dollars [CAD].

4.29.2.2 design_speed_ms

```
double TidalInputs::design_speed_ms = 3
```

The tidal stream speed [m/s] at which the tidal turbine achieves its rated capacity.

4.29.2.3 operation_maintenance_cost_kWh

```
double TidalInputs::operation_maintenance_cost_kWh = -1
```

The operation and maintenance cost of the asset [1/kWh] (undefined currency). This is a cost incurred per unit of energy produced. -1 is a sentinel value, which triggers a generic cost model on construction (in fact, any negative value here will trigger). Note that the generic cost model is in terms of Canadian dollars [CAD/kWh].

4.29.2.4 power_model

```
TidalPowerProductionModel TidalInputs::power_model = TidalPowerProductionModel ::  TIDAL_POWER_CUBIC
```

The tidal power production model to be applied.

4.29.2.5 renewable_inputs

```
RenewableInputs TidalInputs::renewable_inputs
```

An encapsulated RenewableInputs instance.

4.29.2.6 resource_key

```
int TidalInputs::resource_key = 0
```

A key used to index into the Resources object, to associate this asset with the appropriate resource time series.

The documentation for this struct was generated from the following file:

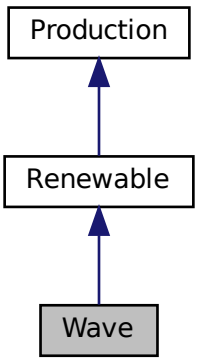
- header/Production/Renewable/Tidal.h

4.30 Wave Class Reference

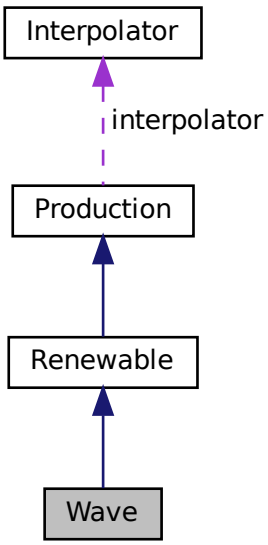
A derived class of the Renewable branch of Production which models wave production.

`#include <Wave.h>`

Inheritance diagram for Wave:



Collaboration diagram for Wave:



Public Member Functions

- Wave (void)

  Constructor (dummy) for the Wave class.
- Wave (int, double, WaveInputs, std::vector< double > *)

  Constructor (intended) for the Wave class.
- void handleReplacement (int)

  Method to handle asset replacement and capital cost incursion, if applicable.
- double computeProductionkW (int, double, double, double)

  Method which takes in the wave resource at a particular point in time, and then returns the wave turbine production at that point in time.
- double commit (int, double, double, double)

  Method which takes in production and load for the current timestep, computes and records dispatch and curtailment, and then returns remaining load.
- ~Wave (void)

  Destructor for the Wave class.

Public Attributes

- double design_significant_wave_height_m

  The significant wave height [m] at which the wave energy converter achieves its rated capacity.
- double design_energy_period_s

  The energy period [s] at which the wave energy converter achieves its rated capacity.
- WavePowerProductionModel power_model

  The wave power production model to be applied.
- std::string power_model_string

  A string describing the active power production model.

Private Member Functions

- void __checkInputs (WaveInputs)

  Helper method to check inputs to the Wave constructor.
- double __getGenericCapitalCost (void)

  Helper method to generate a generic wave energy converter capital cost.
- double __getGenericOpMaintCost (void)

  Helper method to generate a generic wave energy converter operation and maintenance cost. This is a cost incurred per unit energy produced.
- double __computeGaussianProductionkW (int, double, double, double)

  Helper method to compute wave energy converter production under a Gaussian production model.
- double __computeParaboloidProductionkW (int, double, double, double)

  Helper method to compute wave energy converter production under a paraboloid production model.
- double __computeLookupProductionkW (int, double, double, double)

  Helper method to compute wave energy converter production by way of looking up using given performance matrix.
- void __writeSummary (std::string)

  Helper method to write summary results for Wave.
- void __writeTimeSeries (std::string, std::vector< double > *, std::map< int, std::vector< double >> *, std::map< int, std::vector< std::vector< double >>> *, int=-1)

  Helper method to write time series results for Wave.

4.30.1 Detailed Description

A derived class of the Renewable branch of Production which models wave production.

4.30.2 Constructor & Destructor Documentation

4.30.2.1 Wave() [1/2]

```
Wave::Wave (
            void  )
```

Constructor (dummy) for the Wave class.

```
543 {
544     return;
545 }   /* Wave() */
```

4.30.2.2 Wave() [2/2]

```
Wave::Wave (
            int n_points,
            double n_years,
            WaveInputs wave_inputs,
            std::vector< double > * time_vec_hrs_ptr )
```

Constructor (intended) for the Wave class.

Parameters

n_points	The number of points in the modelling time series.
n_years	The number of years being modelled.
wave_inputs	A structure of Wave constructor inputs.
time_vec_hrs_ptr	A pointer to the vector containing the modelling time series.

```
577   :
578 Renewable(
579     n_points,
580     n_years,
581     wave_inputs.renewable_inputs,
582     time_vec_hrs_ptr
583 )
584 {
585     //  1. check inputs
586     this->__checkInputs(wave_inputs);
587
588     //  2. set attributes
589     this->type = RenewableType :: WAVE;
590     this->type_str = "WAVE";
591
592     this->resource_key = wave_inputs.resource_key;
593
594     this->design_significant_wave_height_m =
595         wave_inputs.design_significant_wave_height_m;
596     this->design_energy_period_s = wave_inputs.design_energy_period_s;
597
598     this->power_model = wave_inputs.power_model;
```

```
599
600     switch (this->power_model) {
601         case (WavePowerProductionModel :: WAVE_POWER_GAUSSIAN): {
602             this->power_model_string = "GAUSSIAN";
603
604             break;
605         }
606
607         case (WavePowerProductionModel :: WAVE_POWER_PARABOLOID): {
608             this->power_model_string = "PARABOLOID";
609
610             break;
611         }
612
613         case (WavePowerProductionModel :: WAVE_POWER_LOOKUP): {
614             this->power_model_string = "LOOKUP";
615
616             this->interpolator.addData2D(
617                 0,
618                 wave_inputs.path_2_normalized_performance_matrix
619             );
620
621             break;
622         }
623
624         default: {
625             std::string error_str = "ERROR:  Wave():  ";
626             error_str += "power production model ";
627             error_str += std::to_string(this->power_model);
628             error_str += " not recognized";
629
630             #ifdef _WIN32
631                 std::cout << error_str << std::endl;
632             #endif
633
634             throw std::runtime_error(error_str);
635
636             break;
637         }
638     }
639
640     if (wave_inputs.capital_cost < 0) {
641         this->capital_cost = this->__getGenericCapitalCost();
642     }
643     else {
644         this->capital_cost = wave_inputs.capital_cost;
645     }
646
647     if (wave_inputs.operation_maintenance_cost_kWh < 0) {
648         this->operation_maintenance_cost_kWh = this->__getGenericOpMaintCost();
649     }
650     else {
651         this->operation_maintenance_cost_kWh =
652             wave_inputs.operation_maintenance_cost_kWh;
653     }
654
655     if (not this->is_sunk) {
656         this->capital_cost_vec[0] = this->capital_cost;
657     }
658
659     //  3. construction print
660     if (this->print_flag) {
661         std::cout << "Wave object constructed at " << this << std::endl;
662     }
663
664     return;
665 }   /* Renewable() */
```

4.30.2.3 ~Wave()

```
Wave::~Wave (
            void  )
```

Destructor for the Wave class.

```
858 {
859     //  1. destruction print
860     if (this->print_flag) {
861         std::cout << "Wave object at " << this << " destroyed" << std::endl;
862     }
863
864     return;
865 }   /* ~Wave() */
```

4.30.3 Member Function Documentation

4.30.3.1 __checkInputs()

```
void Wave::__checkInputs (
            WaveInputs wave_inputs )  [private]
```

Helper method to check inputs to the Wave constructor.

Parameters

wave_inputs	A structure of Wave constructor inputs.

```
64 {
65     //  1. check design_significant_wave_height_m
66     if (wave_inputs.design_significant_wave_height_m <= 0) {
67         std::string error_str = "ERROR:  Wave():  ";
68         error_str += "WaveInputs::design_significant_wave_height_m must be > 0";
69 
70         #ifdef _WIN32
71             std::cout << error_str << std::endl;
72         #endif
73 
74         throw std::invalid_argument(error_str);
75     }
76 
77     //  2. check design_energy_period_s
78     if (wave_inputs.design_energy_period_s <= 0) {
79         std::string error_str = "ERROR:  Wave():  ";
80         error_str += "WaveInputs::design_energy_period_s must be > 0";
81 
82         #ifdef _WIN32
83             std::cout << error_str << std::endl;
84         #endif
85 
86         throw std::invalid_argument(error_str);
87     }
88 
89     //  3. if WAVE_POWER_LOOKUP, check that path is given
90     if (
91         wave_inputs.power_model == WavePowerProductionModel :: WAVE_POWER_LOOKUP and
92         wave_inputs.path_2_normalized_performance_matrix.empty()
93     ) {
94         std::string error_str = "ERROR:  Wave()  power model was set to ";
95         error_str += "WavePowerProductionModel::WAVE_POWER_LOOKUP, but no path to a ";
96         error_str += "normalized performance matrix was given";
97 
98         #ifdef _WIN32
99             std::cout << error_str << std::endl;
100         #endif
101 
102         throw std::invalid_argument(error_str);
103     }
104 
105     return;
106 }   /* __checkInputs() */
```

4.30.3.2 __computeGaussianProductionkW()

```
double Wave::__computeGaussianProductionkW (
            int timestep,
            double dt_hrs,
            double significant_wave_height_m,
            double energy_period_s )  [private]
```

Helper method to compute wave energy converter production under a Gaussian production model.

Ref: Truelove et al. [2019]

Parameters

timestep	The current time step of the Model run.
dt_hrs	The interval of time [hrs] associated with the action.
significant_wave_height_m	The significant wave height [m] in the vicinity of the wave energy converter.
energy_period_s	The energy period [s] in the vicinity of the wave energy converter

Returns

The production [kW] of the wave energy converter, under an exponential model.

```
201 {
202     double H_s_nondim =
203         (significant_wave_height_m - this->design_significant_wave_height_m) /
204         this->design_significant_wave_height_m;
205 
206     double T_e_nondim =
207         (energy_period_s - this->design_energy_period_s) /
208         this->design_energy_period_s;
209 
210     double production = exp(
211         -2.25119 * pow(T_e_nondim, 2) +
212         3.44570 * T_e_nondim * H_s_nondim -
213         4.01508 * pow(H_s_nondim, 2)
214     );
215 
216     return production * this->capacity_kW;
217 }   /* __computeGaussianProductionkW() */
```

4.30.3.3 __computeLookupProductionkW()

```
double Wave::__computeLookupProductionkW (
             int timestep,
             double dt_hrs,
             double significant_wave_height_m,
             double energy_period_s )  [private]
```

Helper method to compute wave energy converter production by way of looking up using given performance matrix.

Parameters

timestep	The current time step of the Model run.
dt_hrs	The interval of time [hrs] associated with the action.
significant_wave_height_m	The significant wave height [m] in the vicinity of the wave energy converter.
energy_period_s	The energy period [s] in the vicinity of the wave energy converter

Returns

The interpolated production [kW] of the wave energy converter.

```
318 {
319     double prod = this->interpolator.interp2D(
320         0,
321         significant_wave_height_m,
322         energy_period_s
323     );
324 
325     return prod * this->capacity_kW;
326 }   /* __computeLookupProductionkW() */
```

4.30.3.4 __computeParaboloidProductionkW()

```
double Wave::__computeParaboloidProductionkW (
              int timestep,
              double dt_hrs,
              double significant_wave_height_m,
              double energy_period_s )  [private]
```

Helper method to compute wave energy converter production under a paraboloid production model.

Ref: Robertson et al. [2021]

Parameters

timestep	The current time step of the Model run.
dt_hrs	The interval of time [hrs] associated with the action.
significant_wave_height_m	The significant wave height [m] in the vicinity of the wave energy converter.
energy_period_s	The energy period [s] in the vicinity of the wave energy converter

Returns

The production [kW] of the wave energy converter, under a paraboloid model.

```
258 {
259     // first, check for idealized wave breaking (deep water)
260     if (significant_wave_height_m >= 0.2184 * pow(energy_period_s, 2)) {
261         return 0;
262     }
263 
264     // otherwise, apply generic quadratic performance model
265     // (with outputs bounded to [0, 1])
266     double production =
267         0.289 * significant_wave_height_m -
268         0.00111 * pow(significant_wave_height_m, 2) * energy_period_s -
269         0.0169 * energy_period_s;
270 
271     if (production < 0) {
272         production = 0;
273     }
274 
275     else if (production > 1) {
276         production = 1;
277     }
278 
279     return production * this->capacity_kW;
280 }   /* __computeParaboloidProductionkW() */
```

4.30.3.5 __getGenericCapitalCost()

```
double Wave::__getGenericCapitalCost (
            void  )  [private]
```

Helper method to generate a generic wave energy converter capital cost.

Note that this model expresses cost in terms of Canadian dollars [CAD].

Ref: MacDougall [2019]

Returns

A generic capital cost for the wave energy converter [CAD].

```
128 {
129     double capital_cost_per_kW = 7000 * pow(this->capacity_kW, -0.15) + 5000;
130 
131     return capital_cost_per_kW * this->capacity_kW;
132 }   /* __getGenericCapitalCost() */
```

4.30.3.6 __getGenericOpMaintCost()

```
double Wave::__getGenericOpMaintCost (
            void  )  [private]
```

Helper method to generate a generic wave energy converter operation and maintenance cost. This is a cost incurred per unit energy produced.

Note that this model expresses cost in terms of Canadian dollars [CAD/kWh].

Ref: MacDougall [2019]

Returns

A generic operation and maintenance cost, per unit energy produced, for the wave energy converter [CAD/k↩ Wh].

```
156 {
157     double operation_maintenance_cost_kWh = 0.05 * pow(this->capacity_kW, -0.2) + 0.05;
158 
159     return operation_maintenance_cost_kWh;
160 }   /* __getGenericOpMaintCost() */
```

4.30.3.7 __writeSummary()

```
void Wave::__writeSummary (
            std::string write_path )  [private], [virtual]
```

Helper method to write summary results for Wave.

Parameters

write_path	A path (either relative or absolute) to the directory location where results are to be written. If already exists, will overwrite.

Reimplemented from Renewable.

```
344 {
345     //  1. create filestream
346     write_path += "summary_results.md";
347     std::ofstream ofs;
348     ofs.open(write_path, std::ofstream::out);
349 
350     //  2. write summary results (markdown)
351     ofs « "# ";
352     ofs « std::to_string(int(ceil(this->capacity_kW)));
353     ofs « " kW WAVE Summary Results\n";
354     ofs « "\n--------\n\n";
355 
356     //  2.1. Production attributes
357     ofs « "## Production Attributes\n";
358     ofs « "\n";
359 
360     ofs « "Capacity: " « this->capacity_kW « " kW  \n";
361     ofs « "\n";
362 
363     ofs « "Production Override: (N = 0 / Y = 1): "
364         « this->normalized_production_series_given « "  \n";
365     if (this->normalized_production_series_given) {
366         ofs « "Path to Normalized Production Time Series: "
367             « this->path_2_normalized_production_time_series « "  \n";
368     }
369     ofs « "\n";
370 
371     ofs « "Sunk Cost (N = 0 / Y = 1): " « this->is_sunk « "  \n";
372     ofs « "Capital Cost: " « this->capital_cost « "  \n";
373     ofs « "Operation and Maintenance Cost: " « this->operation_maintenance_cost_kWh
374         « " per kWh produced  \n";
375     ofs « "Nominal Inflation Rate (annual): " « this->nominal_inflation_annual
376         « "  \n";
377     ofs « "Nominal Discount Rate (annual): " « this->nominal_discount_annual
378         « "  \n";
379     ofs « "Real Discount Rate (annual): " « this->real_discount_annual « "  \n";
380     ofs « "\n";
381 
382     ofs « "Replacement Running Hours: " « this->replace_running_hrs « "  \n";
383     ofs « "\n--------\n\n";
384 
385     //  2.2. Renewable attributes
386     ofs « "## Renewable Attributes\n";
387     ofs « "\n";
388 
389     ofs « "Resource Key (2D): " « this->resource_key « "  \n";
390 
391     ofs « "\n--------\n\n";
392 
393     //  2.3. Wave attributes
394     ofs « "## Wave Attributes\n";
395     ofs « "\n";
396 
397     ofs « "Power Production Model: " « this->power_model_string « "  \n";
398     switch (this->power_model) {
399         case (WavePowerProductionModel :: WAVE_POWER_GAUSSIAN): {
400             ofs « "Design Significant Wave Height: "
401                 « this->design_significant_wave_height_m « " m  \n";
402 
403             ofs « "Design Energy Period: " « this->design_energy_period_s « " s  \n";
404 
405             break;
406         }
407 
408         case (WavePowerProductionModel :: WAVE_POWER_LOOKUP): {
409             ofs « "Normalized Performance Matrix: "
410                 « this->interpolator.path_map_2D[0] « "  \n";
411 
412             break;
413         }
414 
415         default: {
416             // write nothing!
417 
418             break;
419         }
420     }
```

```
421
422     ofs « "\n--------\n\n";
423
424     //  2.4. Wave Results
425     ofs « "## Results\n";
426     ofs « "\n";
427
428     ofs « "Net Present Cost: " « this->net_present_cost « "  \n";
429     ofs « "\n";
430
431     ofs « "Total Dispatch: " « this->total_dispatch_kWh
432         « " kWh  \n";
433
434     ofs « "Levellized Cost of Energy: " « this->levellized_cost_of_energy_kWh
435         « " per kWh dispatched  \n";
436     ofs « "\n";
437
438     ofs « "Running Hours: " « this->running_hours « "  \n";
439     ofs « "Replacements: " « this->n_replacements « "  \n";
440
441     ofs « "\n--------\n\n";
442
443     ofs.close();
444
445     return;
446 }   /* __writeSummary() */
```

4.30.3.8 __writeTimeSeries()

```
void Wave::__writeTimeSeries (
              std::string write_path,
              std::vector< double > * time_vec_hrs_ptr,
              std::map< int, std::vector< double >> * resource_map_1D_ptr,
              std::map< int, std::vector< std::vector< double >>> * resource_map_2D_ptr,
              int max_lines = -1 )  [private], [virtual]
```

Helper method to write time series results for Wave.

Parameters

write_path	A path (either relative or absolute) to the directory location where results are to be written. If already exists, will overwrite.
time_vec_hrs_ptr	A pointer to the time_vec_hrs attribute of the ElectricalLoad.
resource_map_1D_ptr	A pointer to the 1D map of Resources.
resource_map_2D_ptr	A pointer to the 2D map of Resources.
max_lines	The maximum number of lines of output to write.

Reimplemented from Renewable.

```
484 {
485     //  1. create filestream
486     write_path += "time_series_results.csv";
487     std::ofstream ofs;
488     ofs.open(write_path, std::ofstream::out);
489
490     //  2. write time series results (comma separated value)
491     ofs « "Time (since start of data) [hrs],";
492     ofs « "Significant Wave Height [m],";
493     ofs « "Energy Period [s],";
494     ofs « "Production [kW],";
495     ofs « "Dispatch [kW],";
496     ofs « "Storage [kW],";
497     ofs « "Curtailment [kW],";
498     ofs « "Capital Cost (actual),";
499     ofs « "Operation and Maintenance Cost (actual),";
500     ofs « "\n";
501
502     for (int i = 0; i < max_lines; i++) {
```

```
503         ofs « time_vec_hrs_ptr->at(i) « ",";
504
505         if (not this->normalized_production_series_given) {
506             ofs « resource_map_2D_ptr->at(this->resource_key)[i][0] « ",";
507             ofs « resource_map_2D_ptr->at(this->resource_key)[i][1] « ",";
508         }
509
510         else {
511             ofs « "OVERRIDE" « ",";
512             ofs « "OVERRIDE" « ",";
513         }
514
515         ofs « this->production_vec_kW[i] « ",";
516         ofs « this->dispatch_vec_kW[i] « ",";
517         ofs « this->storage_vec_kW[i] « ",";
518         ofs « this->curtailment_vec_kW[i] « ",";
519         ofs « this->capital_cost_vec[i] « ",";
520         ofs « this->operation_maintenance_cost_vec[i] « ",";
521         ofs « "\n";
522     }
523
524     return;
525 }   /* __writeTimeSeries() */
```

4.30.3.9 commit()

```
double Wave::commit (
            int timestep,
            double dt_hrs,
            double production_kW,
            double load_kW )  [virtual]
```

Method which takes in production and load for the current timestep, computes and records dispatch and curtailment, and then returns remaining load.

Parameters

timestep	The timestep (i.e., time series index) for the request.
dt_hrs	The interval of time [hrs] associated with the timestep.
production_kW	The production [kW] of the asset in this timestep.
load_kW	The load [kW] passed to the asset in this timestep.

Returns

The load [kW] remaining after the dispatch is deducted from it.

Reimplemented from Renewable.

```
830 {
831     //  1. invoke base class method
832     load_kW = Renewable :: commit(
833         timestep,
834         dt_hrs,
835         production_kW,
836         load_kW
837     );
838
839
840     //...
841
842     return load_kW;
843 }   /* commit() */
```

4.30.3.10 computeProductionkW()

```
double Wave::computeProductionkW (
            int timestep,
            double dt_hrs,
            double significant_wave_height_m,
            double energy_period_s )  [virtual]
```

Method which takes in the wave resource at a particular point in time, and then returns the wave turbine production at that point in time.

Parameters

timestep	The timestep (i.e., time series index) for the request.
dt_hrs	The interval of time [hrs] associated with the timestep.
signficiant_wave_height_m	The significant wave height (wave statistic) [m].
energy_period_s	The energy period (wave statistic) [s].

Returns

The production [kW] of the wave turbine.

Reimplemented from Renewable.

```
727 {
728     //  given production time series override
729     if (this->normalized_production_series_given) {
730         double production_kW = Production :: getProductionkW(timestep);
731 
732         return production_kW;
733     }
734 
735     // check if no resource
736     if (significant_wave_height_m <= 0 or energy_period_s <= 0) {
737         return 0;
738     }
739 
740     // compute production
741     double production_kW = 0;
742 
743     switch (this->power_model) {
744         case (WavePowerProductionModel :: WAVE_POWER_PARABOLOID): {
745             production_kW = this->__computeParaboloidProductionkW(
746                 timestep,
747                 dt_hrs,
748                 significant_wave_height_m,
749                 energy_period_s
750             );
751 
752             break;
753         }
754 
755         case (WavePowerProductionModel :: WAVE_POWER_GAUSSIAN): {
756             production_kW = this->__computeGaussianProductionkW(
757                 timestep,
758                 dt_hrs,
759                 significant_wave_height_m,
760                 energy_period_s
761             );
762 
763             break;
764         }
765 
766         case (WavePowerProductionModel :: WAVE_POWER_LOOKUP): {
767             production_kW = this->__computeLookupProductionkW(
768                 timestep,
769                 dt_hrs,
770                 significant_wave_height_m,
771                 energy_period_s
772             );
773 
```

```
774             break;
775         }
776
777         default: {
778             std::string error_str = "ERROR:  Wave::computeProductionkW():  ";
779             error_str += "power model ";
780             error_str += std::to_string(this->power_model);
781             error_str += " not recognized";
782
783             #ifdef _WIN32
784                 std::cout « error_str « std::endl;
785             #endif
786
787             throw std::runtime_error(error_str);
788
789             break;
790         }
791     }
792
793     return production_kW;
794 }   /* computeProductionkW() */
```

4.30.3.11 handleReplacement()

```
void Wave::handleReplacement (
            int timestep )  [virtual]
```

Method to handle asset replacement and capital cost incursion, if applicable.

Parameters

timestep	The current time step of the Model run.

Reimplemented from Renewable.

```
683 {
684     //  1. reset attributes
685     //...
686
687     //  2. invoke base class method
688     Renewable :: handleReplacement(timestep);
689
690     return;
691 }   /* __handleReplacement() */
```

4.30.4 Member Data Documentation

4.30.4.1 design_energy_period_s

```
double Wave::design_energy_period_s
```

The energy period [s] at which the wave energy converter achieves its rated capacity.

4.30.4.2 design_significant_wave_height_m

```
double Wave::design_significant_wave_height_m
```

The significant wave height [m] at which the wave energy converter achieves its rated capacity.

4.30.4.3 power_model

```
WavePowerProductionModel Wave::power_model
```

The wave power production model to be applied.

4.30.4.4 power_model_string

```
std::string Wave::power_model_string
```

A string describing the active power production model.

The documentation for this class was generated from the following files:

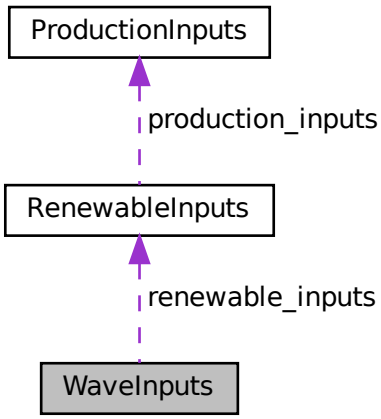
- header/Production/Renewable/Wave.h
- source/Production/Renewable/Wave.cpp

4.31 WaveInputs Struct Reference

A structure which bundles the necessary inputs for the Wave constructor. Provides default values for every necessary input. Note that this structure encapsulates RenewableInputs.

```
#include <Wave.h>
```

Collaboration diagram for WaveInputs:



Public Attributes

- RenewableInputs renewable_inputs

  An encapsulated RenewableInputs instance.
- int resource_key = 0

  A key used to index into the Resources object, to associate this asset with the appropriate resource time series.
- double capital_cost = -1

  The capital cost of the asset (undefined currency). -1 is a sentinel value, which triggers a generic cost model on construction (in fact, any negative value here will trigger). Note that the generic cost model is in terms of Canadian dollars [CAD].
- double operation_maintenance_cost_kWh = -1

  The operation and maintenance cost of the asset [1/kWh] (undefined currency). This is a cost incurred per unit of energy produced. -1 is a sentinel value, which triggers a generic cost model on construction (in fact, any negative value here will trigger). Note that the generic cost model is in terms of Canadian dollars [CAD/kWh].
- double design_significant_wave_height_m = 3

  The significant wave height [m] at which the wave energy converter achieves its rated capacity.
- double design_energy_period_s = 10

  The energy period [s] at which the wave energy converter achieves its rated capacity.
- WavePowerProductionModel power_model = WavePowerProductionModel :: WAVE_POWER_PARABOLOID

  The wave power production model to be applied.
- std::string path_2_normalized_performance_matrix = ""

  A path (either relative or absolute) to a normalized performance matrix for the wave energy converter.

4.31.1 Detailed Description

A structure which bundles the necessary inputs for the Wave constructor. Provides default values for every necessary input. Note that this structure encapsulates RenewableInputs.

4.31.2 Member Data Documentation

4.31.2.1 capital_cost

```
double WaveInputs::capital_cost = -1
```

The capital cost of the asset (undefined currency). -1 is a sentinel value, which triggers a generic cost model on construction (in fact, any negative value here will trigger). Note that the generic cost model is in terms of Canadian dollars [CAD].

4.31.2.2 design_energy_period_s

```
double WaveInputs::design_energy_period_s = 10
```

The energy period [s] at which the wave energy converter achieves its rated capacity.

4.31.2.3 design_significant_wave_height_m

```
double WaveInputs::design_significant_wave_height_m = 3
```

The significant wave height [m] at which the wave energy converter achieves its rated capacity.

4.31.2.4 operation_maintenance_cost_kWh

```
double WaveInputs::operation_maintenance_cost_kWh = -1
```

The operation and maintenance cost of the asset [1/kWh] (undefined currency). This is a cost incurred per unit of energy produced. -1 is a sentinel value, which triggers a generic cost model on construction (in fact, any negative value here will trigger). Note that the generic cost model is in terms of Canadian dollars [CAD/kWh].

4.31.2.5 path_2_normalized_performance_matrix

```
std::string WaveInputs::path_2_normalized_performance_matrix = ""
```

A path (either relative or absolute) to a normalized performance matrix for the wave energy converter.

4.31.2.6 power_model

```
WavePowerProductionModel WaveInputs::power_model = WavePowerProductionModel ::  WAVE_POWER_PARABOLOID
```

The wave power production model to be applied.

4.31.2.7 renewable_inputs

```
RenewableInputs WaveInputs::renewable_inputs
```

An encapsulated RenewableInputs instance.

4.31.2.8 resource_key

```
int WaveInputs::resource_key = 0
```

A key used to index into the Resources object, to associate this asset with the appropriate resource time series.

The documentation for this struct was generated from the following file:

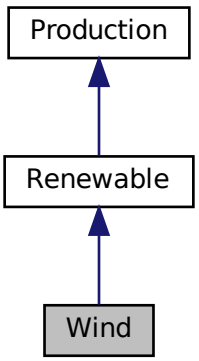
- header/Production/Renewable/Wave.h

4.32 Wind Class Reference

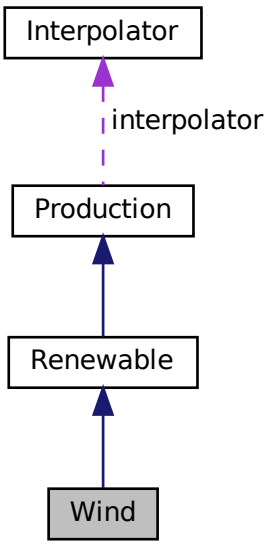
A derived class of the Renewable branch of Production which models wind production.

`#include <Wind.h>`

Inheritance diagram for Wind:



Collaboration diagram for Wind:



Public Member Functions

- Wind (void)

  Constructor (dummy) for the Wind class.
- Wind (int, double, WindInputs, std::vector< double > *)

  Constructor (intended) for the Wind class.
- void handleReplacement (int)

  Method to handle asset replacement and capital cost incursion, if applicable.
- double computeProductionkW (int, double, double)

  Method which takes in the wind resource at a particular point in time, and then returns the wind turbine production at that point in time.
- double commit (int, double, double, double)

  Method which takes in production and load for the current timestep, computes and records dispatch and curtailment, and then returns remaining load.
- ~Wind (void)

  Destructor for the Wind class.

Public Attributes

- double design_speed_ms

  The wind speed [m/s] at which the wind turbine achieves its rated capacity.
- WindPowerProductionModel power_model

  The wind power production model to be applied.
- std::string power_model_string

  A string describing the active power production model.

Private Member Functions

- void __checkInputs (WindInputs)

  Helper method to check inputs to the Wind constructor.
- double __getGenericCapitalCost (void)

  Helper method to generate a generic wind turbine capital cost.
- double __getGenericOpMaintCost (void)

  Helper method to generate a generic wind turbine operation and maintenance cost. This is a cost incurred per unit energy produced.
- double __computeCubicProductionkW (int, double, double)

  Helper method to compute wind turbine production under a cubic production model.
- double __computeExponentialProductionkW (int, double, double)

  Helper method to compute wind turbine production under an exponential production model.
- double __computeLookupProductionkW (int, double, double)

  Helper method to compute wind turbine production by way of looking up using given power curve data.
- void __writeSummary (std::string)

  Helper method to write summary results for Wind.
- void __writeTimeSeries (std::string, std::vector< double > *, std::map< int, std::vector< double >> *, std::map< int, std::vector< std::vector< double >>> *, int=-1)

  Helper method to write time series results for Wind.

4.32.1 Detailed Description

A derived class of the Renewable branch of Production which models wind production.

4.32.2 Constructor & Destructor Documentation

4.32.2.1 Wind() [1/2]

```
Wind::Wind (
            void  )
```

Constructor (dummy) for the Wind class.

```
501 {
502     return;
503 }   /* Wind() */
```

4.32.2.2 Wind() [2/2]

```
Wind::Wind (
            int n_points,
            double n_years,
            WindInputs wind_inputs,
            std::vector< double > * time_vec_hrs_ptr )
```

Constructor (intended) for the Wind class.

Parameters

n_points	The number of points in the modelling time series.
n_years	The number of years being modelled.
wind_inputs	A structure of Wind constructor inputs.
time_vec_hrs_ptr	A pointer to the vector containing the modelling time series.

```
535   :
536 Renewable(
537     n_points,
538     n_years,
539     wind_inputs.renewable_inputs,
540     time_vec_hrs_ptr
541 )
542 {
543     //  1. check inputs
544     this->__checkInputs(wind_inputs);
545 
546     //  2. set attributes
547     this->type = RenewableType :: WIND;
548     this->type_str = "WIND";
549 
550     this->resource_key = wind_inputs.resource_key;
551 
552     this->design_speed_ms = wind_inputs.design_speed_ms;
553 
554     this->power_model = wind_inputs.power_model;
555 
556     switch (this->power_model) {
557         case (WindPowerProductionModel :: WIND_POWER_CUBIC): {
558             this->power_model_string = "CUBIC";
559 
560             break;
561         }
562 
563         case (WindPowerProductionModel :: WIND_POWER_EXPONENTIAL): {
564             this->power_model_string = "EXPONENTIAL";
565 
```

```
566             break;
567         }
568 
569         case (WindPowerProductionModel :: WIND_POWER_LOOKUP): {
570             this->power_model_string = "LOOKUP";
571 
572             break;
573         }
574 
575         default: {
576             std::string error_str = "ERROR:  Wind():  ";
577             error_str += "power production model ";
578             error_str += std::to_string(this->power_model);
579             error_str += " not recognized";
580 
581             #ifdef _WIN32
582                 std::cout << error_str << std::endl;
583             #endif
584 
585             throw std::runtime_error(error_str);
586 
587             break;
588         }
589     }
590 
591     if (wind_inputs.capital_cost < 0) {
592         this->capital_cost = this->__getGenericCapitalCost();
593     }
594     else {
595         this->capital_cost = wind_inputs.capital_cost;
596     }
597 
598     if (wind_inputs.operation_maintenance_cost_kWh < 0) {
599         this->operation_maintenance_cost_kWh = this->__getGenericOpMaintCost();
600     }
601     else {
602         this->operation_maintenance_cost_kWh =
603             wind_inputs.operation_maintenance_cost_kWh;
604     }
605 
606     if (not this->is_sunk) {
607         this->capital_cost_vec[0] = this->capital_cost;
608     }
609 
610     //  3. construction print
611     if (this->print_flag) {
612         std::cout << "Wind object constructed at " << this << std::endl;
613     }
614 
615     return;
616 }   /* Renewable() */
```

4.32.2.3 ~Wind()

```
Wind::~Wind (
            void  )
```

Destructor for the Wind class.

```
802 {
803     //  1. destruction print
804     if (this->print_flag) {
805         std::cout << "Wind object at " << this << " destroyed" << std::endl;
806     }
807 
808     return;
809 }   /* ~Wind() */
```

4.32.3 Member Function Documentation

4.32.3.1 __checkInputs()

```
void Wind::__checkInputs (
            WindInputs wind_inputs )  [private]
```

Helper method to check inputs to the Wind constructor.

Ref: Zafar [2018]

Parameters

wind_inputs	A structure of Wind constructor inputs.

```
66 {
67     //  1. check design_speed_ms
68     if (wind_inputs.design_speed_ms <= 0) {
69         std::string error_str = "ERROR:  Wind():  ";
70         error_str += "WindInputs::design_speed_ms must be > 0";
71 
72         #ifdef _WIN32
73             std::cout « error_str « std::endl;
74         #endif
75 
76         throw std::invalid_argument(error_str);
77     }
78 
79     else if (wind_inputs.design_speed_ms < 12) {
80         std::string warning_str = "WARNING:  Wind():  ";
81         warning_str += "Setting WindInputs::design_speed_ms to less than 12 m/s may be ";
82         warning_str += "technically unrealistic";
83 
84         std::cout « warning_str « std::endl;
85     }
86 
87     return;
88 }   /* __checkInputs() */
```

4.32.3.2 __computeCubicProductionkW()

```
double Wind::__computeCubicProductionkW (
            int timestep,
            double dt_hrs,
            double wind_resource_ms )  [private]
```

Helper method to compute wind turbine production under a cubic production model.

Ref: Milan et al. [2010]
Ref: Zafar [2018]

Parameters

timestep	The current time step of the Model run.
dt_hrs	The interval of time [hrs] associated with the action.
wind_resource_ms	The available wind resource [m/s].

Returns

The production [kW] of the wind turbine, under an exponential model.

```
176 {
177     double production = 0;
178 
179     double turbine_speed = (wind_resource_ms - this->design_speed_ms) /
180         this->design_speed_ms;
181 
182     if (turbine_speed < -0.7857 or turbine_speed > 0.7857) {
183         production = 0;
184     }
185 
186     else if (turbine_speed >= -0.7857 and turbine_speed <= 0) {
187         production = (1 / pow(this->design_speed_ms, 3)) * pow(wind_resource_ms, 3);
188     }
189 
190     else {
191         production = 1;
192     }
193 
194     return production * this->capacity_kW;
195 }   /* __computeCubicProductionkW() */
```

4.32.3.3 __computeExponentialProductionkW()

```
double Wind::__computeExponentialProductionkW (
            int timestep,
            double dt_hrs,
            double wind_resource_ms )  [private]
```

Helper method to compute wind turbine production under an exponential production model.

Ref: Truelove et al. [2019]

Parameters

timestep	The current time step of the Model run.
dt_hrs	The interval of time [hrs] associated with the action.
wind_resource_ms	The available wind resource [m/s].

Returns

The production [kW] of the wind turbine, under an exponential model.

```
229 {
230     double production = 0;
231 
232     double turbine_speed = (wind_resource_ms - this->design_speed_ms) /
233         this->design_speed_ms;
234 
235     if (turbine_speed < -0.76 or turbine_speed > 0.68) {
236         production = 0;
237     }
238 
239     else if (turbine_speed >= -0.76 and turbine_speed <= 0) {
240         production = 1.03273 * exp(-5.97588 * pow(turbine_speed, 2)) - 0.03273;
241     }
242 
243     else {
244         production = 0.16154 * exp(-9.30254 * pow(turbine_speed, 2)) + 0.83846;
245     }
246 
247     return production * this->capacity_kW;
248 }   /* __computeExponentialProductionkW() */
```

4.32.3.4 __computeLookupProductionkW()

```
double Wind::__computeLookupProductionkW (
              int timestep,
              double dt_hrs,
              double wind_resource_ms )  [private]
```

Helper method to compute wind turbine production by way of looking up using given power curve data.

Parameters

timestep	The current time step of the Model run.
dt_hrs	The interval of time [hrs] associated with the action.
wind_resource_ms	The available wind resource [m/s].

Returns

The interpolated production [kW] of the wind turbine.

```
280 {
281     // *** WORK IN PROGRESS *** //
282
283     return 0;
284 }   /* __computeLookupProductionkW() */
```

4.32.3.5 __getGenericCapitalCost()

```
double Wind::__getGenericCapitalCost (
              void  )  [private]
```

Helper method to generate a generic wind turbine capital cost.

This model was obtained by way of surveying an assortment of published wind turbine costs, and then constructing a best fit model. Note that this model expresses cost in terms of Canadian dollars [CAD].

Returns

A generic capital cost for the wind turbine [CAD].

```
110 {
111     double capital_cost_per_kW = 3000 * pow(this->capacity_kW, -0.15) + 3000;
112
113     return capital_cost_per_kW * this->capacity_kW;
114 }   /* __getGenericCapitalCost() */
```

4.32.3.6 __getGenericOpMaintCost()

```
double Wind::__getGenericOpMaintCost (
            void  )  [private]
```

Helper method to generate a generic wind turbine operation and maintenance cost. This is a cost incurred per unit energy produced.

This model was obtained by way of surveying an assortment of published wind turbine costs, and then constructing a best fit model. Note that this model expresses cost in terms of Canadian dollars [CAD/kWh].

Returns

A generic operation and maintenance cost, per unit energy produced, for the wind turbine [CAD/kWh].

```
137 {
138     double operation_maintenance_cost_kWh = 0.025 * pow(this->capacity_kW, -0.2) + 0.025;
139 
140     return operation_maintenance_cost_kWh;
141 }   /* __getGenericOpMaintCost() */
```

4.32.3.7 __writeSummary()

```
void Wind::__writeSummary (
            std::string write_path )  [private], [virtual]
```

Helper method to write summary results for Wind.

Parameters

write_path	A path (either relative or absolute) to the directory location where results are to be written. If already exists, will overwrite.

Reimplemented from Renewable.

```
302 {
303     //  1. create filestream
304     write_path += "summary_results.md";
305     std::ofstream ofs;
306     ofs.open(write_path, std::ofstream::out);
307 
308     //  2. write summary results (markdown)
309     ofs « "# ";
310     ofs « std::to_string(int(ceil(this->capacity_kW)));
311     ofs « " kW WIND Summary Results\n";
312     ofs « "\n--------\n\n";
313 
314 
315     //  2.1. Production attributes
316     ofs « "## Production Attributes\n";
317     ofs « "\n";
318 
319     ofs « "Capacity: " « this->capacity_kW « " kW  \n";
320     ofs « "\n";
321 
322     ofs « "Production Override: (N = 0 / Y = 1): "
323         « this->normalized_production_series_given « "  \n";
324     if (this->normalized_production_series_given) {
325         ofs « "Path to Normalized Production Time Series: "
326             « this->path_2_normalized_production_time_series « "  \n";
327     }
328     ofs « "\n";
329 
330     ofs « "Sunk Cost (N = 0 / Y = 1): " « this->is_sunk « "  \n";
331     ofs « "Capital Cost: " « this->capital_cost « "  \n";
```

```
332     ofs « "Operation and Maintenance Cost: " « this->operation_maintenance_cost_kWh
333         « " per kWh produced  \n";
334     ofs « "Nominal Inflation Rate (annual): " « this->nominal_inflation_annual
335         « "  \n";
336     ofs « "Nominal Discount Rate (annual): " « this->nominal_discount_annual
337         « "  \n";
338     ofs « "Real Discount Rate (annual): " « this->real_discount_annual « "  \n";
339     ofs « "\n";
340 
341     ofs « "Replacement Running Hours: " « this->replace_running_hrs « "  \n";
342     ofs « "\n--------\n\n";
343 
344     //  2.2. Renewable attributes
345     ofs « "## Renewable Attributes\n";
346     ofs « "\n";
347 
348     ofs « "Resource Key (1D): " « this->resource_key « "  \n";
349 
350     ofs « "\n--------\n\n";
351 
352     //  2.3. Wind attributes
353     ofs « "## Wind Attributes\n";
354     ofs « "\n";
355 
356     ofs « "Power Production Model: " « this->power_model_string « "  \n";
357     switch (this->power_model) {
358         case (WindPowerProductionModel :: WIND_POWER_CUBIC): {
359             ofs « "Design Speed: " « this->design_speed_ms « " m/s  \n";
360 
361             break;
362         }
363 
364         case (WindPowerProductionModel :: WIND_POWER_EXPONENTIAL): {
365             ofs « "Design Speed: " « this->design_speed_ms « " m/s  \n";
366 
367             break;
368         }
369 
370         case (WindPowerProductionModel :: WIND_POWER_LOOKUP): {
371             //...
372 
373             break;
374         }
375 
376         default: {
377             // write nothing!
378 
379             break;
380         }
381     }
382 
383     ofs « "\n--------\n\n";
384 
385     //  2.4. Wind Results
386     ofs « "## Results\n";
387     ofs « "\n";
388 
389     ofs « "Net Present Cost: " « this->net_present_cost « "  \n";
390     ofs « "\n";
391 
392     ofs « "Total Dispatch: " « this->total_dispatch_kWh
393         « " kWh  \n";
394 
395     ofs « "Levellized Cost of Energy: " « this->levellized_cost_of_energy_kWh
396         « " per kWh dispatched  \n";
397     ofs « "\n";
398 
399     ofs « "Running Hours: " « this->running_hours « "  \n";
400     ofs « "Replacements: " « this->n_replacements « "  \n";
401 
402     ofs « "\n--------\n\n";
403 
404     ofs.close();
405 
406     return;
407 }   /* __writeSummary() */
```

4.32.3.8 __writeTimeSeries()

```
void Wind::__writeTimeSeries (
            std::string write_path,
```

```
            std::vector< double > * time_vec_hrs_ptr,
            std::map< int, std::vector< double >> * resource_map_1D_ptr,
            std::map< int, std::vector< std::vector< double >>> * resource_map_2D_ptr,
            int max_lines = -1 )  [private], [virtual]
```

Helper method to write time series results for Wind.

Parameters

write_path	A path (either relative or absolute) to the directory location where results are to be written. If already exists, will overwrite.
time_vec_hrs_ptr	A pointer to the time_vec_hrs attribute of the ElectricalLoad.
resource_map_1D_ptr	A pointer to the 1D map of Resources.
resource_map_2D_ptr	A pointer to the 2D map of Resources.
max_lines	The maximum number of lines of output to write.

Reimplemented from Renewable.

```
445 {
446     //  1. create filestream
447     write_path += "time_series_results.csv";
448     std::ofstream ofs;
449     ofs.open(write_path, std::ofstream::out);
450 
451     //  2. write time series results (comma separated value)
452     ofs « "Time (since start of data) [hrs],";
453     ofs « "Wind Resource [m/s],";
454     ofs « "Production [kW],";
455     ofs « "Dispatch [kW],";
456     ofs « "Storage [kW],";
457     ofs « "Curtailment [kW],";
458     ofs « "Capital Cost (actual),";
459     ofs « "Operation and Maintenance Cost (actual),";
460     ofs « "\n";
461 
462     for (int i = 0; i < max_lines; i++) {
463         ofs « time_vec_hrs_ptr->at(i) « ",";
464 
465         if (not this->normalized_production_series_given) {
466             ofs « resource_map_1D_ptr->at(this->resource_key)[i] « ",";
467         }
468 
469         else {
470             ofs « "OVERRIDE" « ",";
471         }
472 
473         ofs « this->production_vec_kW[i] « ",";
474         ofs « this->dispatch_vec_kW[i] « ",";
475         ofs « this->storage_vec_kW[i] « ",";
476         ofs « this->curtailment_vec_kW[i] « ",";
477         ofs « this->capital_cost_vec[i] « ",";
478         ofs « this->operation_maintenance_cost_vec[i] « ",";
479         ofs « "\n";
480     }
481 
482     return;
483 }   /* __writeTimeSeries() */
```

4.32.3.9 commit()

```
double Wind::commit (
            int timestep,
            double dt_hrs,
            double production_kW,
            double load_kW )  [virtual]
```

Method which takes in production and load for the current timestep, computes and records dispatch and curtailment, and then returns remaining load.

Parameters

timestep	The timestep (i.e., time series index) for the request.
dt_hrs	The interval of time [hrs] associated with the timestep.
production_kW	The production [kW] of the asset in this timestep.
load_kW	The load [kW] passed to the asset in this timestep.

Returns

The load [kW] remaining after the dispatch is deducted from it.

Reimplemented from Renewable.

```
774 {
775     //  1. invoke base class method
776     load_kW = Renewable :: commit(
777         timestep,
778         dt_hrs,
779         production_kW,
780         load_kW
781     );
782 
783 
784     //...
785 
786     return load_kW;
787 }   /* commit() */
```

4.32.3.10 computeProductionkW()

```
double Wind::computeProductionkW (
              int timestep,
              double dt_hrs,
              double wind_resource_ms )  [virtual]
```

Method which takes in the wind resource at a particular point in time, and then returns the wind turbine production at that point in time.

Parameters

timestep	The timestep (i.e., time series index) for the request.
dt_hrs	The interval of time [hrs] associated with the timestep.
wind_resource_ms	Wind resource (i.e. wind speed) [m/s].

Returns

The production [kW] of the wind turbine.

Reimplemented from Renewable.

```
674 {
675     //  given production time series override
676     if (this->normalized_production_series_given) {
677         double production_kW = Production :: getProductionkW(timestep);
678 
679         return production_kW;
680     }
681 
```

```
682     // check if no resource
683     if (wind_resource_ms <= 0) {
684         return 0;
685     }
686 
687     // compute production
688     double production_kW = 0;
689 
690     switch (this->power_model) {
691         case (WindPowerProductionModel :: WIND_POWER_CUBIC): {
692             production_kW = this->__computeCubicProductionkW(
693                 timestep,
694                 dt_hrs,
695                 wind_resource_ms
696             );
697 
698             break;
699         }
700 
701         case (WindPowerProductionModel :: WIND_POWER_EXPONENTIAL): {
702             production_kW = this->__computeExponentialProductionkW(
703                 timestep,
704                 dt_hrs,
705                 wind_resource_ms
706             );
707 
708             break;
709         }
710 
711         case (WindPowerProductionModel :: WIND_POWER_LOOKUP): {
712             production_kW = this->__computeLookupProductionkW(
713                 timestep,
714                 dt_hrs,
715                 wind_resource_ms
716             );
717 
718             break;
719         }
720 
721         default: {
722             std::string error_str = "ERROR:  Wind::computeProductionkW():  ";
723             error_str += "power model ";
724             error_str += std::to_string(this->power_model);
725             error_str += " not recognized";
726 
727             #ifdef _WIN32
728                 std::cout « error_str « std::endl;
729             #endif
730 
731             throw std::runtime_error(error_str);
732 
733             break;
734         }
735     }
736 
737     return production_kW;
738 }   /* computeProductionkW() */
```

4.32.3.11 handleReplacement()

```
void Wind::handleReplacement (
            int timestep )  [virtual]
```

Method to handle asset replacement and capital cost incursion, if applicable.

Parameters

timestep	The current time step of the Model run.

Reimplemented from Renewable.

```
634 {
635     //  1. reset attributes
636     //...
```

```
637
638     //  2. invoke base class method
639     Renewable :: handleReplacement(timestep);
640
641     return;
642 }   /* __handleReplacement() */
```

4.32.4 Member Data Documentation

4.32.4.1 design_speed_ms

```
double Wind::design_speed_ms
```

The wind speed [m/s] at which the wind turbine achieves its rated capacity.

4.32.4.2 power_model

```
WindPowerProductionModel Wind::power_model
```

The wind power production model to be applied.

4.32.4.3 power_model_string

```
std::string Wind::power_model_string
```

A string describing the active power production model.

The documentation for this class was generated from the following files:

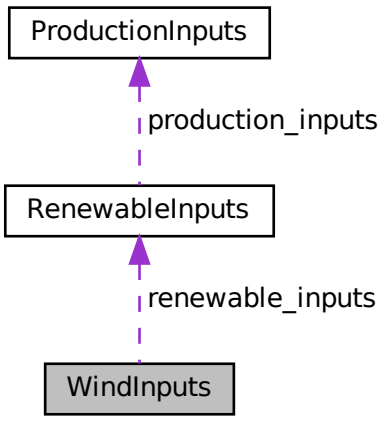
- header/Production/Renewable/Wind.h
- source/Production/Renewable/Wind.cpp

4.33 WindInputs Struct Reference

A structure which bundles the necessary inputs for the Wind constructor. Provides default values for every necessary input. Note that this structure encapsulates RenewableInputs.

`#include <Wind.h>`

Collaboration diagram for WindInputs:



Public Attributes

- RenewableInputs renewable_inputs

  An encapsulated RenewableInputs instance.
- int resource_key = 0

  A key used to index into the Resources object, to associate this asset with the appropriate resource time series.
- double capital_cost = -1

  The capital cost of the asset (undefined currency). -1 is a sentinel value, which triggers a generic cost model on construction (in fact, any negative value here will trigger). Note that the generic cost model is in terms of Canadian dollars [CAD].
- double operation_maintenance_cost_kWh = -1

  The operation and maintenance cost of the asset [1/kWh] (undefined currency). This is a cost incurred per unit of energy produced. -1 is a sentinel value, which triggers a generic cost model on construction (in fact, any negative value here will trigger). Note that the generic cost model is in terms of Canadian dollars [CAD/kWh].
- double design_speed_ms = 14

  The wind speed [m/s] at which the wind turbine achieves its rated capacity.
- WindPowerProductionModel power_model = WindPowerProductionModel :: WIND_POWER_CUBIC

  The wind power production model to be applied.

4.33.1 Detailed Description

A structure which bundles the necessary inputs for the Wind constructor. Provides default values for every necessary input. Note that this structure encapsulates RenewableInputs.

4.33.2 Member Data Documentation

4.33.2.1 capital_cost

```
double WindInputs::capital_cost = -1
```

The capital cost of the asset (undefined currency). -1 is a sentinel value, which triggers a generic cost model on construction (in fact, any negative value here will trigger). Note that the generic cost model is in terms of Canadian dollars [CAD].

4.33.2.2 design_speed_ms

```
double WindInputs::design_speed_ms = 14
```

The wind speed [m/s] at which the wind turbine achieves its rated capacity.

4.33.2.3 operation_maintenance_cost_kWh

```
double WindInputs::operation_maintenance_cost_kWh = -1
```

The operation and maintenance cost of the asset [1/kWh] (undefined currency). This is a cost incurred per unit of energy produced. -1 is a sentinel value, which triggers a generic cost model on construction (in fact, any negative value here will trigger). Note that the generic cost model is in terms of Canadian dollars [CAD/kWh].

4.33.2.4 power_model

```
WindPowerProductionModel WindInputs::power_model = WindPowerProductionModel ::  WIND_POWER_CUBIC
```

The wind power production model to be applied.

4.33.2.5 renewable_inputs

```
RenewableInputs WindInputs::renewable_inputs
```

An encapsulated RenewableInputs instance.

4.33.2.6 resource_key

```
int WindInputs::resource_key = 0
```

A key used to index into the Resources object, to associate this asset with the appropriate resource time series.

The documentation for this struct was generated from the following file:

- header/Production/Renewable/Wind.h

Chapter 5

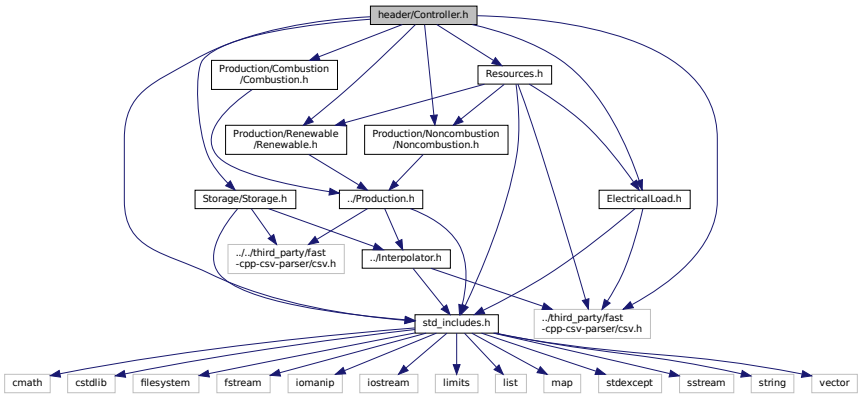
File Documentation

5.1 header/Controller.h File Reference

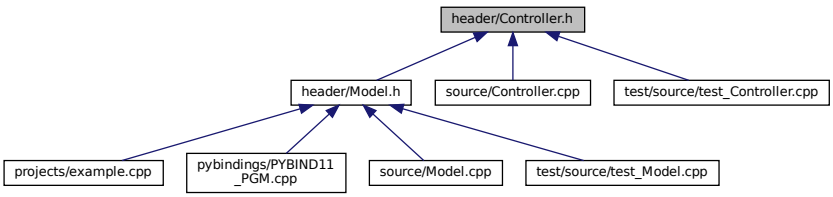
Header file for the Controller class.

```
#include "std_includes.h"
#include "../third_party/fast-cpp-csv-parser/csv.h"
#include "ElectricalLoad.h"
#include "Resources.h"
#include "Production/Combustion/Combustion.h"
#include "Production/Noncombustion/Noncombustion.h"
#include "Production/Renewable/Renewable.h"
#include "Storage/Storage.h"
```

Include dependency graph for Controller.h:



This graph shows which files directly or indirectly include this file:



Classes

- class Controller

  A class which contains a various dispatch control logic. Intended to serve as a component class of Model.

Enumerations

- enum ControlMode { LOAD_FOLLOWING , CYCLE_CHARGING , N_CONTROL_MODES }

  An enumeration of the types of control modes supported by PGMcpp.

5.1.1 Detailed Description

Header file for the Controller class.

5.1.2 Enumeration Type Documentation

5.1.2.1 ControlMode

```
enum ControlMode
```

An enumeration of the types of control modes supported by PGMcpp.

Enumerator

LOAD_FOLLOWING	Load following control, with in-order dispatch of non-Combustion assets and optimal dispatch of Combustion assets.
CYCLE_CHARGING	Cycle charging control, with in-order dispatch of non-Combustion assets and optimal dispatch of Combustion assets.
N_CONTROL_MODES	A simple hack to get the number of elements in ControlMode.

```
69                  {
70     LOAD_FOLLOWING,
71     CYCLE_CHARGING,
72     N_CONTROL_MODES
73 };
```

5.2 header/doxygen_cite.h File Reference

Header file which simply cites the doxygen tool.

5.2.1 Detailed Description

Header file which simply cites the doxygen tool.

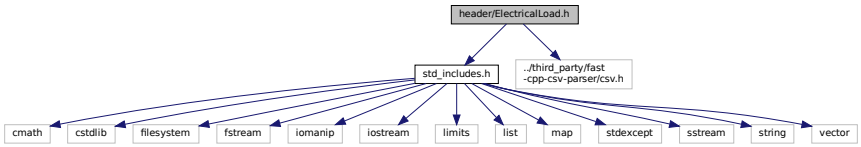
Ref: van Heesch. [2023]

5.3 header/ElectricalLoad.h File Reference

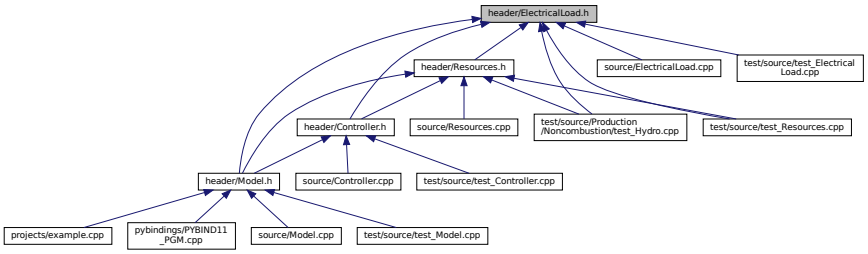
Header file for the ElectricalLoad class.

```
#include "std_includes.h"
#include "../third_party/fast-cpp-csv-parser/csv.h"
```

Include dependency graph for ElectricalLoad.h:



This graph shows which files directly or indirectly include this file:



Classes

- class ElectricalLoad

  A class which contains time and electrical load data. Intended to serve as a component class of Model.

5.3.1 Detailed Description

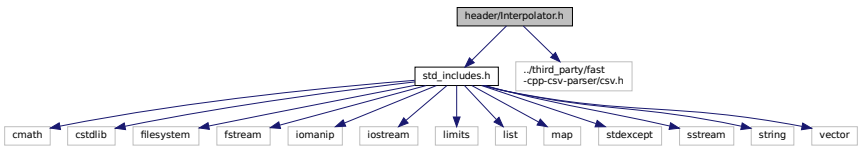
Header file for the ElectricalLoad class.

5.4 header/Interpolator.h File Reference

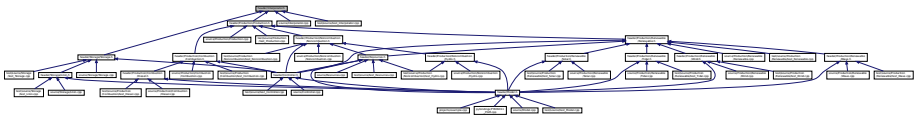
Header file for the Interpolator class.

```
#include "std_includes.h"
#include "../third_party/fast-cpp-csv-parser/csv.h"
```

Include dependency graph for Interpolator.h:



This graph shows which files directly or indirectly include this file:



Classes

- struct InterpolatorStruct1D

  A struct which holds two parallel vectors for use in 1D interpolation.
- struct InterpolatorStruct2D

  A struct which holds two parallel vectors and a matrix for use in 2D interpolation.
- class Interpolator

  A class which contains interpolation data and functionality. Intended to serve as a component of the Production and Storage hierarchies.

5.4.1 Detailed Description

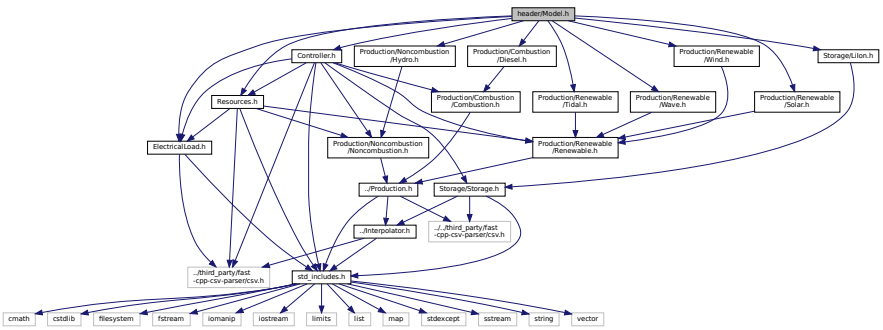
Header file for the Interpolator class.

5.5 header/Model.h File Reference

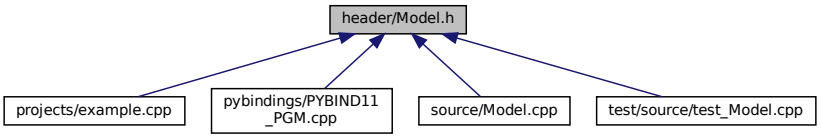
Header file for the Model class.

```
#include "Controller.h"
#include "ElectricalLoad.h"
#include "Resources.h"
#include "Production/Combustion/Diesel.h"
#include "Production/Noncombustion/Hydro.h"
#include "Production/Renewable/Solar.h"
#include "Production/Renewable/Tidal.h"
#include "Production/Renewable/Wave.h"
#include "Production/Renewable/Wind.h"
#include "Storage/LiIon.h"
```

Include dependency graph for Model.h:



This graph shows which files directly or indirectly include this file:



Classes

- struct ModelInputs

  A structure which bundles the necessary inputs for the Model constructor. Provides default values for every necessary input (except path_2_electrical_load_time_series, for which a valid input must be provided).
- class Model

  A container class which forms the centre of PGMcpp. The Model class is intended to serve as the primary user interface with the functionality of PGMcpp, and as such it contains all other classes.

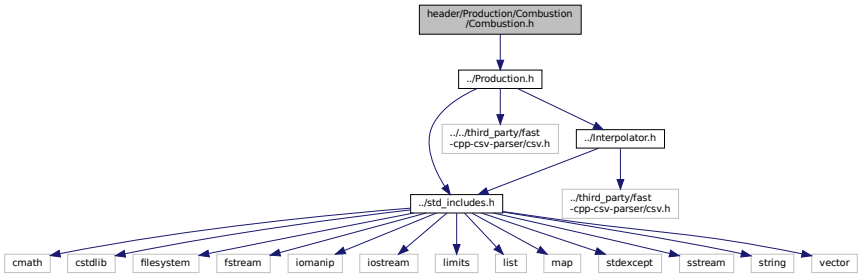
5.5.1 Detailed Description

Header file for the Model class.

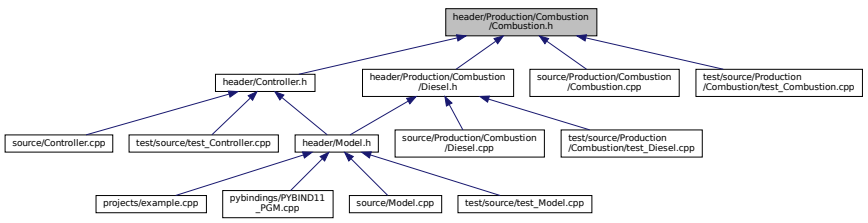
5.6 header/Production/Combustion/Combustion.h File Reference

Header file for the Combustion class.

`#include "../Production.h"`
Include dependency graph for Combustion.h:



This graph shows which files directly or indirectly include this file:



Classes

- struct CombustionInputs

  A structure which bundles the necessary inputs for the Combustion constructor. Provides default values for every necessary input. Note that this structure encapsulates ProductionInputs.
- struct Emissions

  A structure which bundles the emitted masses of various emissions chemistries.
- class Combustion

  The root of the Combustion branch of the Production hierarchy. This branch contains derived classes which model the production of energy by way of combustibles.

Enumerations

- enum CombustionType { DIESEL , N_COMBUSTION_TYPES }

  An enumeration of the types of Combustion asset supported by PGMcpp.
- enum FuelMode { FUEL_MODE_LINEAR , FUEL_MODE_LOOKUP , N_FUEL_MODES }

  An enumeration of the fuel modes for the Combustion asset which are supported by PGMcpp.

5.6.1 Detailed Description

Header file for the Combustion class.

Header file for the Noncombustion class.

5.6.2 Enumeration Type Documentation

5.6.2.1 CombustionType

```
enum CombustionType
```

An enumeration of the types of Combustion asset supported by PGMcpp.

Enumerator

DIESEL	A diesel generator.
N_COMBUSTION_TYPES	A simple hack to get the number of elements in CombustionType.

```
58                      {
59     DIESEL,
60     N_COMBUSTION_TYPES
61 };
```

5.6.2.2 FuelMode

```
enum FuelMode
```

An enumeration of the fuel modes for the Combustion asset which are supported by PGMcpp.

Enumerator

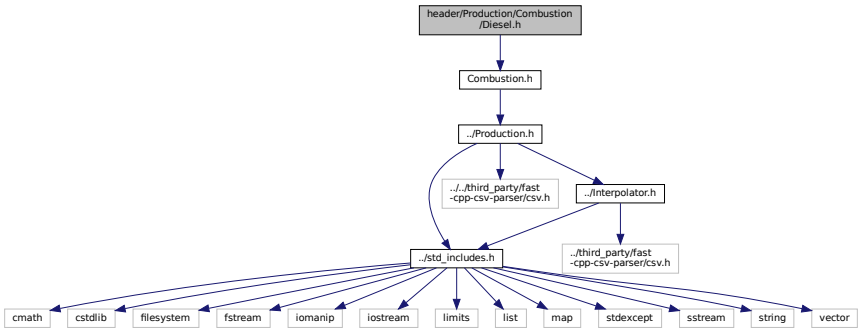
FUEL_MODE_LINEAR	A linearized fuel curve model (i.e., HOMER-like model)
FUEL_MODE_LOOKUP	Interpolating over a given fuel lookup table.
N_FUEL_MODES	A simple hack to get the number of elements in FuelMode.

```
71             {
72     FUEL_MODE_LINEAR,
73     FUEL_MODE_LOOKUP,
74     N_FUEL_MODES
75 };
```

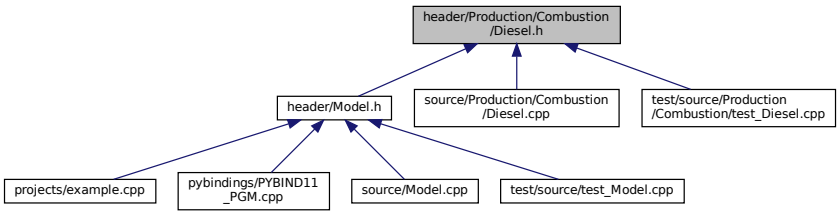
5.7 header/Production/Combustion/Diesel.h File Reference

Header file for the Diesel class.

`#include "Combustion.h"`
Include dependency graph for Diesel.h:



This graph shows which files directly or indirectly include this file:



Classes

- struct DieselInputs

  A structure which bundles the necessary inputs for the Diesel constructor. Provides default values for every necessary input. Note that this structure encapsulates CombustionInputs.
- class Diesel

  A derived class of the Combustion branch of Production which models production using a diesel generator.

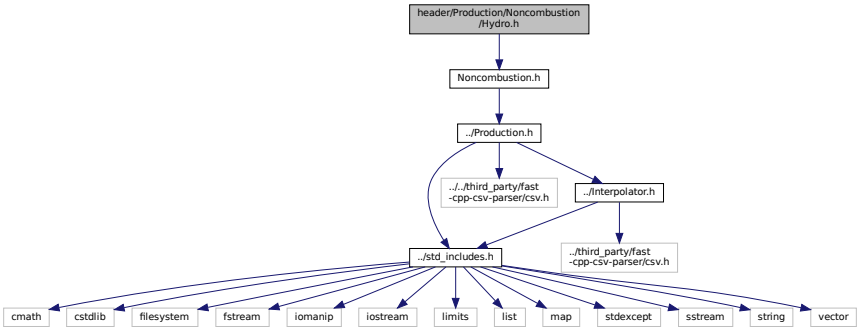
5.7.1 Detailed Description

Header file for the Diesel class.

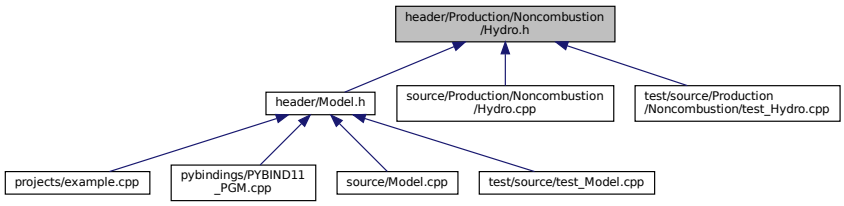
5.8 header/Production/Noncombustion/Hydro.h File Reference

Header file for the Hydro class.

```
#include "Noncombustion.h"
```
Include dependency graph for Hydro.h:



This graph shows which files directly or indirectly include this file:



Classes

- struct HydroInputs

  A structure which bundles the necessary inputs for the Hydro constructor. Provides default values for every necessary input. Note that this structure encapsulates NoncombustionInputs.
- class Hydro

  A derived class of the Noncombustion branch of Production which models production using a hydroelectric asset (either with reservoir or not).

Enumerations

- enum HydroTurbineType { HYDRO_TURBINE_PELTON , HYDRO_TURBINE_FRANCIS , HYDRO_TURBINE_KAPLAN , N_HYDRO_TURBINES }

  An enumeration of the types of hydroelectric turbine supported by PGMcpp.
- enum HydroInterpKeys { GENERATOR_EFFICIENCY_INTERP_KEY , TURBINE_EFFICIENCY_INTERP_KEY , FLOW_TO_POWER_INTERP_KEY , N_HYDRO_INTERP_KEYS }

  An enumeration of the Interpolator keys used by the Hydro asset.

5.8.1 Detailed Description

Header file for the Hydro class.

5.8.2 Enumeration Type Documentation

5.8.2.1 HydroInterpKeys

```
enum HydroInterpKeys
```

An enumeration of the Interpolator keys used by the Hydro asset.

Enumerator

GENERATOR_EFFICIENCY_INTERP_KEY	The key for generator efficiency interpolation.
TURBINE_EFFICIENCY_INTERP_KEY	The key for turbine efficiency interpolation.
FLOW_TO_POWER_INTERP_KEY	The key for flow to power interpolation.
N_HYDRO_INTERP_KEYS	A simple hack to get the number of elements in HydroInterpKeys.

```
72                      {
73     GENERATOR_EFFICIENCY_INTERP_KEY,
74     TURBINE_EFFICIENCY_INTERP_KEY,
75     FLOW_TO_POWER_INTERP_KEY,
76     N_HYDRO_INTERP_KEYS
77 };
```

5.8.2.2 HydroTurbineType

```
enum HydroTurbineType
```

An enumeration of the types of hydroelectric turbine supported by PGMcpp.

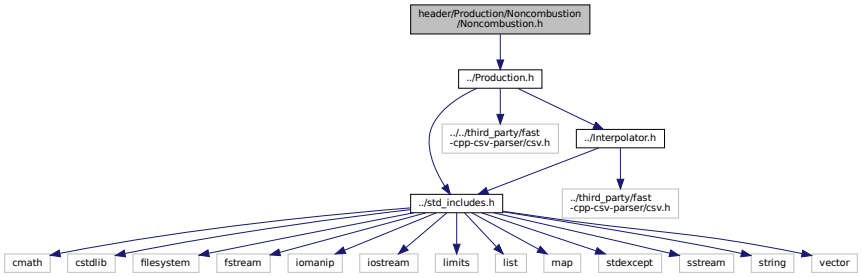
Enumerator

HYDRO_TURBINE_PELTON	A Pelton turbine (impluse)
HYDRO_TURBINE_FRANCIS	A Francis turbine (reaction)
HYDRO_TURBINE_KAPLAN	A Kaplan turbine (reaction)
N_HYDRO_TURBINES	A simple hack to get the number of elements in HydroTurbineType.

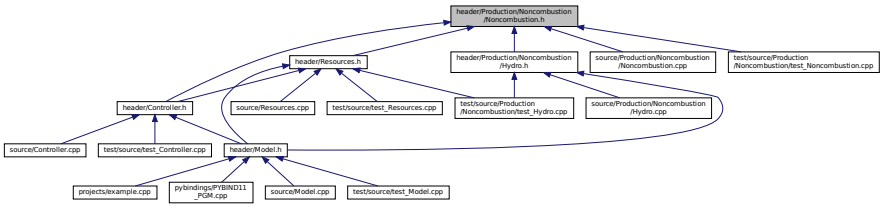
```
58                      {
59     HYDRO_TURBINE_PELTON,
60     HYDRO_TURBINE_FRANCIS,
61     HYDRO_TURBINE_KAPLAN,
62     N_HYDRO_TURBINES
63 };
```

5.9 header/Production/Noncombustion/Noncombustion.h File Reference

`#include "../Production.h"`
Include dependency graph for Noncombustion.h:



This graph shows which files directly or indirectly include this file:



Classes

- struct NoncombustionInputs

  A structure which bundles the necessary inputs for the Noncombustion constructor. Provides default values for every necessary input. Note that this structure encapsulates ProductionInputs.
- class Noncombustion

  The root of the Noncombustion branch of the Production hierarchy. This branch contains derived classes which model controllable production which is not based on combustion.

Enumerations

- enum NoncombustionType { HYDRO , N_NONCOMBUSTION_TYPES }

  An enumeration of the types of Noncombustion asset supported by PGMcpp.

5.9.1 Enumeration Type Documentation

5.9.1.1 NoncombustionType

```
enum NoncombustionType
```

An enumeration of the types of Noncombustion asset supported by PGMcpp.

Enumerator

HYDRO	A hydroelectric generator (either with reservoir or not)
N_NONCOMBUSTION_TYPES	A simple hack to get the number of elements in NoncombustionType.

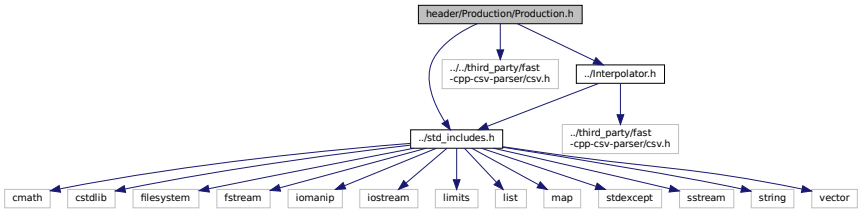
```
58                          {
59     HYDRO,
60     N_NONCOMBUSTION_TYPES
61 };
```

5.10 header/Production/Production.h File Reference

Header file for the Production class.

```
#include "../std_includes.h"
#include "../../third_party/fast-cpp-csv-parser/csv.h"
#include "../Interpolator.h"
```

Include dependency graph for Production.h:



This graph shows which files directly or indirectly include this file:

Classes

- struct ProductionInputs

  A structure which bundles the necessary inputs for the Production constructor. Provides default values for every necessary input.
- class Production

  The base class of the Production hierarchy. This hierarchy contains derived classes which model the production of energy, be it renewable or otherwise.

5.10.1 Detailed Description

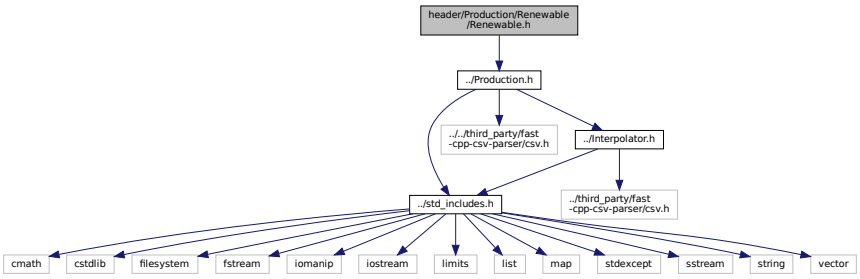
Header file for the Production class.

5.11 header/Production/Renewable/Renewable.h File Reference

Header file for the Renewable class.

```
#include "../Production.h"
```

Include dependency graph for Renewable.h:



This graph shows which files directly or indirectly include this file:

Classes

- struct RenewableInputs

  A structure which bundles the necessary inputs for the Renewable constructor. Provides default values for every necessary input. Note that this structure encapsulates ProductionInputs.
- class Renewable

  The root of the Renewable branch of the Production hierarchy. This branch contains derived classes which model the renewable production of energy.

Enumerations

- enum RenewableType {
  SOLAR , TIDAL , WAVE , WIND ,
  N_RENEWABLE_TYPES }

  An enumeration of the types of Renewable asset supported by PGMcpp.

5.11.1 Detailed Description

Header file for the Renewable class.

5.11.2 Enumeration Type Documentation

5.11.2.1 RenewableType

```
enum RenewableType
```

An enumeration of the types of Renewable asset supported by PGMcpp.

Enumerator

SOLAR	A solar photovoltaic (PV) array.
TIDAL	A tidal stream turbine (or tidal energy converter, TEC)
WAVE	A wave energy converter (WEC)
WIND	A wind turbine.
N_RENEWABLE_TYPES	A simple hack to get the number of elements in RenewableType.

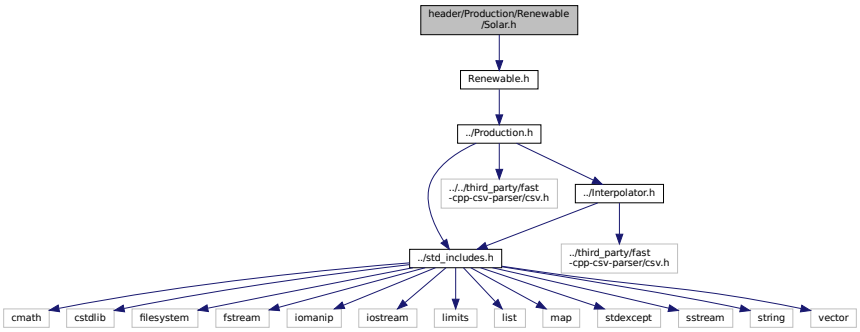
```
58                  {
59     SOLAR,
60     TIDAL,
61     WAVE,
62     WIND,
63     N_RENEWABLE_TYPES
64 };
```

5.12 header/Production/Renewable/Solar.h File Reference

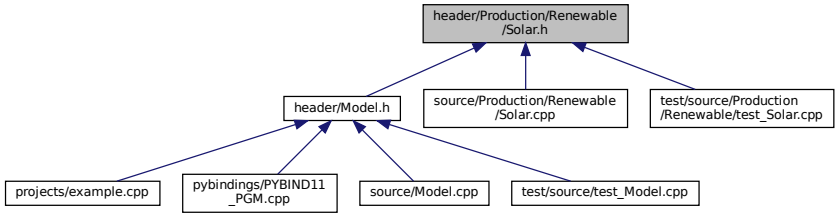
Header file for the Solar class.

```
#include "Renewable.h"
```

Include dependency graph for Solar.h:



This graph shows which files directly or indirectly include this file:



Classes

- struct SolarInputs

  A structure which bundles the necessary inputs for the Solar constructor. Provides default values for every necessary input. Note that this structure encapsulates RenewableInputs.
- class Solar

  A derived class of the Renewable branch of Production which models solar production.

Enumerations

- enum SolarPowerProductionModel { SOLAR_POWER_SIMPLE , SOLAR_POWER_DETAILED , N_SOLAR_POWER_PRODUCTION_MODELS }

5.12.1 Detailed Description

Header file for the Solar class.

5.12.2 Enumeration Type Documentation

5.12.2.1 SolarPowerProductionModel

```
enum SolarPowerProductionModel
```

Enumerator

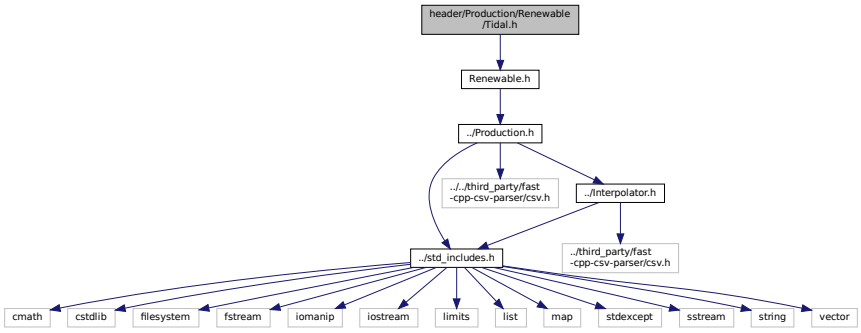
SOLAR_POWER_SIMPLE	A simple "HOMER-like" power production model.
SOLAR_POWER_DETAILED	A more detailed "PVWatts/SAM-like" production model.
N_SOLAR_POWER_PRODUCTION_MODELS	A simple hack to get the number of elements in SolarPowerProductionModel.

```
59                                {
60     SOLAR_POWER_SIMPLE,
61     SOLAR_POWER_DETAILED,
62     N_SOLAR_POWER_PRODUCTION_MODELS
63 };
```

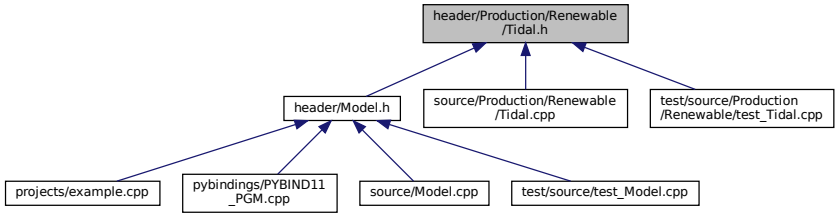
5.13 header/Production/Renewable/Tidal.h File Reference

Header file for the Tidal class.

`#include "Renewable.h"`
Include dependency graph for Tidal.h:



This graph shows which files directly or indirectly include this file:



Classes

- struct TidalInputs

  A structure which bundles the necessary inputs for the Tidal constructor. Provides default values for every necessary input. Note that this structure encapsulates RenewableInputs.
- class Tidal

  A derived class of the Renewable branch of Production which models tidal production.

Enumerations

- enum TidalPowerProductionModel { TIDAL_POWER_CUBIC , TIDAL_POWER_EXPONENTIAL , TIDAL_POWER_LOOKUP , N_TIDAL_POWER_PRODUCTION_MODELS }

5.13.1 Detailed Description

Header file for the Tidal class.

5.13.2 Enumeration Type Documentation

5.13.2.1 TidalPowerProductionModel

```
enum TidalPowerProductionModel
```

Enumerator

TIDAL_POWER_CUBIC	A cubic power production model.
TIDAL_POWER_EXPONENTIAL	An exponential power production model.
TIDAL_POWER_LOOKUP	Lookup from a given set of power curve data.
N_TIDAL_POWER_PRODUCTION_MODELS	A simple hack to get the number of elements in TidalPowerProductionModel.

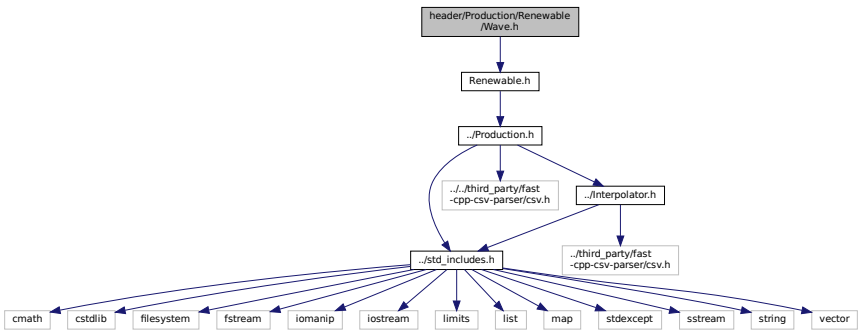
```
59                                {
60     TIDAL_POWER_CUBIC,
61     TIDAL_POWER_EXPONENTIAL,
62     TIDAL_POWER_LOOKUP,
63     N_TIDAL_POWER_PRODUCTION_MODELS
64 };
```

5.14 header/Production/Renewable/Wave.h File Reference

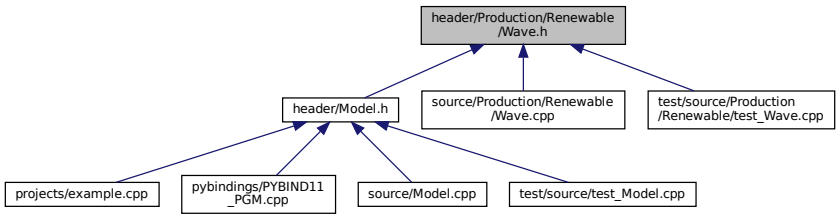
Header file for the Wave class.

```
#include "Renewable.h"
```

Include dependency graph for Wave.h:



This graph shows which files directly or indirectly include this file:



Classes

- struct WaveInputs

  A structure which bundles the necessary inputs for the Wave constructor. Provides default values for every necessary input. Note that this structure encapsulates RenewableInputs.
- class Wave

  A derived class of the Renewable branch of Production which models wave production.

Enumerations

- enum WavePowerProductionModel { WAVE_POWER_GAUSSIAN , WAVE_POWER_PARABOLOID , WAVE_POWER_LOOKUP , N_WAVE_POWER_PRODUCTION_MODELS }

5.14.1 Detailed Description

Header file for the Wave class.

5.14.2 Enumeration Type Documentation

5.14.2.1 WavePowerProductionModel

```
enum WavePowerProductionModel
```

Enumerator

WAVE_POWER_GAUSSIAN	A Gaussian power production model.
WAVE_POWER_PARABOLOID	A paraboloid power production model.
WAVE_POWER_LOOKUP	Lookup from a given performance matrix.
N_WAVE_POWER_PRODUCTION_MODELS	A simple hack to get the number of elements in WavePowerProductionModel.

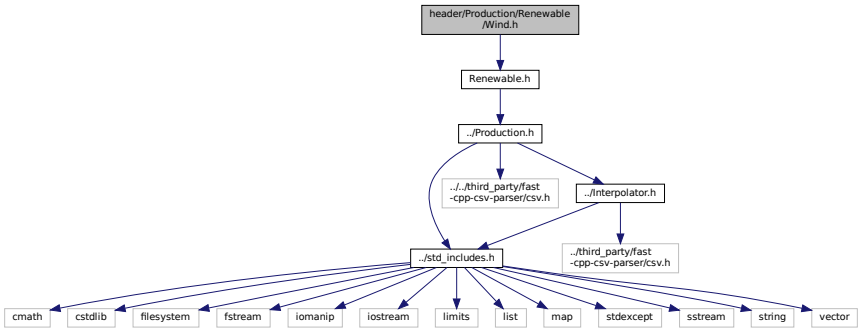
```
59                              {
60     WAVE_POWER_GAUSSIAN,
```

```
61     WAVE_POWER_PARABOLOID,
62     WAVE_POWER_LOOKUP,
63     N_WAVE_POWER_PRODUCTION_MODELS
64 };
```

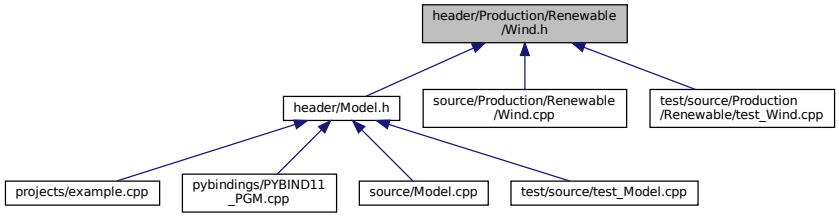
5.15 header/Production/Renewable/Wind.h File Reference

Header file for the Wind class.

`#include "Renewable.h"`
Include dependency graph for Wind.h:



This graph shows which files directly or indirectly include this file:



Classes

- struct WindInputs

  A structure which bundles the necessary inputs for the Wind constructor. Provides default values for every necessary input. Note that this structure encapsulates RenewableInputs.
- class Wind

  A derived class of the Renewable branch of Production which models wind production.

Enumerations

- enum WindPowerProductionModel { WIND_POWER_CUBIC , WIND_POWER_EXPONENTIAL , WIND_POWER_LOOKUP , N_WIND_POWER_PRODUCTION_MODELS }

5.15.1 Detailed Description

Header file for the Wind class.

5.15.2 Enumeration Type Documentation

5.15.2.1 WindPowerProductionModel

```
enum WindPowerProductionModel
```

Enumerator

WIND_POWER_CUBIC	A cubic power production model.
WIND_POWER_EXPONENTIAL	An exponential power production model.
WIND_POWER_LOOKUP	Lookup from a given set of power curve data.
N_WIND_POWER_PRODUCTION_MODELS	A simple hack to get the number of elements in WindPowerProductionModel.

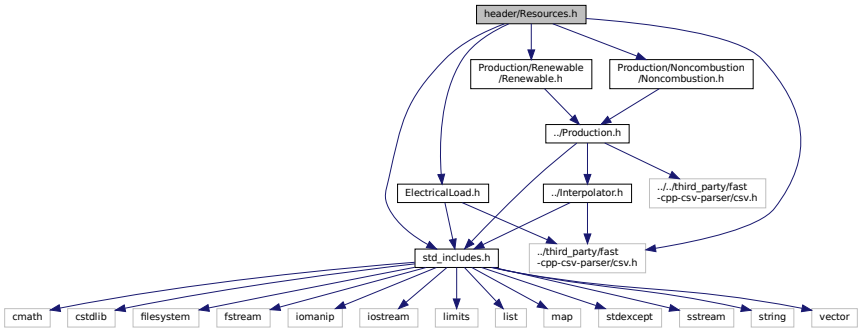
```
59                              {
60     WIND_POWER_CUBIC,
61     WIND_POWER_EXPONENTIAL,
62     WIND_POWER_LOOKUP,
63     N_WIND_POWER_PRODUCTION_MODELS
64 };
```

5.16 header/Resources.h File Reference

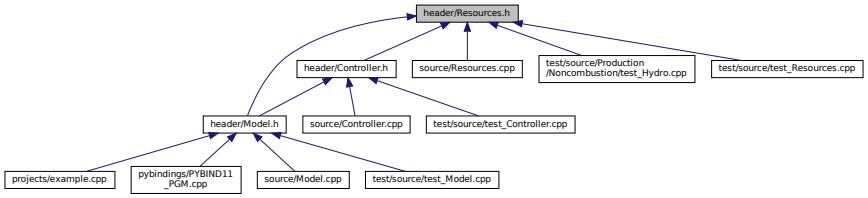
Header file for the Resources class.

```
#include "std_includes.h"
#include "../third_party/fast-cpp-csv-parser/csv.h"
#include "ElectricalLoad.h"
#include "Production/Noncombustion/Noncombustion.h"
#include "Production/Renewable/Renewable.h"
```

Include dependency graph for Resources.h:



This graph shows which files directly or indirectly include this file:



Classes

- class Resources

  A class which contains renewable resource data. Intended to serve as a component class of Model.

5.16.1 Detailed Description

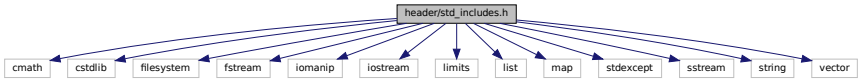
Header file for the Resources class.

5.17 header/std_includes.h File Reference

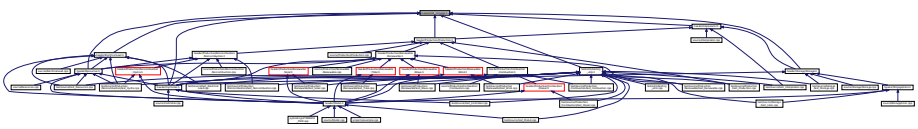
Header file which simply batches together some standard includes.

```
#include <cmath>
#include <cstdlib>
#include <filesystem>
#include <fstream>
#include <iomanip>
#include <iostream>
#include <limits>
#include <list>
#include <map>
#include <stdexcept>
#include <sstream>
#include <string>
#include <vector>
```

Include dependency graph for std_includes.h:



This graph shows which files directly or indirectly include this file:



5.17.1 Detailed Description

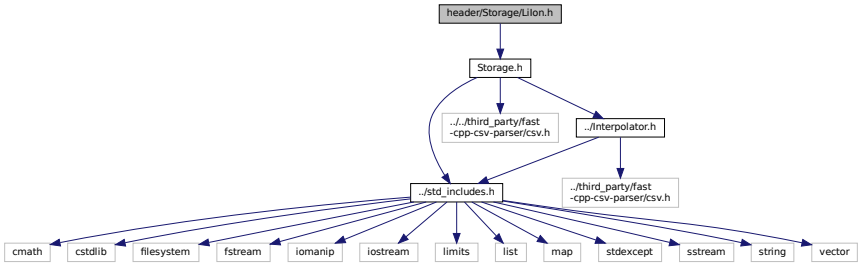
Header file which simply batches together some standard includes.

5.18 header/Storage/LiIon.h File Reference

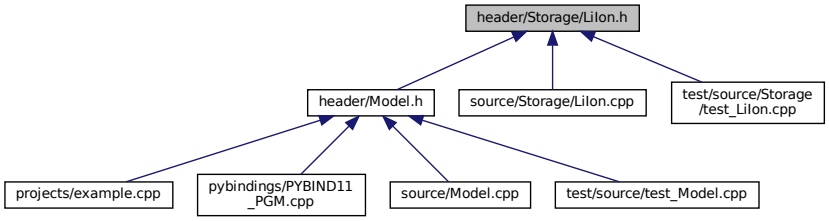
Header file for the LiIon class.

```
#include "Storage.h"
```

Include dependency graph for LiIon.h:



This graph shows which files directly or indirectly include this file:



Classes

- struct LiIonInputs

  A structure which bundles the necessary inputs for the LiIon constructor. Provides default values for every necessary input. Note that this structure encapsulates StorageInputs.
- class LiIon

  A derived class of Storage which models energy storage by way of lithium-ion batteries.

5.18.1 Detailed Description

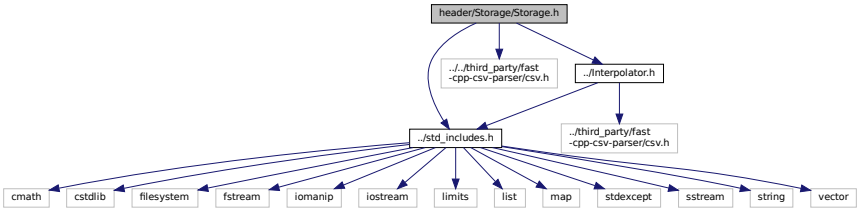
Header file for the LiIon class.

5.19 header/Storage/Storage.h File Reference

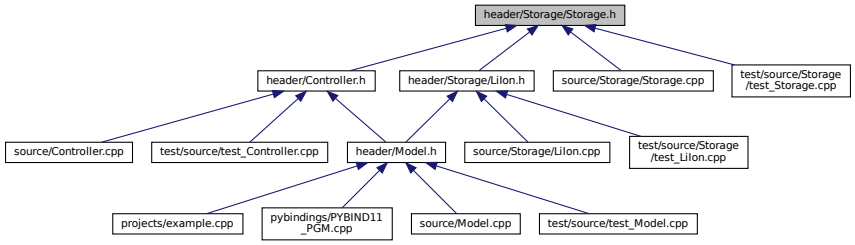
Header file for the Storage class.

```
#include "../std_includes.h"
#include "../../third_party/fast-cpp-csv-parser/csv.h"
#include "../Interpolator.h"
```

Include dependency graph for Storage.h:



This graph shows which files directly or indirectly include this file:



Classes

- struct StorageInputs

  A structure which bundles the necessary inputs for the Storage constructor. Provides default values for every necessary input.
- class Storage

  The base class of the Storage hierarchy. This hierarchy contains derived classes which model the storage of energy.

Enumerations

- enum StorageType { LIION , N_STORAGE_TYPES }

  An enumeration of the types of Storage asset supported by PGMcpp.

5.19.1 Detailed Description

Header file for the Storage class.

5.19.2 Enumeration Type Documentation

5.19.2.1 StorageType

```
enum StorageType
```

An enumeration of the types of Storage asset supported by PGMcpp.

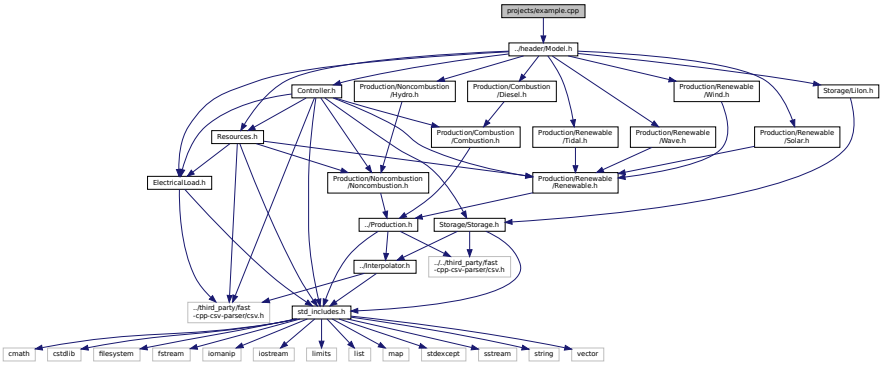
Enumerator

LIION	A system of lithium ion batteries.
N_STORAGE_TYPES	A simple hack to get the number of elements in StorageType.

```
61                  {
62     LIION,
63     N_STORAGE_TYPES
64 };
```

5.20 projects/example.cpp File Reference

```
#include "../header/Model.h"
```
Include dependency graph for example.cpp:



Functions

- int main (int argc, char **argv)

5.20.1 Function Documentation

5.20.1.1 main()

```
int main (
              int argc,
              char ** argv )
51 {
52     /*
53      *  1. construct Model object
54      *
55      *  This block constructs a Model object, which is the central container for the
56      *  entire microgrid model.
57      *
58      *  The fist argument that must be provided to the Model constructor is a valid
59      *  path (either relative or absolute) to a time series of electrical load data.
60      *  For an example of the expected format, see
61      *
62      *  data/test/electrical_load/electrical_load_generic_peak-500kW_1yr_dt-1hr.csv
63      *
64      *  Note that the length of the given electrical load time series defines the
65      *  modelled project life (so if you want to model n years of microgrid operation,
66      *  then you must pass a path to n years worth of electrical load data). In addition,
67      *  the given electrical load time series defines which points in time are modelled.
68      *  As such, all subsequent time series data which is passed in must (1) be of the
69      *  same length as the electrical load time series, and (2) provide data for the
70      *  same set of points in time. Of course, the electrical load time series can be
71      *  of arbitrary length, and it need not be a uniform time series.
72      *
73      *  The second argument that one can provide is the desired disptach control mode.
74      *  If nothing is given here, then the model will default to simple load following
75      *  control. However, one can stipulate which control mode to use by altering the
76      *  control_mode attribute of the ModelInputs structure. In this case, the
77      *  cycle charging control mode is being set.
78      */
79
80     std::string path_2_electrical_load_time_series =
81         "data/test/electrical_load/electrical_load_generic_peak-500kW_1yr_dt-1hr.csv";
82
83     ModelInputs model_inputs;
84
85     model_inputs.path_2_electrical_load_time_series =
86         path_2_electrical_load_time_series;
87
88     model_inputs.control_mode = ControlMode :: CYCLE_CHARGING;
89
90     Model model(model_inputs);
91
92
93
94     /*
95      *  2. add Diesel objects to Model
96      *
97      *  This block defines and adds a set of diesel generators to the Model object.
98      *
99      *  In this example, a single DieselInputs structure is used to define and add
100      *  three diesel generators to the model.
101      *
102      *  The first diesel generator is defined as a 300 kW generator (which shows an
103      *  example of how to access and alter an encapsulated attribute of DieselInputs).
104      *  In addition, the diesel generator is taken to be a sunk cost (and so no capital
105      *  cost is incurred in the first time step; the opposite is true for non-sunk
106      *  assets).
107      *
108      *  The last two diesel generators are defined as 150 kW each. Likewise, they are
109      *  also sunk assets (since the same DieselInputs structure is being re-used without
110      *  overwriting the is_sunk attribute).
111      *
112      *  For more details on the various attributes of DieselInputs, refer to the
113      *  PGMcpp manual. For instance, note that no economic inputs are given; in this
114      *  example, the default values apply.
115      */
116
117     DieselInputs diesel_inputs;
118
119     //  2.1. add 1 x 300 kW diesel generator (since mean load is ~250 kW)
120     diesel_inputs.combustion_inputs.production_inputs.capacity_kW = 300;
121     diesel_inputs.combustion_inputs.production_inputs.is_sunk = true;
122
123     model.addDiesel(diesel_inputs);
124
125     //  2.2. add 2 x 150 kW diesel generators (since max load is 500 kW)
126     diesel_inputs.combustion_inputs.production_inputs.capacity_kW = 150;
127
128     model.addDiesel(diesel_inputs);
129     model.addDiesel(diesel_inputs);
130
```

```
131
132
133     /*
134      *  3. add renewable resources to Model
135      *
136      *  This block adds a set of renewable resource time series to the Model object.
137      *
138      *  The first resource added is a solar resource time series, which gives
139      *  horizontal irradiance [kW/m2] at each point in time. Again, remember that all
140      *  given time series must align with the electrical load time series (i.e., same
141      *  length, same points). For an example of the expected format, see
142      *
143      *  data/test/resources/solar_GHI_peak-1kWm2_1yr_dt-1hr.csv
144      *
145      *  Finally, note the declaration of a solar resource key. This variable will be
146      *  re-used later to associate a solar PV array object with this particular solar
147      *  resource. This method of key association between resource and asset allows for
148      *  greater flexibility in modelling production assets that are exposed to different
149      *  renewable resources (due to being geographically separated, etc.).
150      *
151      *  The second resource added is a tidal resource time series, which gives tidal
152      *  stream speed [m/s] at each point in time. For an example of the expected format,
153      *  see
154      *
155      *  data/test/resources/tidal_speed_peak-3ms_1yr_dt-1hr.csv
156      *
157      *  Again, note the tidal resource key.
158      *
159      *  The third resource added is a wave resource time series, which gives significant
160      *  wave height [m] and energy period [s] at each point in time. For an example of
161      *  the expected format, see
162      *
163      *  data/test/resources/waves_H_s_peak-8m_T_e_peak-15s_1yr_dt-1hr.csv
164      *
165      *  Again, note the wave resource key.
166      *
167      *  The fourth resource added is a wind resource time series, which gives wind speed
168      *  [m/s] at each point in time. For an example of the expected format, see
169      *
170      *  data/test/resources/wind_speed_peak-25ms_1yr_dt-1hr.csv
171      *
172      *  Again, note the wind resource key.
173      *
174      *  The fifth resource added is a hydro resource time series, which gives inflow
175      *  rate [m3/hr] at each point in time. For an example of the expected format, see
176      *
177      *  data/test/resources/hydro_inflow_peak-20000m3hr_1yr_dt-1hr.csv
178      *
179      *  Again, note the hydro resource key.
180      */
181
182     //  3.1. add solar resource time series
183     int solar_resource_key = 0;
184     std::string path_2_solar_resource_data =
185         "data/test/resources/solar_GHI_peak-1kWm2_1yr_dt-1hr.csv";
186
187     model.addResource(
188         RenewableType :: SOLAR,
189         path_2_solar_resource_data,
190         solar_resource_key
191     );
192
193     //  3.2. add tidal resource time series
194     int tidal_resource_key = 1;
195     std::string path_2_tidal_resource_data =
196         "data/test/resources/tidal_speed_peak-3ms_1yr_dt-1hr.csv";
197
198     model.addResource(
199         RenewableType :: TIDAL,
200         path_2_tidal_resource_data,
201         tidal_resource_key
202     );
203
204     //  3.3. add wave resource time series
205     int wave_resource_key = 2;
206     std::string path_2_wave_resource_data =
207         "data/test/resources/waves_H_s_peak-8m_T_e_peak-15s_1yr_dt-1hr.csv";
208
209     model.addResource(
210         RenewableType :: WAVE,
211         path_2_wave_resource_data,
212         wave_resource_key
213     );
214
215     //  3.4. add wind resource time series
216     int wind_resource_key = 3;
217     std::string path_2_wind_resource_data =
```

```
218         "data/test/resources/wind_speed_peak-25ms_1yr_dt-1hr.csv";
219
220     model.addResource(
221         RenewableType :: WIND,
222         path_2_wind_resource_data,
223         wind_resource_key
224     );
225
226     //  3.5. add hydro resource time series
227     int hydro_resource_key = 4;
228     std::string path_2_hydro_resource_data =
229         "data/test/resources/hydro_inflow_peak-20000m3hr_1yr_dt-1hr.csv";
230
231     model.addResource(
232         NoncombustionType :: HYDRO,
233         path_2_hydro_resource_data,
234         hydro_resource_key
235     );
236
237
238
239     /*
240      *  4. add Hydro object to Model
241      *
242      *  This block defines and adds a hydroelectric asset to the Model object.
243      *
244      *  In this example, a 300 kW hydroelectric station with a 10,000 m3 reservoir
245      *  is defined. The initial reservoir state is set to 50% (so half full), and the
246      *  hydroelectric asset is taken to be a sunk asset (so no capital cost incurred
247      *  in the first time step). Note the association with the previously given hydro
248      *  resource series by way of the hydro resource key.
249      *
250      *  For more details on the various attributes of HydroInputs, refer to the
251      *  PGMcpp manual. For instance, note that no economic inputs are given; in this
252      *  example, the default values apply.
253      */
254
255     HydroInputs hydro_inputs;
256     hydro_inputs.noncombustion_inputs.production_inputs.capacity_kW = 300;
257     hydro_inputs.reservoir_capacity_m3 = 10000;
258     hydro_inputs.init_reservoir_state = 0.5;
259     hydro_inputs.noncombustion_inputs.production_inputs.is_sunk = true;
260     hydro_inputs.resource_key = hydro_resource_key;
261
262     model.addHydro(hydro_inputs);
263
264
265
266     /*
267      *  5. add Renewable objects to Model
268      *
269      *  This block defines and adds a set of renewable production assets to the Model
270      *  object.
271      *
272      *  The first block defines and adds a solar PV array to the Model object. In this
273      *  example, the installed solar capacity is set to 250 kW. Note the association
274      *  with the previously given solar resource series by way of the solar resource
275      *  key. Also, note that this asset is not taken as sunk (as the is_sunk attribute
276      *  of the SolarInputs structure is unchanged and thus defaults to true). As such,
277      *  this asset will incur a capital cost in the first time step.
278      *
279      *  For more details on the various attributes of SolarInputs, refer to the PGMcpp
280      *  manual. For instance, note that no economic inputs are given; in this
281      *  example, the default values apply.
282      *
283      *  The second block defines and adds a tidal turbine to the Model object. In this
284      *  example, the installed tidal capacity is set to 120 kW. In addition, the design
285      *  speed of the asset (i.e., the speed at which the rated capacity is achieved) is
286      *  set to 2.5 m/s. Note the association with the previously given tidal resource
287      *  series by way of the tidal resource key.
288      *
289      *  For more details on the various attributes of TidalInputs, refer to the PGMcpp
290      *  manual. For instance, note that no economic inputs are given; in this
291      *  example, the default values apply.
292      *
293      *  The third block defines and adds a wind turbine to the Model object. In this
294      *  example, the installed wind capacity is set to 150 kW. In addition, the design
295      *  speed of the asset is not given, and so will default to 8 m/s. Note the
296      *  association with the previously given tidal resource series by way of the wind
297      *  resource key.
298      *
299      *  For more details on the various attributes of WindInputs, refer to the PGMcpp
300      *  manual. For instance, note that no economic inputs are given; in this
301      *  example, the default values apply.
302      *
303      *  The fourth block defines and adds a wave energy converter to the Model object.
304      *  In this example, the installed wave capacity is set to 100 kW. Note the
```

```
305      *  association with the previously given wave resource series by way of the wave
306      *  resource key.
307      *
308      *  For more details on the various attributes of WaveInputs, refer to the PGMcpp
309      *  manual. For instance, note that no economic inputs are given; in this
310      *  example, the default values apply.
311      */
312
313     //  5.1. add 1 x 250 kW solar PV array
314     SolarInputs solar_inputs;
315
316     solar_inputs.renewable_inputs.production_inputs.capacity_kW = 250;
317     solar_inputs.resource_key = solar_resource_key;
318
319     model.addSolar(solar_inputs);
320
321     //  5.2. add 1 x 120 kW tidal turbine
322     TidalInputs tidal_inputs;
323
324     tidal_inputs.renewable_inputs.production_inputs.capacity_kW = 120;
325     tidal_inputs.design_speed_ms = 2.5;
326     tidal_inputs.resource_key = tidal_resource_key;
327
328     model.addTidal(tidal_inputs);
329
330     //  5.3. add 1 x 150 kW wind turbine
331     WindInputs wind_inputs;
332
333     wind_inputs.renewable_inputs.production_inputs.capacity_kW = 150;
334     wind_inputs.resource_key = wind_resource_key;
335
336     model.addWind(wind_inputs);
337
338     //  5.4. add 1 x 100 kW wave energy converter
339     WaveInputs wave_inputs;
340
341     wave_inputs.renewable_inputs.production_inputs.capacity_kW = 100;
342     wave_inputs.resource_key = wave_resource_key;
343
344     model.addWave(wave_inputs);
345
346
347
348     /*
349      *  6. add LiIon object to Model
350      *
351      *  This block defines and adds a lithium ion battery energy storage system to the
352      *  Model object.
353      *
354      *  In this example, a battery energy storage system with a 500 kW power capacity
355      *  and a 1050 kWh energy capacity (which represents about four hours of mean load
356      *  autonomy) is defined.
357      *
358      *  For more details on the various attributes of LiIonInputs, refer to the PGMcpp
359      *  manual. For instance, note that no economic inputs are given; in this
360      *  example, the default values apply.
361      */
362
363     //  6.1. add 1 x (500 kW, ) lithium ion battery energy storage system
364     LiIonInputs liion_inputs;
365
366     liion_inputs.storage_inputs.power_capacity_kW = 500;
367     liion_inputs.storage_inputs.energy_capacity_kWh = 1050;
368
369     model.addLiIon(liion_inputs);
370
371
372
373     /*
374      *  7. run and write results
375      *
376      *  This block runs the model and then writes results to the given output path
377      *  (either relative or absolute). Note that the writeResults() will create the
378      *  last directory on the given path, but not any in-between directories, so be
379      *  sure those exist before calling out to this method.
380      */
381
382     model.run();
383
384     model.writeResults("projects/example_cpp");
385
386     return 0;
387 }   /* main() */
```

5.21 pybindings/PYBIND11_PGM.cpp File Reference

Bindings file for PGMcpp.

```
#include <pybind11/pybind11.h>
#include <pybind11/stl.h>
#include "../header/Model.h"
#include "snippets/PYBIND11_Controller.cpp"
#include "snippets/PYBIND11_ElectricalLoad.cpp"
#include "snippets/PYBIND11_Interpolator.cpp"
#include "snippets/PYBIND11_Model.cpp"
#include "snippets/PYBIND11_Resources.cpp"
#include "snippets/Production/PYBIND11_Production.cpp"
#include "snippets/Production/Noncombustion/PYBIND11_Noncombustion.cpp"
#include "snippets/Production/Noncombustion/PYBIND11_Hydro.cpp"
#include "snippets/Production/Combustion/PYBIND11_Combustion.cpp"
#include "snippets/Production/Combustion/PYBIND11_Diesel.cpp"
#include "snippets/Production/Renewable/PYBIND11_Renewable.cpp"
#include "snippets/Production/Renewable/PYBIND11_Solar.cpp"
#include "snippets/Production/Renewable/PYBIND11_Tidal.cpp"
#include "snippets/Production/Renewable/PYBIND11_Wave.cpp"
#include "snippets/Production/Renewable/PYBIND11_Wind.cpp"
#include "snippets/Storage/PYBIND11_Storage.cpp"
#include "snippets/Storage/PYBIND11_LiIon.cpp"
```

Include dependency graph for PYBIND11_PGM.cpp:

Functions

- PYBIND11_MODULE (PGMcpp, m)

5.21.1 Detailed Description

Bindings file for PGMcpp.

Ref: Jakob [2023]
A file which instructs pybind11 how to build Python bindings for PGMcpp. Only public attributes/methods are bound!

5.21.2 Function Documentation

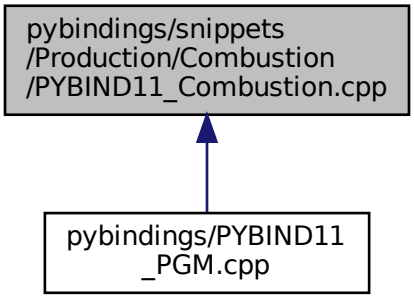
5.21.2.1 PYBIND11_MODULE()

```
PYBIND11_MODULE (
              PGMcpp ,
              m  )
56                            {
57
58      #include "snippets/PYBIND11_Controller.cpp"
59      #include "snippets/PYBIND11_ElectricalLoad.cpp"
60      #include "snippets/PYBIND11_Interpolator.cpp"
61      #include "snippets/PYBIND11_Model.cpp"
62      #include "snippets/PYBIND11_Resources.cpp"
63
64      #include "snippets/Production/PYBIND11_Production.cpp"
65
66      #include "snippets/Production/Noncombustion/PYBIND11_Noncombustion.cpp"
67      #include "snippets/Production/Noncombustion/PYBIND11_Hydro.cpp"
68
69      #include "snippets/Production/Combustion/PYBIND11_Combustion.cpp"
70      #include "snippets/Production/Combustion/PYBIND11_Diesel.cpp"
71
72      #include "snippets/Production/Renewable/PYBIND11_Renewable.cpp"
73      #include "snippets/Production/Renewable/PYBIND11_Solar.cpp"
74      #include "snippets/Production/Renewable/PYBIND11_Tidal.cpp"
75      #include "snippets/Production/Renewable/PYBIND11_Wave.cpp"
76      #include "snippets/Production/Renewable/PYBIND11_Wind.cpp"
77
78      #include "snippets/Storage/PYBIND11_Storage.cpp"
79      #include "snippets/Storage/PYBIND11_LiIon.cpp"
80
81  }   /* PYBIND11_MODULE() */
```

5.22 pybindings/snippets/Production/Combustion/PYBIND11_↩ Combustion.cpp File Reference

Bindings file for the Combustion class. Intended to be #include'd in PYBIND11_PGM.cpp.

This graph shows which files directly or indirectly include this file:



Functions

- CombustionType::DIESEL value ("N_COMBUSTION_TYPES", CombustionType::N_COMBUSTION_↩ TYPES)

- FuelMode::FUEL_MODE_LINEAR value ("FUEL_MODE_LOOKUP", FuelMode::FUEL_MODE_LOOKUP) .value("N_FUEL_MODES"
- &CombustionInputs::production_inputs def_readwrite ("fuel_mode", &CombustionInputs::fuel_mode) .def_↩ readwrite("nominal_fuel_escalation_annual"
- &CombustionInputs::production_inputs &CombustionInputs::nominal_fuel_escalation_annual def_readwrite ("cycle_charging_setpoint", &CombustionInputs::cycle_charging_setpoint) .def_readwrite("path_2_fuel_↩ interp_data"
- &CombustionInputs::production_inputs &CombustionInputs::nominal_fuel_escalation_annual &CombustionInputs::path_2_fuel_ def (pybind11::init())
- &Emissions::CO2_kg def_readwrite ("CO_kg", &Emissions::CO_kg) .def_readwrite("NOx_kg"
- &Emissions::CO2_kg &Emissions::NOx_kg def_readwrite ("SOx_kg", &Emissions::SOx_kg) .def_↩ readwrite("CH4_kg"

Variables

- &Emissions::CO2_kg &Emissions::NOx_kg &Emissions::CH4_kg def_readwrite("PM_kg", &Emissions::↩ PM_kg) .def(pybind11 &Combustion::type def_readwrite ("fuel_mode", &Combustion::fuel_mode) .def_↩ readwrite("total_emissions"

5.22.1 Detailed Description

Bindings file for the Combustion class. Intended to be #include'd in PYBIND11_PGM.cpp.

Ref: Jakob [2023]
A file which instructs pybind11 how to build Python bindings for the Combustion class. Only public attributes/methods are bound!

5.22.2 Function Documentation

5.22.2.1 def()

```
&InterpolatorStruct2D::n_rows &InterpolatorStruct2D::x_vec &InterpolatorStruct2D::max_x &InterpolatorStruct2D:
&InterpolatorStruct2D::z_matrix def (
            pybind11::init()  )
```

5.22.2.2 def_readwrite() [1/4]

```
& Emissions::CO2_kg def_readwrite (
            "CO_kg" ,
            &Emissions::CO_kg  )
```

5.22.2.3 def_readwrite() [2/4]

```
& CombustionInputs::production_inputs & CombustionInputs::nominal_fuel_escalation_annual def↩
_readwrite (
             "cycle_charging_setpoint" ,
             &CombustionInputs::cycle_charging_setpoint  )
```

5.22.2.4 def_readwrite() [3/4]

```
& CombustionInputs::production_inputs def_readwrite (
             "fuel_mode" ,
             &CombustionInputs::fuel_mode  )
```

5.22.2.5 def_readwrite() [4/4]

```
& Emissions::CO2_kg & Emissions::NOx_kg def_readwrite (
             "SOx_kg" ,
             &Emissions::SOx_kg  )
```

5.22.2.6 value() [1/2]

```
FuelMode::FUEL_MODE_LINEAR value (
             "FUEL_MODE_LOOKUP" ,
             FuelMode::FUEL_MODE_LOOKUP  )
```

5.22.2.7 value() [2/2]

```
CombustionType::DIESEL value (
             "N_COMBUSTION_TYPES" ,
             CombustionType::N_COMBUSTION_TYPES  )
```

5.22.3 Variable Documentation

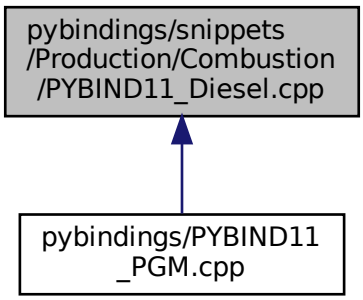
5.22.3.1 def_readwrite

```
&StorageInputs::print_flag &StorageInputs::power_capacity_kW &StorageInputs::nominal_inflation_annual
def_readwrite (
             "fuel_mode" ,
             &Combustion::fuel_mode  )
```

5.23 pybindings/snippets/Production/Combustion/PYBIND11_Diesel.cpp File Reference

Bindings file for the Diesel class. Intended to be #include'd in PYBIND11_PGM.cpp.

This graph shows which files directly or indirectly include this file:



Functions

- &DieselInputs::combustion_inputs def_readwrite ("replace_running_hrs", &DieselInputs::replace_running_↩ hrs) .def_readwrite("capital_cost"
- &DieselInputs::combustion_inputs &DieselInputs::capital_cost def_readwrite ("operation_maintenance_↩ cost_kWh", &DieselInputs::operation_maintenance_cost_kWh) .def_readwrite("fuel_cost_L"
- &DieselInputs::combustion_inputs &DieselInputs::capital_cost &DieselInputs::fuel_cost_L def_readwrite ("minimum_load_ratio", &DieselInputs::minimum_load_ratio) .def_readwrite("minimum_runtime_hrs"
- &DieselInputs::combustion_inputs &DieselInputs::capital_cost &DieselInputs::fuel_cost_L &DieselInputs::minimum_runtime_hr def_readwrite ("linear_fuel_slope_LkWh", &DieselInputs::linear_fuel_slope_LkWh) .def_readwrite("linear_↩ fuel_intercept_LkWh"
- &DieselInputs::combustion_inputs &DieselInputs::capital_cost &DieselInputs::fuel_cost_L &DieselInputs::minimum_runtime_hr &DieselInputs::linear_fuel_intercept_LkWh def_readwrite ("CO2_emissions_intensity_kgL", &DieselInputs↩ ::CO2_emissions_intensity_kgL) .def_readwrite("CO_emissions_intensity_kgL"
- &DieselInputs::combustion_inputs &DieselInputs::capital_cost &DieselInputs::fuel_cost_L &DieselInputs::minimum_runtime_hr &DieselInputs::linear_fuel_intercept_LkWh &DieselInputs::CO_emissions_intensity_kgL def_readwrite ("NOx_emissions_intensity_kgL", &DieselInputs::NOx_emissions_intensity_kgL) .def_readwrite("SOx_↩ emissions_intensity_kgL"
- &DieselInputs::combustion_inputs &DieselInputs::capital_cost &DieselInputs::fuel_cost_L &DieselInputs::minimum_runtime_hr &DieselInputs::linear_fuel_intercept_LkWh &DieselInputs::CO_emissions_intensity_kgL &DieselInputs::SOx_emissions_intens def_readwrite ("CH4_emissions_intensity_kgL", &DieselInputs::CH4_emissions_intensity_kgL) .def_↩ readwrite("PM_emissions_intensity_kgL"
- &DieselInputs::combustion_inputs &DieselInputs::capital_cost &DieselInputs::fuel_cost_L &DieselInputs::minimum_runtime_hr &DieselInputs::linear_fuel_intercept_LkWh &DieselInputs::CO_emissions_intensity_kgL &DieselInputs::SOx_emissions_intens &DieselInputs::PM_emissions_intensity_kgL def (pybind11::init())
- &Diesel::minimum_load_ratio def_readwrite ("minimum_runtime_hrs", &Diesel::minimum_runtime_hrs) .def_readwrite("time_since_last_start_hrs"

5.23.1 Detailed Description

Bindings file for the Diesel class. Intended to be #include'd in PYBIND11_PGM.cpp.

Ref: Jakob [2023]
A file which instructs pybind11 how to build Python bindings for the Diesel class. Only public attributes/methods are bound!

5.23.2 Function Documentation

5.23.2.1 def()

```
& DieselInputs::combustion_inputs & DieselInputs::capital_cost & DieselInputs::fuel_cost_L &
DieselInputs::minimum_runtime_hrs & DieselInputs::linear_fuel_intercept_LkWh & DieselInputs::CO_emissions_inte
& DieselInputs::SOx_emissions_intensity_kgL & DieselInputs::PM_emissions_intensity_kgL def (
            pybind11::init()  )
```

5.23.2.2 def_readwrite() [1/8]

```
& DieselInputs::combustion_inputs & DieselInputs::capital_cost & DieselInputs::fuel_cost_L &
DieselInputs::minimum_runtime_hrs & DieselInputs::linear_fuel_intercept_LkWh & DieselInputs::CO_emissions_inte
& DieselInputs::SOx_emissions_intensity_kgL def_readwrite (
            "CH4_emissions_intensity_kgL" ,
            &DieselInputs::CH4_emissions_intensity_kgL  )
```

5.23.2.3 def_readwrite() [2/8]

```
& DieselInputs::combustion_inputs & DieselInputs::capital_cost & DieselInputs::fuel_cost_L &
DieselInputs::minimum_runtime_hrs & DieselInputs::linear_fuel_intercept_LkWh def_readwrite (
            "CO2_emissions_intensity_kgL" ,
            &DieselInputs::CO2_emissions_intensity_kgL  )
```

5.23.2.4 def_readwrite() [3/8]

```
& DieselInputs::combustion_inputs & DieselInputs::capital_cost & DieselInputs::fuel_cost_L &
DieselInputs::minimum_runtime_hrs def_readwrite (
            "linear_fuel_slope_LkWh" ,
            &DieselInputs::linear_fuel_slope_LkWh  )
```

5.23.2.5 def_readwrite() [4/8]

```
& DieselInputs::combustion_inputs & DieselInputs::capital_cost & DieselInputs::fuel_cost_L
def_readwrite (
             "minimum_load_ratio" ,
             &DieselInputs::minimum_load_ratio  )
```

5.23.2.6 def_readwrite() [5/8]

```
& Diesel::minimum_load_ratio def_readwrite (
             "minimum_runtime_hrs" ,
             &Diesel::minimum_runtime_hrs  )
```

5.23.2.7 def_readwrite() [6/8]

```
& DieselInputs::combustion_inputs & DieselInputs::capital_cost & DieselInputs::fuel_cost_L &
DieselInputs::minimum_runtime_hrs & DieselInputs::linear_fuel_intercept_LkWh & DieselInputs::CO_emissions_inte
def_readwrite (
             "NOx_emissions_intensity_kgL" ,
             &DieselInputs::NOx_emissions_intensity_kgL  )
```

5.23.2.8 def_readwrite() [7/8]

```
& DieselInputs::combustion_inputs & DieselInputs::capital_cost def_readwrite (
             "operation_maintenance_cost_kWh" ,
             &DieselInputs::operation_maintenance_cost_kWh  )
```

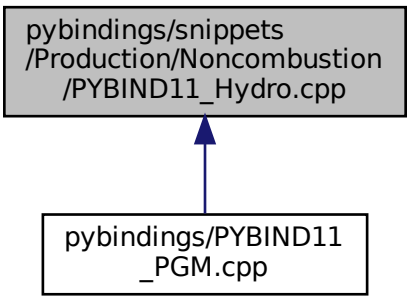
5.23.2.9 def_readwrite() [8/8]

```
& DieselInputs::combustion_inputs def_readwrite (
             "replace_running_hrs" ,
             &DieselInputs::replace_running_hrs  )
```

5.24 pybindings/snippets/Production/Noncombustion/PYBIND11_↩ Hydro.cpp File Reference

Bindings file for the Hydro class. Intended to be #include'd in PYBIND11_PGM.cpp.

This graph shows which files directly or indirectly include this file:



Functions

- HydroTurbineType::HYDRO_TURBINE_PELTON value ("HYDRO_TURBINE_FRANCIS", HydroTurbine↩ Type::HYDRO_TURBINE_FRANCIS) .value("HYDRO_TURBINE_KAPLAN"
- HydroTurbineType::HYDRO_TURBINE_PELTON HydroTurbineType::HYDRO_TURBINE_KAPLAN value ("N_HYDRO_TURBINES", HydroTurbineType::N_HYDRO_TURBINES)
- &HydroInputs::noncombustion_inputs def_readwrite ("resource_key", &HydroInputs::resource_key) .def_↩ readwrite("capital_cost"
- &HydroInputs::noncombustion_inputs &HydroInputs::capital_cost def_readwrite ("operation_maintenance↩ _cost_kWh", &HydroInputs::operation_maintenance_cost_kWh) .def_readwrite("fluid_density_kgm3"
- &HydroInputs::noncombustion_inputs &HydroInputs::capital_cost &HydroInputs::fluid_density_kgm3 def_readwrite ("net_head_m", &HydroInputs::net_head_m) .def_readwrite("reservoir_capacity_m3"
- &HydroInputs::noncombustion_inputs &HydroInputs::capital_cost &HydroInputs::fluid_density_kgm3 &HydroInputs::reservoir_capacity_m3 def_readwrite ("init_reservoir_state", &HydroInputs::init_reservoir↩ _state) .def_readwrite("turbine_type"
- &HydroInputs::noncombustion_inputs &HydroInputs::capital_cost &HydroInputs::fluid_density_kgm3 &HydroInputs::reservoir_capacity_m3 &HydroInputs::turbine_type def (pybind11::init())
- &Hydro::turbine_type def_readwrite ("fluid_density_kgm3", &Hydro::fluid_density_kgm3) .def_readwrite("net↩ _head_m"
- &Hydro::turbine_type &Hydro::net_head_m def_readwrite ("reservoir_capacity_m3", &Hydro::reservoir_↩ capacity_m3) .def_readwrite("init_reservoir_state"
- &Hydro::turbine_type &Hydro::net_head_m &Hydro::init_reservoir_state def_readwrite ("stored_volume_↩ m3", &Hydro::stored_volume_m3) .def_readwrite("minimum_power_kW"
- &Hydro::turbine_type &Hydro::net_head_m &Hydro::init_reservoir_state &Hydro::minimum_power_kW def_readwrite ("minimum_flow_m3hr", &Hydro::minimum_flow_m3hr) .def_readwrite("maximum_flow_m3hr"
- &Hydro::turbine_type &Hydro::net_head_m &Hydro::init_reservoir_state &Hydro::minimum_power_kW &Hydro::maximum_flow_m3hr def_readwrite ("turbine_flow_vec_m3hr", &Hydro::turbine_flow_vec_m3hr) .def_readwrite("spill_rate_vec_m3hr"

5.24.1 Detailed Description

Bindings file for the Hydro class. Intended to be #include'd in PYBIND11_PGM.cpp.

Ref: Jakob [2023]
A file which instructs pybind11 how to build Python bindings for the Hydro class. Only public attributes/methods are bound!

5.24.2 Function Documentation

5.24.2.1 def()

```
& HydroInputs::noncombustion_inputs & HydroInputs::capital_cost & HydroInputs::fluid_density_kgm3
& HydroInputs::reservoir_capacity_m3 & HydroInputs::turbine_type def (
            pybind11::init()  )
```

5.24.2.2 def_readwrite() [1/9]

```
& Hydro::turbine_type def_readwrite (
            "fluid_density_kgm3" ,
            &Hydro::fluid_density_kgm3  )
```

5.24.2.3 def_readwrite() [2/9]

```
& HydroInputs::noncombustion_inputs & HydroInputs::capital_cost & HydroInputs::fluid_density_kgm3
& HydroInputs::reservoir_capacity_m3 def_readwrite (
            "init_reservoir_state" ,
            &HydroInputs::init_reservoir_state  )
```

5.24.2.4 def_readwrite() [3/9]

```
& Hydro::turbine_type & Hydro::net_head_m & Hydro::init_reservoir_state & Hydro::minimum_power_kW
def_readwrite (
            "minimum_flow_m3hr" ,
            &Hydro::minimum_flow_m3hr  )
```

5.24.2.5 def_readwrite() [4/9]

```
& HydroInputs::noncombustion_inputs & HydroInputs::capital_cost & HydroInputs::fluid_density_kgm3
def_readwrite (
              "net_head_m" ,
              &HydroInputs::net_head_m  )
```

5.24.2.6 def_readwrite() [5/9]

```
& HydroInputs::noncombustion_inputs & HydroInputs::capital_cost def_readwrite (
              "operation_maintenance_cost_kWh" ,
              &HydroInputs::operation_maintenance_cost_kWh  )
```

5.24.2.7 def_readwrite() [6/9]

```
& Hydro::turbine_type & Hydro::net_head_m def_readwrite (
              "reservoir_capacity_m3" ,
              &Hydro::reservoir_capacity_m3  )
```

5.24.2.8 def_readwrite() [7/9]

```
& HydroInputs::noncombustion_inputs def_readwrite (
              "resource_key" ,
              &HydroInputs::resource_key  )
```

5.24.2.9 def_readwrite() [8/9]

```
& Hydro::turbine_type & Hydro::net_head_m & Hydro::init_reservoir_state def_readwrite (
              "stored_volume_m3" ,
              &Hydro::stored_volume_m3  )
```

5.24.2.10 def_readwrite() [9/9]

```
& Hydro::turbine_type & Hydro::net_head_m & Hydro::init_reservoir_state & Hydro::minimum_power_kW
& Hydro::maximum_flow_m3hr def_readwrite (
              "turbine_flow_vec_m3hr" ,
              &Hydro::turbine_flow_vec_m3hr  )
```

5.24.2.11 value() [1/2]

```
HydroTurbineType::HYDRO_TURBINE_PELTON value (
             "HYDRO_TURBINE_FRANCIS" ,
             HydroTurbineType::HYDRO_TURBINE_FRANCIS  )
```

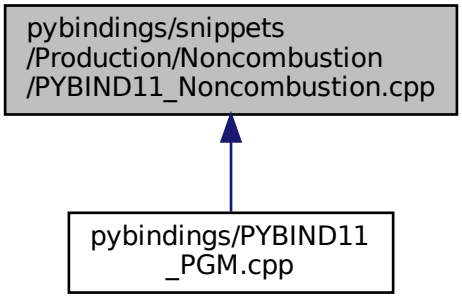
5.24.2.12 value() [2/2]

```
HydroTurbineType::HYDRO_TURBINE_PELTON HydroTurbineType::HYDRO_TURBINE_KAPLAN value (
             "N_HYDRO_TURBINES" ,
             HydroTurbineType::N_HYDRO_TURBINES  )
```

5.25 pybindings/snippets/Production/Noncombustion/PYBIND11_↩ Noncombustion.cpp File Reference

Bindings file for the Noncombustion class. Intended to be #include'd in PYBIND11_PGM.cpp.

This graph shows which files directly or indirectly include this file:



Functions

- NoncombustionType::HYDRO value ("N_NONCOMBUSTION_TYPES", NoncombustionType::N_↩ NONCOMBUSTION_TYPES)
- &NoncombustionInputs::production_inputs def (pybind11::init())

5.25.1 Detailed Description

Bindings file for the Noncombustion class. Intended to be #include'd in PYBIND11_PGM.cpp.

Ref: Jakob [2023]
A file which instructs pybind11 how to build Python bindings for the Noncombustion class. Only public attributes/methods are bound!

5.25.2 Function Documentation

5.25.2.1 def()

```
& NoncombustionInputs::production_inputs def (
            pybind11::init()  )
```

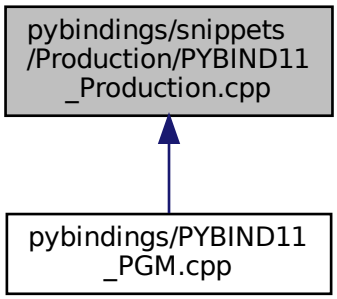
5.25.2.2 value()

```
NoncombustionType::HYDRO value (
            "N_NONCOMBUSTION_TYPES" ,
            NoncombustionType::N_NONCOMBUSTION_TYPES  )
```

5.26 pybindings/snippets/Production/PYBIND11_Production.cpp File Reference

Bindings file for the Production class. Intended to be #include'd in PYBIND11_PGM.cpp.

This graph shows which files directly or indirectly include this file:



Functions

- &ProductionInputs::print_flag def_readwrite ("is_sunk", &ProductionInputs::is_sunk) .def_readwrite("capacity↩ _kW"
- &ProductionInputs::print_flag &ProductionInputs::capacity_kW def_readwrite ("nominal_inflation_annual", &ProductionInputs::nominal_inflation_annual) .def_readwrite("nominal_discount_annual"
- &ProductionInputs::print_flag &ProductionInputs::capacity_kW &ProductionInputs::nominal_discount_annual def_readwrite ("replace_running_hrs", &ProductionInputs::replace_running_hrs) .def_readwrite("path_2_↩ normalized_production_time_series"
- &ProductionInputs::print_flag &ProductionInputs::capacity_kW &ProductionInputs::nominal_discount_annual &ProductionInputs::path_2_normalized_production_time_series def (pybind11::init())
- &Production::interpolator def_readwrite ("print_flag", &Production::print_flag) .def_readwrite("is_running"
- &Production::interpolator &Production::is_running def_readwrite ("is_sunk", &Production::is_sunk) .def_↩ readwrite("normalized_production_series_given"
- &Production::interpolator &Production::is_running &Production::normalized_production_series_given def_readwrite ("n_points", &Production::n_points) .def_readwrite("n_starts"
- &Production::interpolator &Production::is_running &Production::normalized_production_series_given &Production::n_starts def_readwrite ("n_replacements", &Production::n_replacements) .def_readwrite("n_↩ years"
- &Production::interpolator &Production::is_running &Production::normalized_production_series_given &Production::n_starts &Production::n_years def_readwrite ("running_hours", &Production::running_hours) .def_readwrite("replace_running_hrs"
- &Production::interpolator &Production::is_running &Production::normalized_production_series_given &Production::n_starts &Production::n_years &Production::replace_running_hrs def_readwrite ("capacity_↩ kW", &Production::capacity_kW) .def_readwrite("nominal_inflation_annual"
- &Production::interpolator &Production::is_running &Production::normalized_production_series_given &Production::n_starts &Production::n_years &Production::replace_running_hrs &Production::nominal_inflation_annual def_readwrite ("nominal_discount_annual", &Production::nominal_discount_annual) .def_readwrite("real_↩ discount_annual"
- &Production::interpolator &Production::is_running &Production::normalized_production_series_given &Production::n_starts &Production::n_years &Production::replace_running_hrs &Production::nominal_inflation_annual &Production::real_discount_annual def_readwrite ("capital_cost", &Production::capital_cost) .def_↩ readwrite("operation_maintenance_cost_kWh"
- &Production::interpolator &Production::is_running &Production::normalized_production_series_given &Production::n_starts &Production::n_years &Production::replace_running_hrs &Production::nominal_inflation_annual &Production::real_discount_annual &Production::operation_maintenance_cost_kWh def_readwrite ("net_↩ present_cost", &Production::net_present_cost) .def_readwrite("total_dispatch_kWh"
- &Production::interpolator &Production::is_running &Production::normalized_production_series_given &Production::n_starts &Production::n_years &Production::replace_running_hrs &Production::nominal_inflation_annual &Production::real_discount_annual &Production::operation_maintenance_cost_kWh &Production::total_dispatch_kWh def_readwrite ("levellized_cost_of_energy_kWh", &Production::levellized_cost_of_energy_kWh) .def_↩ readwrite("type_str"
- &Production::interpolator &Production::is_running &Production::normalized_production_series_given &Production::n_starts &Production::n_years &Production::replace_running_hrs &Production::nominal_inflation_annual &Production::real_discount_annual &Production::operation_maintenance_cost_kWh &Production::total_dispatch_kWh &Production::type_str def_readwrite ("path_2_normalized_production_time_series", &Production::path_2_↩ normalized_production_time_series) .def_readwrite("is_running_vec"
- &Production::interpolator &Production::is_running &Production::normalized_production_series_given &Production::n_starts &Production::n_years &Production::replace_running_hrs &Production::nominal_inflation_annual &Production::real_discount_annual &Production::operation_maintenance_cost_kWh &Production::total_dispatch_kWh &Production::type_str &Production::is_running_vec def_readwrite ("normalized_production_vec", &Production↩ ::normalized_production_vec) .def_readwrite("production_vec_kW"
- &Production::interpolator &Production::is_running &Production::normalized_production_series_given &Production::n_starts &Production::n_years &Production::replace_running_hrs &Production::nominal_inflation_annual &Production::real_discount_annual &Production::operation_maintenance_cost_kWh &Production::total_dispatch_kWh &Production::type_str &Production::is_running_vec &Production::production_vec_kW def_readwrite ("dispatch_vec_kW", &Production::dispatch_vec_kW) .def_readwrite("storage_vec_kW"

- &Production::interpolator &Production::is_running &Production::normalized_production_series_given &Production::n_starts &Production::n_years &Production::replace_running_hrs &Production::nominal_inflation_annual &Production::real_discount_annual &Production::operation_maintenance_cost_kWh &Production::total_dispatch_kWh &Production::type_str &Production::is_running_vec &Production::production_vec_kW &Production::storage_vec_kW def_readwrite ("curtailment_vec_kW", &Production::curtailment_vec_kW) .def_readwrite("capital_cost_vec"

5.26.1 Detailed Description

Bindings file for the Production class. Intended to be #include'd in PYBIND11_PGM.cpp.

Ref: Jakob [2023]
A file which instructs pybind11 how to build Python bindings for the Production class. Only public attributes/methods are bound!

5.26.2 Function Documentation

5.26.2.1 def()

```
& ProductionInputs::print_flag & ProductionInputs::capacity_kW & ProductionInputs::nominal_discount_annual
& ProductionInputs::path_2_normalized_production_time_series def (
            pybind11::init()  )
```

5.26.2.2 def_readwrite() [1/17]

```
& Production::interpolator & Production::is_running & Production::normalized_production_series_given
& Production::n_starts & Production::n_years & Production::replace_running_hrs def_readwrite (
            "capacity_kW" ,
            &Production::capacity_kW  )
```

5.26.2.3 def_readwrite() [2/17]

```
& Production::interpolator & Production::is_running & Production::normalized_production_series_given
& Production::n_starts & Production::n_years & Production::replace_running_hrs & Production::nominal_inflation
& Production::real_discount_annual def_readwrite (
            "capital_cost" ,
            &Production::capital_cost  )
```

5.26.2.4 def_readwrite() [3/17]

```
& Production::interpolator & Production::is_running & Production::normalized_production_series_given
& Production::n_starts & Production::n_years & Production::replace_running_hrs & Production::nominal_inflation
& Production::real_discount_annual & Production::operation_maintenance_cost_kWh & Production::total_dispatch_k
& Production::type_str & Production::is_running_vec & Production::production_vec_kW & Production::storage_vec_
def_readwrite (
            "curtailment_vec_kW" ,
            &Production::curtailment_vec_kW  )
```

5.26.2.5 def_readwrite() [4/17]

```
& Production::interpolator & Production::is_running & Production::normalized_production_series_given
& Production::n_starts & Production::n_years & Production::replace_running_hrs & Production::nominal_inflation
& Production::real_discount_annual & Production::operation_maintenance_cost_kWh & Production::total_dispatch_k
& Production::type_str & Production::is_running_vec & Production::production_vec_kW def_↩
readwrite (
            "dispatch_vec_kW" ,
            &Production::dispatch_vec_kW  )
```

5.26.2.6 def_readwrite() [5/17]

```
& Production::interpolator & Production::is_running def_readwrite (
            "is_sunk" ,
            &Production::is_sunk  )
```

5.26.2.7 def_readwrite() [6/17]

```
& ProductionInputs::print_flag def_readwrite (
            "is_sunk" ,
            &ProductionInputs::is_sunk  )
```

5.26.2.8 def_readwrite() [7/17]

```
& Production::interpolator & Production::is_running & Production::normalized_production_series_given
& Production::n_starts & Production::n_years & Production::replace_running_hrs & Production::nominal_inflation
& Production::real_discount_annual & Production::operation_maintenance_cost_kWh & Production::total_dispatch_k
def_readwrite (
            "levellized_cost_of_energy_kWh" ,
            &Production::levellized_cost_of_energy_kWh  )
```

5.26.2.9 def_readwrite() [8/17]

```
& Production::interpolator & Production::is_running & Production::normalized_production_series_given
def_readwrite (
              "n_points" ,
              &Production::n_points  )
```

5.26.2.10 def_readwrite() [9/17]

```
& Production::interpolator & Production::is_running & Production::normalized_production_series_given
& Production::n_starts def_readwrite (
              "n_replacements" ,
              &Production::n_replacements  )
```

5.26.2.11 def_readwrite() [10/17]

```
& Production::interpolator & Production::is_running & Production::normalized_production_series_given
& Production::n_starts & Production::n_years & Production::replace_running_hrs & Production::nominal_inflation
& Production::real_discount_annual & Production::operation_maintenance_cost_kWh def_readwrite
(
              "net_present_cost" ,
              &Production::net_present_cost  )
```

5.26.2.12 def_readwrite() [11/17]

```
& Production::interpolator & Production::is_running & Production::normalized_production_series_given
& Production::n_starts & Production::n_years & Production::replace_running_hrs & Production::nominal_inflation
def_readwrite (
              "nominal_discount_annual" ,
              &Production::nominal_discount_annual  )
```

5.26.2.13 def_readwrite() [12/17]

```
& ProductionInputs::print_flag & ProductionInputs::capacity_kW def_readwrite (
              "nominal_inflation_annual" ,
              &ProductionInputs::nominal_inflation_annual  )
```

5.26.2.14 def_readwrite() [13/17]

```
& Production::interpolator & Production::is_running & Production::normalized_production_series_given
& Production::n_starts & Production::n_years & Production::replace_running_hrs & Production::nominal_inflation
& Production::real_discount_annual & Production::operation_maintenance_cost_kWh & Production::total_dispatch_k
& Production::type_str & Production::is_running_vec def_readwrite (
            "normalized_production_vec" ,
            &Production::normalized_production_vec  )
```

5.26.2.15 def_readwrite() [14/17]

```
& Production::interpolator & Production::is_running & Production::normalized_production_series_given
& Production::n_starts & Production::n_years & Production::replace_running_hrs & Production::nominal_inflation
& Production::real_discount_annual & Production::operation_maintenance_cost_kWh & Production::total_dispatch_k
& Production::type_str def_readwrite (
            "path_2_normalized_production_time_series" ,
            &Production::path_2_normalized_production_time_series  )
```

5.26.2.16 def_readwrite() [15/17]

```
& Production::interpolator def_readwrite (
            "print_flag" ,
            &Production::print_flag  )
```

5.26.2.17 def_readwrite() [16/17]

```
& ProductionInputs::print_flag & ProductionInputs::capacity_kW & ProductionInputs::nominal_discount_annual
def_readwrite (
            "replace_running_hrs" ,
            &ProductionInputs::replace_running_hrs  )
```

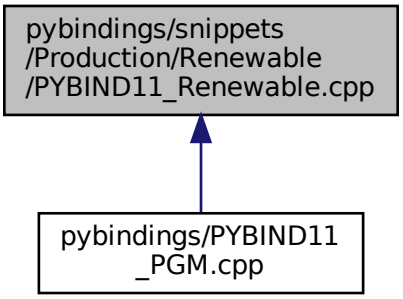
5.26.2.18 def_readwrite() [17/17]

```
& Production::interpolator & Production::is_running & Production::normalized_production_series_given
& Production::n_starts & Production::n_years def_readwrite (
            "running_hours" ,
            &Production::running_hours  )
```

5.27 pybindings/snippets/Production/Renewable/PYBIND11_Renewable.cpp File Reference

Bindings file for the Renewable class. Intended to be #include'd in PYBIND11_PGM.cpp.

This graph shows which files directly or indirectly include this file:



Functions

- RenewableType::SOLAR value ("TIDAL", RenewableType::TIDAL) .value("WAVE"
- RenewableType::SOLAR RenewableType::WAVE value ("WIND", RenewableType::WIND) .value("N_RENEWABLE_TYPES"
- &RenewableInputs::production_inputs def (pybind11::init())

5.27.1 Detailed Description

Bindings file for the Renewable class. Intended to be #include'd in PYBIND11_PGM.cpp.

Ref: Jakob [2023]
A file which instructs pybind11 how to build Python bindings for the Renewable class. Only public attributes/methods are bound!

5.27.2 Function Documentation

5.27.2.1 def()

```
& RenewableInputs::production_inputs def (
            pybind11::init()  )
```

5.27.2.2 value() [1/2]

```
RenewableType::SOLAR value (
            "TIDAL" ,
            RenewableType::TIDAL  )
```

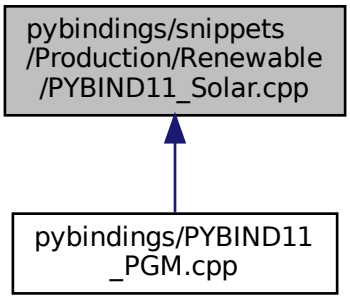
5.27.2.3 value() [2/2]

```
RenewableType::SOLAR RenewableType::WAVE value (
            "WIND" ,
            RenewableType::WIND  )
```

5.28 pybindings/snippets/Production/Renewable/PYBIND11_Solar.cpp File Reference

Bindings file for the Solar class. Intended to be #include'd in PYBIND11_PGM.cpp.

This graph shows which files directly or indirectly include this file:



Functions

- SolarPowerProductionModel::SOLAR_POWER_SIMPLE value ("SOLAR_POWER_DETAILED", Solar↩ PowerProductionModel::SOLAR_POWER_DETAILED) .value("N_SOLAR_POWER_PRODUCTION_↩ MODELS"
- &SolarInputs::renewable_inputs def_readwrite ("resource_key", &SolarInputs::resource_key) .def_↩ readwrite("capital_cost"
- &SolarInputs::renewable_inputs &SolarInputs::capital_cost def_readwrite ("operation_maintenance_cost_↩ kWh", &SolarInputs::operation_maintenance_cost_kWh) .def_readwrite("derating"
- &SolarInputs::renewable_inputs &SolarInputs::capital_cost &SolarInputs::derating def_readwrite ("julian_↩ day", &SolarInputs::julian_day) .def_readwrite("latitude_deg"
- &SolarInputs::renewable_inputs &SolarInputs::capital_cost &SolarInputs::derating &SolarInputs::latitude_deg def_readwrite ("longitude_deg", &SolarInputs::longitude_deg) .def_readwrite("panel_azimuth_deg"
- &SolarInputs::renewable_inputs &SolarInputs::capital_cost &SolarInputs::derating &SolarInputs::latitude_deg &SolarInputs::panel_azimuth_deg def_readwrite ("panel_tilt_deg", &SolarInputs::panel_tilt_deg) .def_↩ readwrite("albedo_ground_reflectance"

Variables

- &SolarInputs::renewable_inputs &SolarInputs::capital_cost &SolarInputs::derating &SolarInputs::latitude_deg &SolarInputs::panel_azimuth_deg &SolarInputs::albedo_ground_reflectance def_readwrite("power_model", &SolarInputs::power_model) .def(pybind11 &Solar::derating def_readwrite ("power_model", &Solar::power↩ _model) .def_readwrite("power_model_string"

5.28.1 Detailed Description

Bindings file for the Solar class. Intended to be #include'd in PYBIND11_PGM.cpp.

Ref: Jakob [2023]
A file which instructs pybind11 how to build Python bindings for the Solar class. Only public attributes/methods are bound!

5.28.2 Function Documentation

5.28.2.1 def_readwrite() [1/5]

```
& SolarInputs::renewable_inputs & SolarInputs::capital_cost & SolarInputs::derating def_↩
readwrite (
             "julian_day" ,
             &SolarInputs::julian_day  )
```

5.28.2.2 def_readwrite() [2/5]

```
& SolarInputs::renewable_inputs & SolarInputs::capital_cost & SolarInputs::derating & SolarInputs::latitude_de
def_readwrite (
             "longitude_deg" ,
             &SolarInputs::longitude_deg  )
```

5.28.2.3 def_readwrite() [3/5]

```
& SolarInputs::renewable_inputs & SolarInputs::capital_cost def_readwrite (
             "operation_maintenance_cost_kWh" ,
             &SolarInputs::operation_maintenance_cost_kWh  )
```

5.28.2.4 def_readwrite() [4/5]

```
& SolarInputs::renewable_inputs & SolarInputs::capital_cost & SolarInputs::derating & SolarInputs::latitude_de
& SolarInputs::panel_azimuth_deg def_readwrite (
             "panel_tilt_deg" ,
             &SolarInputs::panel_tilt_deg  )
```

5.28.2.5 def_readwrite() [5/5]

```
& SolarInputs::renewable_inputs def_readwrite (
             "resource_key" ,
             &SolarInputs::resource_key  )
```

5.28.2.6 value()

```
SolarPowerProductionModel::SOLAR_POWER_SIMPLE value (
             "SOLAR_POWER_DETAILED" ,
             SolarPowerProductionModel::SOLAR_POWER_DETAILED  )
```

5.28.3 Variable Documentation

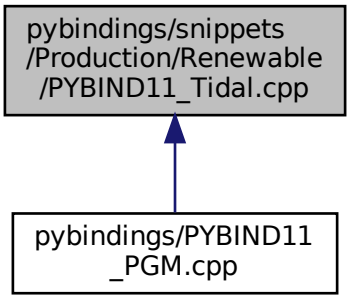
5.28.3.1 def_readwrite

```
& SolarInputs::renewable_inputs & SolarInputs::capital_cost & SolarInputs::derating & SolarInputs::latitude_de
& SolarInputs::panel_azimuth_deg & SolarInputs::albedo_ground_reflectance def_readwrite ("power↩
_model", &SolarInputs::power_model) .def(pybind11 & Solar::derating def_readwrite("power_↩
model", &Solar::power_model) .def_readwrite("power_model_string" (
             "power_model" ,
             &Solar::power_model  )
```

5.29 pybindings/snippets/Production/Renewable/PYBIND11_Tidal.cpp File Reference

Bindings file for the Tidal class. Intended to be #include'd in PYBIND11_PGM.cpp.

This graph shows which files directly or indirectly include this file:



Functions

- TidalPowerProductionModel::TIDAL_POWER_CUBIC value ("TIDAL_POWER_EXPONENTIAL", Tidal↩ PowerProductionModel::TIDAL_POWER_EXPONENTIAL) .value("TIDAL_POWER_LOOKUP"
- TidalPowerProductionModel::TIDAL_POWER_CUBIC TidalPowerProductionModel::TIDAL_POWER_LOOKUP value ("N_TIDAL_POWER_PRODUCTION_MODELS", TidalPowerProductionModel::N_TIDAL_POWER_↩ PRODUCTION_MODELS)
- &TidalInputs::renewable_inputs def_readwrite ("resource_key", &TidalInputs::resource_key) .def_↩ readwrite("capital_cost"
- &TidalInputs::renewable_inputs &TidalInputs::capital_cost def_readwrite ("operation_maintenance_cost_k↩ Wh", &TidalInputs::operation_maintenance_cost_kWh) .def_readwrite("design_speed_ms"

Variables

- &TidalInputs::renewable_inputs &TidalInputs::capital_cost &TidalInputs::design_speed_ms def_readwrite("power↩ _model", &TidalInputs::power_model) .def(pybind11 &Tidal::design_speed_ms def_readwrite ("power_↩ model", &Tidal::power_model) .def_readwrite("power_model_string"

5.29.1 Detailed Description

Bindings file for the Tidal class. Intended to be #include'd in PYBIND11_PGM.cpp.

Ref: Jakob [2023]
A file which instructs pybind11 how to build Python bindings for the Tidal class. Only public attributes/methods are bound!

5.29.2 Function Documentation

5.29.2.1 def_readwrite() [1/2]

```
& TidalInputs::renewable_inputs & TidalInputs::capital_cost def_readwrite (
             "operation_maintenance_cost_kWh" ,
             &TidalInputs::operation_maintenance_cost_kWh  )
```

5.29.2.2 def_readwrite() [2/2]

```
& TidalInputs::renewable_inputs def_readwrite (
             "resource_key" ,
             &TidalInputs::resource_key  )
```

5.29.2.3 value() [1/2]

```
TidalPowerProductionModel::TIDAL_POWER_CUBIC TidalPowerProductionModel::TIDAL_POWER_LOOKUP
value (
             "N_TIDAL_POWER_PRODUCTION_MODELS" ,
             TidalPowerProductionModel::N_TIDAL_POWER_PRODUCTION_MODELS  )
```

5.29.2.4 value() [2/2]

```
TidalPowerProductionModel::TIDAL_POWER_CUBIC value (
             "TIDAL_POWER_EXPONENTIAL" ,
             TidalPowerProductionModel::TIDAL_POWER_EXPONENTIAL  )
```

5.29.3 Variable Documentation

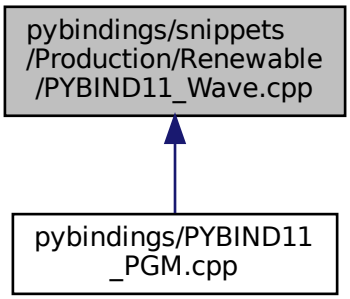
5.29.3.1 def_readwrite

```
& TidalInputs::renewable_inputs & TidalInputs::capital_cost & TidalInputs::design_speed_ms
def_readwrite ("power_model", &TidalInputs::power_model) .def(pybind11 & Tidal::design_speed_ms
def_readwrite("power_model", &Tidal::power_model) .def_readwrite("power_model_string" (
             "power_model" ,
             &Tidal::power_model  )
```

5.30 pybindings/snippets/Production/Renewable/PYBIND11_Wave.cpp File Reference

Bindings file for the Wave class. Intended to be #include'd in PYBIND11_PGM.cpp.

This graph shows which files directly or indirectly include this file:



Functions

- WavePowerProductionModel::WAVE_POWER_GAUSSIAN value ("WAVE_POWER_PARABOLOID", WavePowerProductionModel::WAVE_POWER_PARABOLOID) .value("WAVE_POWER_LOOKUP"
- WavePowerProductionModel::WAVE_POWER_GAUSSIAN WavePowerProductionModel::WAVE_POWER_LOOKUP value ("N_WAVE_POWER_PRODUCTION_MODELS", WavePowerProductionModel::N_WAVE_POWER↩ _PRODUCTION_MODELS)
- &WaveInputs::renewable_inputs def_readwrite ("resource_key", &WaveInputs::resource_key) .def_↩ readwrite("capital_cost"
- &WaveInputs::renewable_inputs &WaveInputs::capital_cost def_readwrite ("operation_maintenance_cost_↩ kWh", &WaveInputs::operation_maintenance_cost_kWh) .def_readwrite("design_significant_wave_height↩ _m"
- &WaveInputs::renewable_inputs &WaveInputs::capital_cost &WaveInputs::design_significant_wave_height_m def_readwrite ("design_energy_period_s", &WaveInputs::design_energy_period_s) .def_readwrite("power↩ _model"

Variables

- &WaveInputs::renewable_inputs &WaveInputs::capital_cost &WaveInputs::design_significant_wave_height_m &WaveInputs::power_model def_readwrite("path_2_normalized_performance_matrix", &WaveInputs↩ ::path_2_normalized_performance_matrix) .def(pybind11 &Wave::design_significant_wave_height_m def_readwrite ("design_energy_period_s", &Wave::design_energy_period_s) .def_readwrite("power_model"

5.30.1 Detailed Description

Bindings file for the Wave class. Intended to be #include'd in PYBIND11_PGM.cpp.

Ref: Jakob [2023]
A file which instructs pybind11 how to build Python bindings for the Wave class. Only public attributes/methods are bound!

5.30.2 Function Documentation

5.30.2.1 def_readwrite() [1/3]

```
& WaveInputs::renewable_inputs & WaveInputs::capital_cost & WaveInputs::design_significant_wave_height_m
def_readwrite (
             "design_energy_period_s" ,
             &WaveInputs::design_energy_period_s  )
```

5.30.2.2 def_readwrite() [2/3]

```
& WaveInputs::renewable_inputs & WaveInputs::capital_cost def_readwrite (
             "operation_maintenance_cost_kWh" ,
             &WaveInputs::operation_maintenance_cost_kWh  )
```

5.30.2.3 def_readwrite() [3/3]

```
& WaveInputs::renewable_inputs def_readwrite (
             "resource_key" ,
             &WaveInputs::resource_key  )
```

5.30.2.4 value() [1/2]

```
WavePowerProductionModel::WAVE_POWER_GAUSSIAN WavePowerProductionModel::WAVE_POWER_LOOKUP
value (
             "N_WAVE_POWER_PRODUCTION_MODELS" ,
             WavePowerProductionModel::N_WAVE_POWER_PRODUCTION_MODELS  )
```

5.30.2.5 value() [2/2]

```
WavePowerProductionModel::WAVE_POWER_GAUSSIAN value (
             "WAVE_POWER_PARABOLOID" ,
             WavePowerProductionModel::WAVE_POWER_PARABOLOID  )
```

5.30.3 Variable Documentation

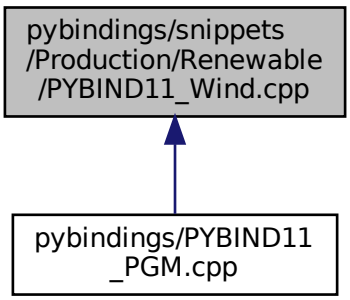
5.30.3.1 def_readwrite

```
& WaveInputs::renewable_inputs & WaveInputs::capital_cost & WaveInputs::design_significant_wave_height_m
& WaveInputs::power_model def_readwrite ( "path_2_normalized_performance_matrix", &Wave↩
Inputs::path_2_normalized_performance_matrix ) .def(pybind11 & Wave::design_significant_wave_height_m
def_readwrite("design_energy_period_s", &Wave::design_energy_period_s) .def_readwrite("power↩
_model" (
             "design_energy_period_s" ,
             &Wave::design_energy_period_s  )
```

5.31 pybindings/snippets/Production/Renewable/PYBIND11_Wind.cpp File Reference

Bindings file for the Wind class. Intended to be #include'd in PYBIND11_PGM.cpp.

This graph shows which files directly or indirectly include this file:



Functions

- WindPowerProductionModel::WIND_POWER_CUBIC value ("WIND_POWER_EXPONENTIAL", Wind↩ PowerProductionModel::WIND_POWER_EXPONENTIAL) .value("WIND_POWER_LOOKUP"
- WindPowerProductionModel::WIND_POWER_CUBIC WindPowerProductionModel::WIND_POWER_LOOKUP value ("N_WIND_POWER_PRODUCTION_MODELS", WindPowerProductionModel::N_WIND_POWER_↩ PRODUCTION_MODELS)
- &WindInputs::renewable_inputs def_readwrite ("resource_key", &WindInputs::resource_key) .def_↩ readwrite("capital_cost"
- &WindInputs::renewable_inputs &WindInputs::capital_cost def_readwrite ("operation_maintenance_cost_↩ kWh", &WindInputs::operation_maintenance_cost_kWh) .def_readwrite("design_speed_ms"

Variables

- &WindInputs::renewable_inputs &WindInputs::capital_cost &WindInputs::design_speed_ms def_↩ readwrite("power_model", &WindInputs::power_model) .def(pybind11 &Wind::design_speed_ms def_readwrite ("power_model", &Wind::power_model) .def_readwrite("power_model_string"

5.31.1 Detailed Description

Bindings file for the Wind class. Intended to be #include'd in PYBIND11_PGM.cpp.

Ref: Jakob [2023]
A file which instructs pybind11 how to build Python bindings for the Wind class. Only public attributes/methods are bound!

5.31.2 Function Documentation

5.31.2.1 def_readwrite() [1/2]

```
& WindInputs::renewable_inputs & WindInputs::capital_cost def_readwrite (
             "operation_maintenance_cost_kWh" ,
             &WindInputs::operation_maintenance_cost_kWh  )
```

5.31.2.2 def_readwrite() [2/2]

```
& WindInputs::renewable_inputs def_readwrite (
             "resource_key" ,
             &WindInputs::resource_key  )
```

5.31.2.3 value() [1/2]

```
WindPowerProductionModel::WIND_POWER_CUBIC WindPowerProductionModel::WIND_POWER_LOOKUP value (
             "N_WIND_POWER_PRODUCTION_MODELS" ,
             WindPowerProductionModel::N_WIND_POWER_PRODUCTION_MODELS  )
```

5.31.2.4 value() [2/2]

```
WindPowerProductionModel::WIND_POWER_CUBIC value (
             "WIND_POWER_EXPONENTIAL" ,
             WindPowerProductionModel::WIND_POWER_EXPONENTIAL  )
```

5.31.3 Variable Documentation

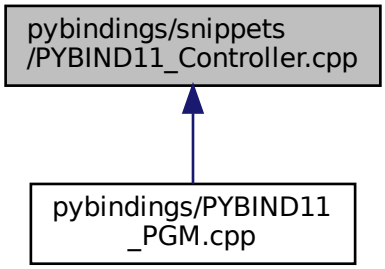
5.31.3.1 def_readwrite

```
& WindInputs::renewable_inputs & WindInputs::capital_cost & WindInputs::design_speed_ms def↩
_readwrite ("power_model", &WindInputs::power_model) .def(pybind11 & Wind::design_speed_ms
def_readwrite("power_model", &Wind::power_model) .def_readwrite("power_model_string" (
             "power_model" ,
             &Wind::power_model  )
```

5.32 pybindings/snippets/PYBIND11_Controller.cpp File Reference

Bindings file for the Controller class. Intended to be #include'd in PYBIND11_PGM.cpp.

This graph shows which files directly or indirectly include this file:



Functions

- ControlMode::LOAD_FOLLOWING value ("CYCLE_CHARGING", ControlMode::CYCLE_CHARGING) .value("N_CONTROL_MODES"
- &Controller::control_mode def_readwrite ("control_string", &Controller::control_string) .def_readwrite("net↩ _load_vec_kW"
- &Controller::control_mode &Controller::net_load_vec_kW def_readwrite ("missed_load_vec_kW", &Controller↩ ::missed_load_vec_kW) .def_readwrite("combustion_map"
- &Controller::control_mode &Controller::net_load_vec_kW &Controller::combustion_map def (pybind11↩ ::init<>()) .def("setControlMode"
- &Controller::control_mode &Controller::net_load_vec_kW &Controller::combustion_map &Controller::setControlMode def ("init", &Controller::init) .def("applyDispatchControl"
- &Controller::control_mode &Controller::net_load_vec_kW &Controller::combustion_map &Controller::setControlMode &Controller::applyDispatchControl def ("clear", &Controller::clear)

5.32.1 Detailed Description

Bindings file for the Controller class. Intended to be #include'd in PYBIND11_PGM.cpp.

Ref: Jakob [2023]
A file which instructs pybind11 how to build Python bindings for the Controller class. Only public attributes/methods are bound!

5.32.2 Function Documentation

5.32.2.1 def() [1/3]

```
& Controller::control_mode & Controller::net_load_vec_kW & Controller::combustion_map & Controller::setControl
& Controller::applyDispatchControl def (
             "clear" ,
             &Controller::clear  )
```

5.32.2.2 def() [2/3]

```
& Controller::control_mode & Controller::net_load_vec_kW & Controller::combustion_map & Controller::setControl
def (
             "init" ,
             &Controller::init  )
```

5.32.2.3 def() [3/3]

```
& Controller::control_mode & Controller::net_load_vec_kW & Controller::combustion_map def (
             pybind11::init<> () )
```

5.32.2.4 def_readwrite() [1/2]

```
& Controller::control_mode def_readwrite (
             "control_string" ,
             &Controller::control_string  )
```

5.32.2.5 def_readwrite() [2/2]

```
& Controller::control_mode & Controller::net_load_vec_kW def_readwrite (
             "missed_load_vec_kW" ,
             &Controller::missed_load_vec_kW  )
```

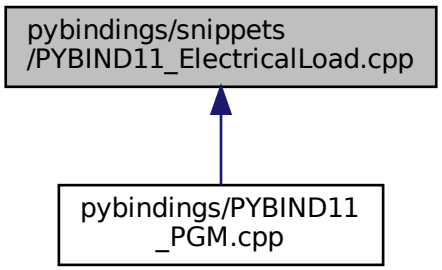
5.32.2.6 value()

```
ControlMode::LOAD_FOLLOWING value (
            "CYCLE_CHARGING" ,
            ControlMode::CYCLE_CHARGING  )
```

5.33 pybindings/snippets/PYBIND11_ElectricalLoad.cpp File Reference

Bindings file for the ElectricalLoad class. Intended to be #include'd in PYBIND11_PGM.cpp.

This graph shows which files directly or indirectly include this file:



Functions

- &ElectricalLoad::n_points def_readwrite ("n_years", &ElectricalLoad::n_years) .def_readwrite("min_load_↩ kW"
- &ElectricalLoad::n_points &ElectricalLoad::min_load_kW def_readwrite ("mean_load_kW", &Electrical↩ Load::mean_load_kW) .def_readwrite("max_load_kW"
- &ElectricalLoad::n_points &ElectricalLoad::min_load_kW &ElectricalLoad::max_load_kW def_readwrite ("path_2_electrical_load_time_series", &ElectricalLoad::path_2_electrical_load_time_series) .def_↩ readwrite("time_vec_hrs"
- &ElectricalLoad::n_points &ElectricalLoad::min_load_kW &ElectricalLoad::max_load_kW &ElectricalLoad::time_vec_hrs def_readwrite ("dt_vec_hrs", &ElectricalLoad::dt_vec_hrs) .def_readwrite("load_vec_kW"

5.33.1 Detailed Description

Bindings file for the ElectricalLoad class. Intended to be #include'd in PYBIND11_PGM.cpp.

Ref: Jakob [2023]
A file which instructs pybind11 how to build Python bindings for the ElectricalLoad class. Only public attributes/methods are bound!

5.33.2 Function Documentation

5.33.2.1 def_readwrite() [1/4]

```
& ElectricalLoad::n_points & ElectricalLoad::min_load_kW & ElectricalLoad::max_load_kW & ElectricalLoad::time_
def_readwrite (
             "dt_vec_hrs" ,
             &ElectricalLoad::dt_vec_hrs  )
```

5.33.2.2 def_readwrite() [2/4]

```
& ElectricalLoad::n_points & ElectricalLoad::min_load_kW def_readwrite (
             "mean_load_kW" ,
             &ElectricalLoad::mean_load_kW  )
```

5.33.2.3 def_readwrite() [3/4]

```
& ElectricalLoad::n_points def_readwrite (
             "n_years" ,
             &ElectricalLoad::n_years  )
```

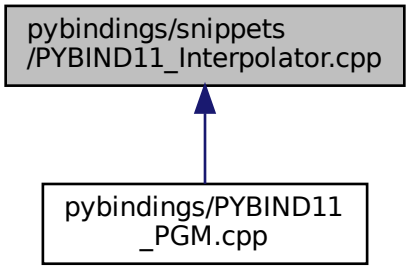
5.33.2.4 def_readwrite() [4/4]

```
& ElectricalLoad::n_points & ElectricalLoad::min_load_kW & ElectricalLoad::max_load_kW def_↩
readwrite (
             "path_2_electrical_load_time_series" ,
             &ElectricalLoad::path_2_electrical_load_time_series  )
```

5.34 pybindings/snippets/PYBIND11_Interpolator.cpp File Reference

Bindings file for the Interpolator class. Intended to be #include'd in PYBIND11_PGM.cpp.

This graph shows which files directly or indirectly include this file:



Functions

- &InterpolatorStruct1D::n_points def_readwrite ("x_vec", &InterpolatorStruct1D::x_vec) .def_readwrite("min↩ _x"
- &InterpolatorStruct1D::n_points &InterpolatorStruct1D::min_x def_readwrite ("max_x", &Interpolator↩ Struct1D::max_x) .def_readwrite("y_vec"
- &InterpolatorStruct1D::n_points &InterpolatorStruct1D::min_x &InterpolatorStruct1D::y_vec def (pybind11↩ ::init())
- &InterpolatorStruct2D::n_rows def_readwrite ("n_cols", &InterpolatorStruct2D::n_cols) .def_readwrite("x_↩ vec"
- &InterpolatorStruct2D::n_rows &InterpolatorStruct2D::x_vec def_readwrite ("min_x", &InterpolatorStruct2↩ D::min_x) .def_readwrite("max_x"
- &InterpolatorStruct2D::n_rows &InterpolatorStruct2D::x_vec &InterpolatorStruct2D::max_x def_readwrite ("y_vec", &InterpolatorStruct2D::y_vec) .def_readwrite("min_y"
- &InterpolatorStruct2D::n_rows &InterpolatorStruct2D::x_vec &InterpolatorStruct2D::max_x &InterpolatorStruct2D::min_y def_readwrite ("max_y", &InterpolatorStruct2D::max_y) .def_readwrite("z_matrix"
- &Interpolator::interp_map_1D def_readwrite ("path_map_1D", &Interpolator::path_map_1D) .def_↩ readwrite("interp_map_2D"

5.34.1 Detailed Description

Bindings file for the Interpolator class. Intended to be #include'd in PYBIND11_PGM.cpp.

Ref: Jakob [2023]
A file which instructs pybind11 how to build Python bindings for the Interpolator class. Only public attributes/methods are bound!

5.34.2 Function Documentation

5.34.2.1 def()

```
& InterpolatorStruct1D::n_points & InterpolatorStruct1D::min_x & InterpolatorStruct1D::y_vec
def (
            pybind11::init()  )
```

5.34.2.2 def_readwrite() [1/7]

```
& InterpolatorStruct1D::n_points & InterpolatorStruct1D::min_x def_readwrite (
            "max_x" ,
            &InterpolatorStruct1D::max_x  )
```

5.34.2.3 def_readwrite() [2/7]

```
& InterpolatorStruct2D::n_rows & InterpolatorStruct2D::x_vec & InterpolatorStruct2D::max_x &
InterpolatorStruct2D::min_y def_readwrite (
             "max_y" ,
             &InterpolatorStruct2D::max_y  )
```

5.34.2.4 def_readwrite() [3/7]

```
& InterpolatorStruct2D::n_rows & InterpolatorStruct2D::x_vec def_readwrite (
             "min_x" ,
             &InterpolatorStruct2D::min_x  )
```

5.34.2.5 def_readwrite() [4/7]

```
& InterpolatorStruct2D::n_rows def_readwrite (
             "n_cols" ,
             &InterpolatorStruct2D::n_cols  )
```

5.34.2.6 def_readwrite() [5/7]

```
& Interpolator::interp_map_1D def_readwrite (
             "path_map_1D" ,
             &Interpolator::path_map_1D  )
```

5.34.2.7 def_readwrite() [6/7]

```
& InterpolatorStruct1D::n_points def_readwrite (
             "x_vec" ,
             &InterpolatorStruct1D::x_vec  )
```

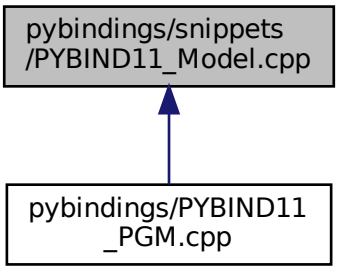
5.34.2.8 def_readwrite() [7/7]

```
& InterpolatorStruct2D::n_rows & InterpolatorStruct2D::x_vec & InterpolatorStruct2D::max_x
def_readwrite (
             "y_vec" ,
             &InterpolatorStruct2D::y_vec  )
```

5.35 pybindings/snippets/PYBIND11_Model.cpp File Reference

Bindings file for the Model class. Intended to be #include'd in PYBIND11_PGM.cpp.

This graph shows which files directly or indirectly include this file:



Variables

- &ModelInputs::path_2_electrical_load_time_series def_readwrite("control_mode", &ModelInputs::control_↩ mode) .def(pybind11 &Model::total_fuel_consumed_L def_readwrite ("total_emissions", &Model::total_↩ emissions) .def_readwrite("net_present_cost"

5.35.1 Detailed Description

Bindings file for the Model class. Intended to be #include'd in PYBIND11_PGM.cpp.

Ref: Jakob [2023]
A file which instructs pybind11 how to build Python bindings for the Model class. Only public attributes/methods are bound!

5.35.2 Variable Documentation

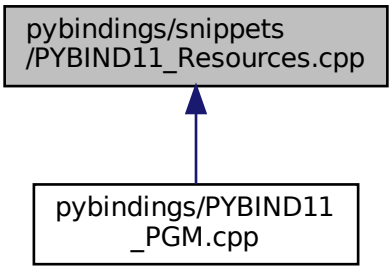
5.35.2.1 def_readwrite

```
& ModelInputs::path_2_electrical_load_time_series def_readwrite ("control_mode", &Model↩
Inputs::control_mode) .def(pybind11 & Model::total_fuel_consumed_L & Model::net_present_cost &
Model::total_dispatch_discharge_kWh & Model::controller & Model::resources & Model::noncombustion_ptr_vec
def_readwrite("renewable_ptr_vec", &Model::renewable_ptr_vec) .def_readwrite("storage_ptr_vec"
(
            "total_emissions" ,
            &Model::total_emissions  )
```

5.36 pybindings/snippets/PYBIND11_Resources.cpp File Reference

Bindings file for the Resources class. Intended to be #include'd in PYBIND11_PGM.cpp.

This graph shows which files directly or indirectly include this file:



Functions

- &Resources::resource_map_1D def_readwrite ("string_map_1D", &Resources::string_map_1D) .def_↩ readwrite("path_map_1D"
- &Resources::resource_map_1D &Resources::path_map_1D def_readwrite ("resource_map_2D", &Resources↩ ::resource_map_2D) .def_readwrite("string_map_2D"

5.36.1 Detailed Description

Bindings file for the Resources class. Intended to be #include'd in PYBIND11_PGM.cpp.

Ref: Jakob [2023]
A file which instructs pybind11 how to build Python bindings for the Resources class. Only public attributes/methods are bound!

5.36.2 Function Documentation

5.36.2.1 def_readwrite() [1/2]

```
& Resources::resource_map_1D & Resources::path_map_1D def_readwrite (
             "resource_map_2D" ,
             &Resources::resource_map_2D  )
```

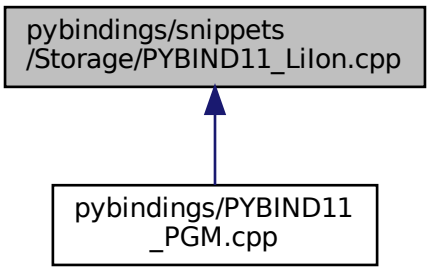
5.36.2.2 def_readwrite() [2/2]

```
& Resources::resource_map_1D def_readwrite (
              "string_map_1D" ,
              &Resources::string_map_1D  )
```

5.37 pybindings/snippets/Storage/PYBIND11_LiIon.cpp File Reference

Bindings file for the LiIon class. Intended to be #include'd in PYBIND11_PGM.cpp.

This graph shows which files directly or indirectly include this file:



Functions

- &LiIonInputs::storage_inputs def_readwrite ("capital_cost", &LiIonInputs::capital_cost) .def_readwrite("operation↩ _maintenance_cost_kWh"
- &LiIonInputs::storage_inputs &LiIonInputs::operation_maintenance_cost_kWh def_readwrite ("init_SOC", &LiIonInputs::init_SOC) .def_readwrite("min_SOC"
- &LiIonInputs::storage_inputs &LiIonInputs::operation_maintenance_cost_kWh &LiIonInputs::min_SOC def_readwrite ("hysteresis_SOC", &LiIonInputs::hysteresis_SOC) .def_readwrite("max_SOC"
- &LiIonInputs::storage_inputs &LiIonInputs::operation_maintenance_cost_kWh &LiIonInputs::min_SOC &LiIonInputs::max_SOC def_readwrite ("charging_efficiency", &LiIonInputs::charging_efficiency) .def_↩ readwrite("discharging_efficiency"
- &LiIonInputs::storage_inputs &LiIonInputs::operation_maintenance_cost_kWh &LiIonInputs::min_SOC &LiIonInputs::max_SOC &LiIonInputs::discharging_efficiency def_readwrite ("replace_SOH", &LiIonInputs↩ ::replace_SOH) .def_readwrite("power_degradation_flag"
- &LiIonInputs::storage_inputs &LiIonInputs::operation_maintenance_cost_kWh &LiIonInputs::min_SOC &LiIonInputs::max_SOC &LiIonInputs::discharging_efficiency &LiIonInputs::power_degradation_flag def_readwrite ("degradation_alpha", &LiIonInputs::degradation_alpha) .def_readwrite("degradation_beta"
- &LiIonInputs::storage_inputs &LiIonInputs::operation_maintenance_cost_kWh &LiIonInputs::min_SOC &LiIonInputs::max_SOC &LiIonInputs::discharging_efficiency &LiIonInputs::power_degradation_flag &LiIonInputs::degradation_beta def_readwrite ("degradation_B_hat_cal_0", &LiIonInputs::degradation_↩ B_hat_cal_0) .def_readwrite("degradation_r_cal"
- &LiIonInputs::storage_inputs &LiIonInputs::operation_maintenance_cost_kWh &LiIonInputs::min_SOC &LiIonInputs::max_SOC &LiIonInputs::discharging_efficiency &LiIonInputs::power_degradation_flag &LiIonInputs::degradation_beta &LiIonInputs::degradation_r_cal def_readwrite ("degradation_Ea_cal_0", &LiIonInputs::degradation_Ea_cal_0) .def_readwrite("degradation_a_cal"
- &LiIonInputs::storage_inputs &LiIonInputs::operation_maintenance_cost_kWh &LiIonInputs::min_SOC &LiIonInputs::max_SOC &LiIonInputs::discharging_efficiency &LiIonInputs::power_degradation_flag &LiIonInputs::degradation_beta &LiIonInputs::degradation_r_cal &LiIonInputs::degradation_a_cal def_readwrite ("degradation_s_cal", &LiIonInputs::degradation_s_cal) .def_readwrite("gas_constant_JmolK"

Variables

- &LiIonInputs::storage_inputs &LiIonInputs::operation_maintenance_cost_kWh &LiIonInputs::min_SOC &LiIonInputs::max_SOC &LiIonInputs::discharging_efficiency &LiIonInputs::power_degradation_flag &LiIonInputs::degradation_beta &LiIonInputs::degradation_r_cal &LiIonInputs::degradation_a_cal &LiIonInputs::gas_constant_ def_readwrite("gas_constant_JmolK", &LiIonInputs::gas_constant_JmolK) .def(pybind11 &LiIon::power_degradation_flag def_readwrite ("dynamic_energy_capacity_kWh", &LiIon::dynamic_energy_capacity_kWh) .def_readwrite("dynamic↩ _power_capacity_kW"

5.37.1 Detailed Description

Bindings file for the LiIon class. Intended to be #include'd in PYBIND11_PGM.cpp.

Ref: Jakob [2023]
A file which instructs pybind11 how to build Python bindings for the LiIon class. Only public attributes/methods are bound!

5.37.2 Function Documentation

5.37.2.1 def_readwrite() [1/9]

```
& LiIonInputs::storage_inputs def_readwrite (
             "capital_cost" ,
             &LiIonInputs::capital_cost  )
```

5.37.2.2 def_readwrite() [2/9]

```
& LiIonInputs::storage_inputs & LiIonInputs::operation_maintenance_cost_kWh & LiIonInputs::min_SOC
& LiIonInputs::max_SOC def_readwrite (
             "charging_efficiency" ,
             &LiIonInputs::charging_efficiency  )
```

5.37.2.3 def_readwrite() [3/9]

```
& LiIonInputs::storage_inputs & LiIonInputs::operation_maintenance_cost_kWh & LiIonInputs::min_SOC
& LiIonInputs::max_SOC & LiIonInputs::discharging_efficiency & LiIonInputs::power_degradation_flag
def_readwrite (
             "degradation_alpha" ,
             &LiIonInputs::degradation_alpha  )
```

5.37.2.4 def_readwrite() [4/9]

```
& LiIonInputs::storage_inputs & LiIonInputs::operation_maintenance_cost_kWh & LiIonInputs::min_SOC
& LiIonInputs::max_SOC & LiIonInputs::discharging_efficiency & LiIonInputs::power_degradation_flag
& LiIonInputs::degradation_beta def_readwrite (
             "degradation_B_hat_cal_0" ,
             &LiIonInputs::degradation_B_hat_cal_0  )
```

5.37.2.5 def_readwrite() [5/9]

```
& LiIonInputs::storage_inputs & LiIonInputs::operation_maintenance_cost_kWh & LiIonInputs::min_SOC
& LiIonInputs::max_SOC & LiIonInputs::discharging_efficiency & LiIonInputs::power_degradation_flag
& LiIonInputs::degradation_beta & LiIonInputs::degradation_r_cal def_readwrite (
             "degradation_Ea_cal_0" ,
             &LiIonInputs::degradation_Ea_cal_0  )
```

5.37.2.6 def_readwrite() [6/9]

```
& LiIonInputs::storage_inputs & LiIonInputs::operation_maintenance_cost_kWh & LiIonInputs::min_SOC
& LiIonInputs::max_SOC & LiIonInputs::discharging_efficiency & LiIonInputs::power_degradation_flag
& LiIonInputs::degradation_beta & LiIonInputs::degradation_r_cal & LiIonInputs::degradation_a_cal
def_readwrite (
             "degradation_s_cal" ,
             &LiIonInputs::degradation_s_cal  )
```

5.37.2.7 def_readwrite() [7/9]

```
& LiIonInputs::storage_inputs & LiIonInputs::operation_maintenance_cost_kWh & LiIonInputs::min_SOC
def_readwrite (
             "hysteresis_SOC" ,
             &LiIonInputs::hysteresis_SOC  )
```

5.37.2.8 def_readwrite() [8/9]

```
& LiIonInputs::storage_inputs & LiIonInputs::operation_maintenance_cost_kWh def_readwrite (
             "init_SOC" ,
             &LiIonInputs::init_SOC  )
```

5.37.2.9 def_readwrite() [9/9]

```
& LiIonInputs::storage_inputs & LiIonInputs::operation_maintenance_cost_kWh & LiIonInputs::min_SOC
& LiIonInputs::max_SOC & LiIonInputs::discharging_efficiency def_readwrite (
             "replace_SOH" ,
             &LiIonInputs::replace_SOH  )
```

5.37.3 Variable Documentation

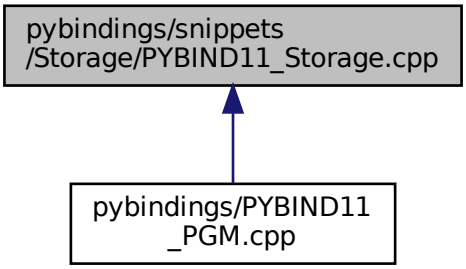
5.37.3.1 def_readwrite

```
& LiIonInputs::storage_inputs & LiIonInputs::operation_maintenance_cost_kWh & LiIonInputs::min_SOC
& LiIonInputs::max_SOC & LiIonInputs::discharging_efficiency & LiIonInputs::power_degradation_flag
& LiIonInputs::degradation_beta & LiIonInputs::degradation_r_cal & LiIonInputs::degradation_a_cal
& LiIonInputs::gas_constant_JmolK def_readwrite ("gas_constant_JmolK", &LiIonInputs::gas_↩
constant_JmolK) .def(pybind11 & LiIon::power_degradation_flag & LiIon::dynamic_power_capacity_kW
& LiIon::replace_SOH & LiIon::degradation_beta & LiIon::degradation_r_cal & LiIon::degradation_a_cal
& LiIon::gas_constant_JmolK & LiIon::init_SOC & LiIon::hysteresis_SOC & LiIon::charging_efficiency
def_readwrite("discharging_efficiency", &LiIon::discharging_efficiency) .def_readwrite("SOH_↩
vec" (
             "dynamic_energy_capacity_kWh" ,
             &LiIon::dynamic_energy_capacity_kWh  )
```

5.38 pybindings/snippets/Storage/PYBIND11_Storage.cpp File Reference

Bindings file for the Storage class. Intended to be #include'd in PYBIND11_PGM.cpp.

This graph shows which files directly or indirectly include this file:



Functions

- StorageType::LIION value ("N_STORAGE_TYPES", StorageType::N_STORAGE_TYPES)
- &StorageInputs::print_flag def_readwrite ("is_sunk", &StorageInputs::is_sunk) .def_readwrite("power_↩ capacity_kW"
- &StorageInputs::print_flag &StorageInputs::power_capacity_kW def_readwrite ("energy_capacity_kWh", &StorageInputs::energy_capacity_kWh) .def_readwrite("nominal_inflation_annual"

Variables

- &StorageInputs::print_flag &StorageInputs::power_capacity_kW &StorageInputs::nominal_inflation_annual def_readwrite("nominal_discount_annual", &StorageInputs::nominal_discount_annual) .def(pybind11 &Storage::type def_readwrite ("interpolator", &Storage::interpolator) .def_readwrite("print_flag"

5.38.1 Detailed Description

Bindings file for the Storage class. Intended to be #include'd in PYBIND11_PGM.cpp.

Ref: Jakob [2023]
A file which instructs pybind11 how to build Python bindings for the Storage class. Only public attributes/methods are bound!

5.38.2 Function Documentation

5.38.2.1 def_readwrite() [1/2]

```
& StorageInputs::print_flag & StorageInputs::power_capacity_kW def_readwrite (
             "energy_capacity_kWh" ,
             &StorageInputs::energy_capacity_kWh  )
```

5.38.2.2 def_readwrite() [2/2]

```
& StorageInputs::print_flag def_readwrite (
             "is_sunk" ,
             &StorageInputs::is_sunk  )
```

5.38.2.3 value()

```
StorageType::LIION value (
             "N_STORAGE_TYPES" ,
             StorageType::N_STORAGE_TYPES  )
```

5.38.3 Variable Documentation

5.38.3.1 def_readwrite

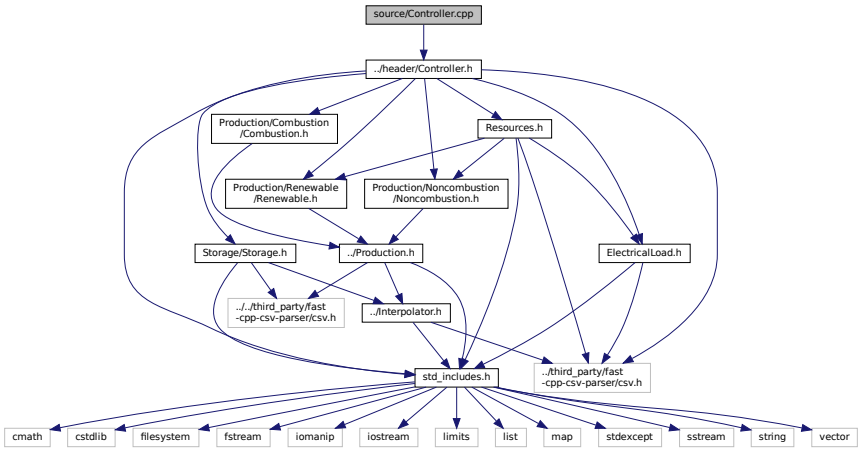
```
& StorageInputs::print_flag & StorageInputs::power_capacity_kW & StorageInputs::nominal_inflation_annual
def_readwrite ("nominal_discount_annual", &StorageInputs::nominal_discount_annual) .def(pybind11
& Storage::type & Storage::print_flag & Storage::is_sunk & Storage::n_replacements & Storage::power_capacity_k
& Storage::charge_kWh & Storage::nominal_inflation_annual & Storage::real_discount_annual &
Storage::operation_maintenance_cost_kWh & Storage::total_discharge_kWh & Storage::type_str &
Storage::charging_power_vec_kW def_readwrite("discharging_power_vec_kW", &Storage::discharging↩
_power_vec_kW) .def_readwrite("capital_cost_vec" (
            "interpolator" ,
            &Storage::interpolator  )
```

5.39 source/Controller.cpp File Reference

Implementation file for the Controller class.

```
#include "../header/Controller.h"
```

Include dependency graph for Controller.cpp:



5.39.1 Detailed Description

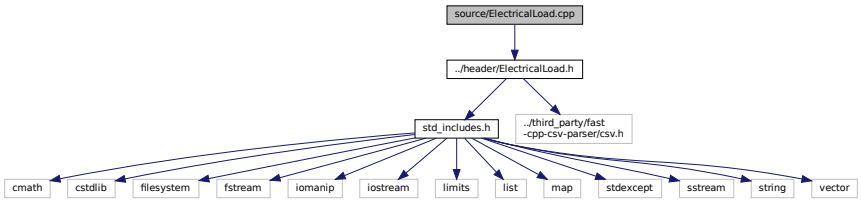
Implementation file for the Controller class.

A class which contains a various dispatch control logic. Intended to serve as a component class of Controller.

5.40 source/ElectricalLoad.cpp File Reference

Implementation file for the ElectricalLoad class.

```
#include "../header/ElectricalLoad.h"
```
Include dependency graph for ElectricalLoad.cpp:



5.40.1 Detailed Description

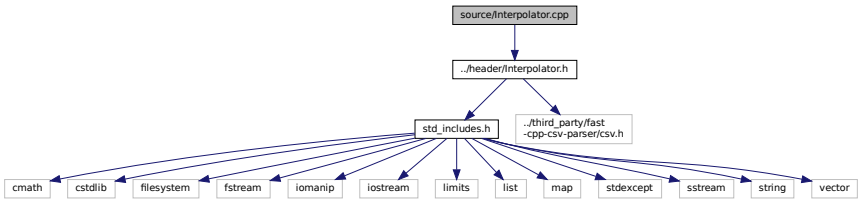
Implementation file for the ElectricalLoad class.

A class which contains time and electrical load data. Intended to serve as a component class of Model.

5.41 source/Interpolator.cpp File Reference

Implementation file for the Interpolator class.

```
#include "../header/Interpolator.h"
```
Include dependency graph for Interpolator.cpp:



5.41.1 Detailed Description

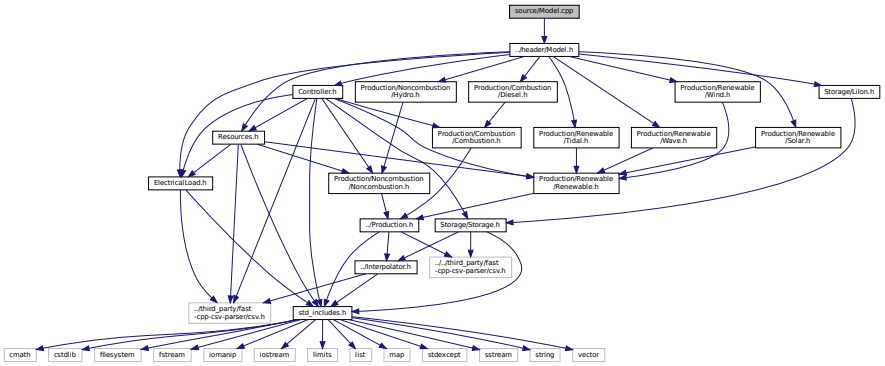
Implementation file for the Interpolator class.

A class which contains interpolation data and functionality. Intended to serve as a component of the Production and Storage hierarchies.

5.42 source/Model.cpp File Reference

Implementation file for the Model class.

```
#include "../header/Model.h"
```
Include dependency graph for Model.cpp:



5.42.1 Detailed Description

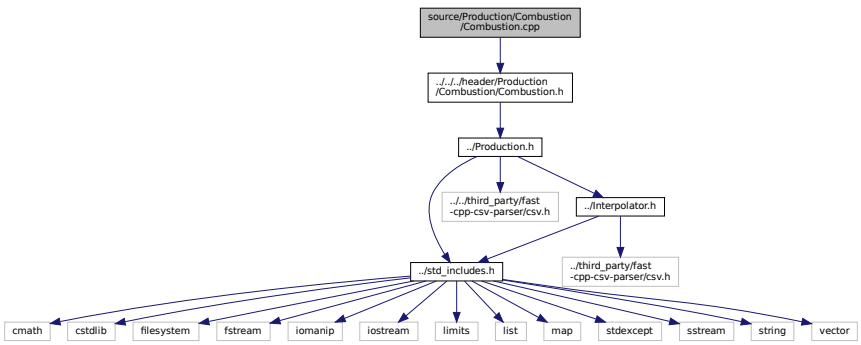
Implementation file for the Model class.

A container class which forms the centre of PGMcpp. The Model class is intended to serve as the primary user interface with the functionality of PGMcpp, and as such it contains all other classes.

5.43 source/Production/Combustion/Combustion.cpp File Reference

Implementation file for the Combustion class.

```
#include "../../../header/Production/Combustion/Combustion.h"
```
Include dependency graph for Combustion.cpp:



5.43.1 Detailed Description

Implementation file for the Combustion class.

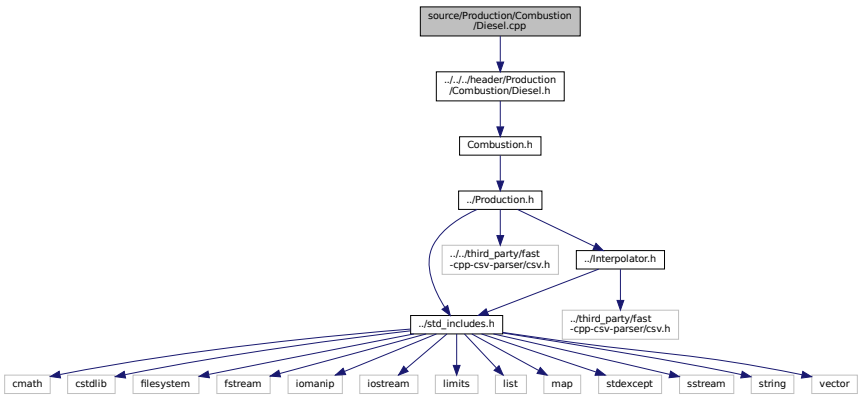
The root of the Combustion branch of the Production hierarchy. This branch contains derived classes which model the production of energy by way of combustibles.

5.44 source/Production/Combustion/Diesel.cpp File Reference

Implementation file for the Diesel class.

```
#include "../../../header/Production/Combustion/Diesel.h"
```

Include dependency graph for Diesel.cpp:



5.44.1 Detailed Description

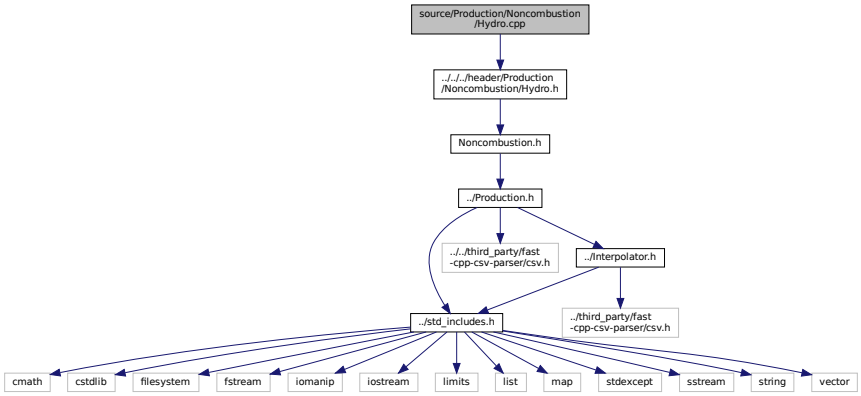
Implementation file for the Diesel class.

A derived class of the Combustion branch of Production which models production using a diesel generator.

5.45 source/Production/Noncombustion/Hydro.cpp File Reference

Implementation file for the Hydro class.

```
#include "../../../header/Production/Noncombustion/Hydro.h"
```
Include dependency graph for Hydro.cpp:



5.45.1 Detailed Description

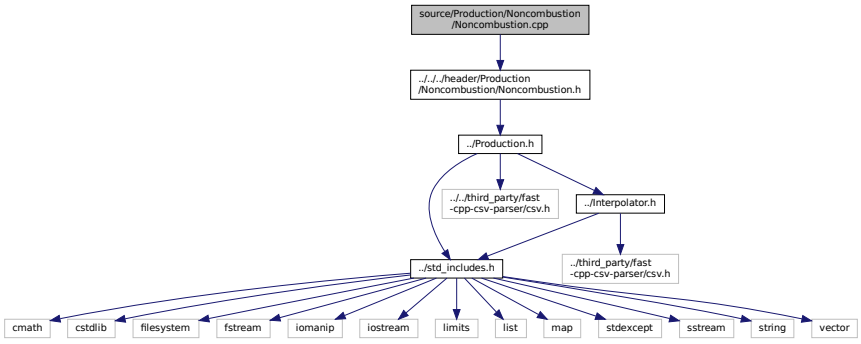
Implementation file for the Hydro class.

A derived class of the Noncombustion branch of Production which models production using a hydroelectric asset (either with reservoir or not).

5.46 source/Production/Noncombustion/Noncombustion.cpp File Reference

Implementation file for the Noncombustion class.

```
#include "../../../header/Production/Noncombustion/Noncombustion.h"
```
Include dependency graph for Noncombustion.cpp:



5.46.1 Detailed Description

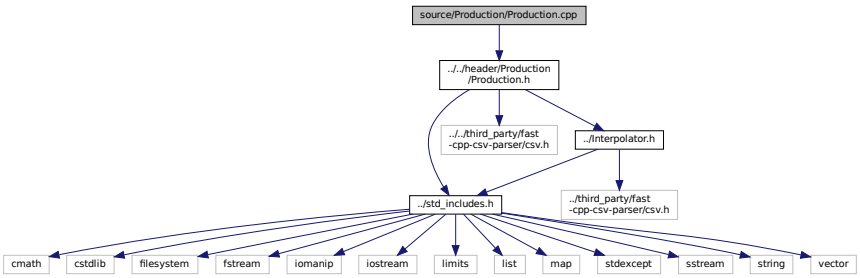
Implementation file for the Noncombustion class.

The root of the Noncombustion branch of the Production hierarchy. This branch contains derived classes which model controllable production which is not based on combustion.

5.47 source/Production/Production.cpp File Reference

Implementation file for the Production class.

`#include "../../header/Production/Production.h"`
Include dependency graph for Production.cpp:



5.47.1 Detailed Description

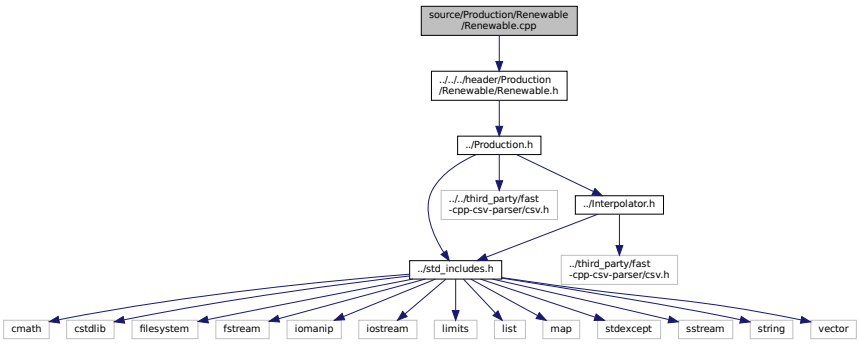
Implementation file for the Production class.

The base class of the Production hierarchy. This hierarchy contains derived classes which model the production of energy, be it renewable or otherwise.

5.48 source/Production/Renewable/Renewable.cpp File Reference

Implementation file for the Renewable class.

`#include "../../../header/Production/Renewable/Renewable.h"`
Include dependency graph for Renewable.cpp:



5.48.1 Detailed Description

Implementation file for the Renewable class.

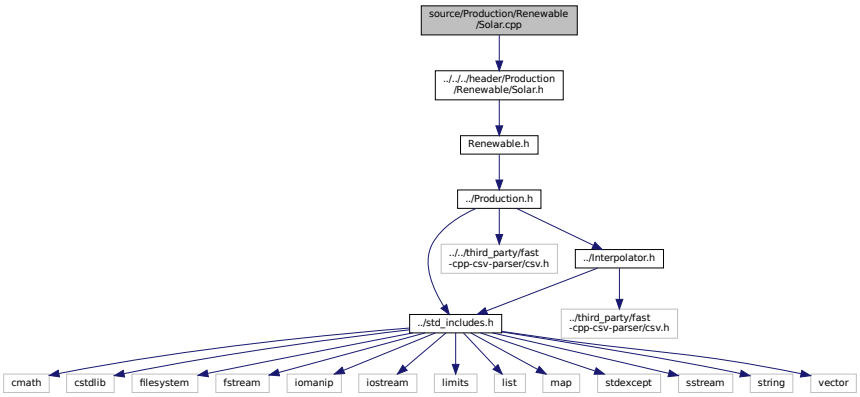
The root of the Renewable branch of the Production hierarchy. This branch contains derived classes which model the renewable production of energy.

5.49 source/Production/Renewable/Solar.cpp File Reference

Implementation file for the Solar class.

```
#include "../../../header/Production/Renewable/Solar.h"
```

Include dependency graph for Solar.cpp:



5.49.1 Detailed Description

Implementation file for the Solar class.

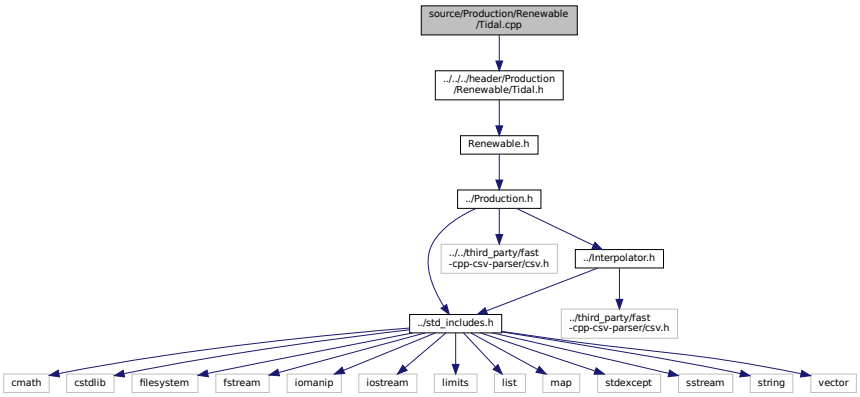
A derived class of the Renewable branch of Production which models solar production.

5.50 source/Production/Renewable/Tidal.cpp File Reference

Implementation file for the Tidal class.

```
#include "../../../header/Production/Renewable/Tidal.h"
```

Include dependency graph for Tidal.cpp:



5.50.1 Detailed Description

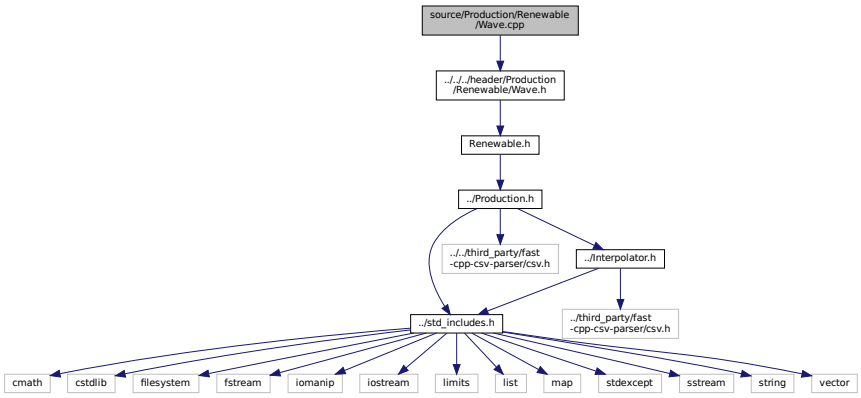
Implementation file for the Tidal class.

A derived class of the Renewable branch of Production which models tidal production.

5.51 source/Production/Renewable/Wave.cpp File Reference

Implementation file for the Wave class.

```
#include "../../../header/Production/Renewable/Wave.h"
```
Include dependency graph for Wave.cpp:



5.51.1 Detailed Description

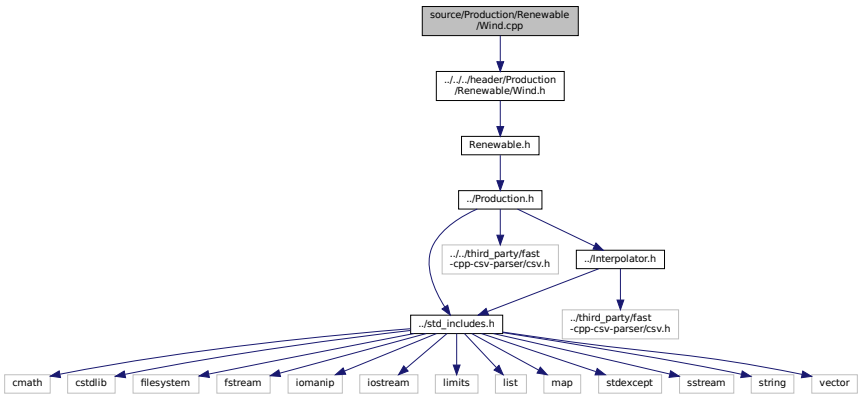
Implementation file for the Wave class.

A derived class of the Renewable branch of Production which models wave production.

5.52 source/Production/Renewable/Wind.cpp File Reference

Implementation file for the Wind class.

```
#include "../../../header/Production/Renewable/Wind.h"
```
Include dependency graph for Wind.cpp:



5.52.1 Detailed Description

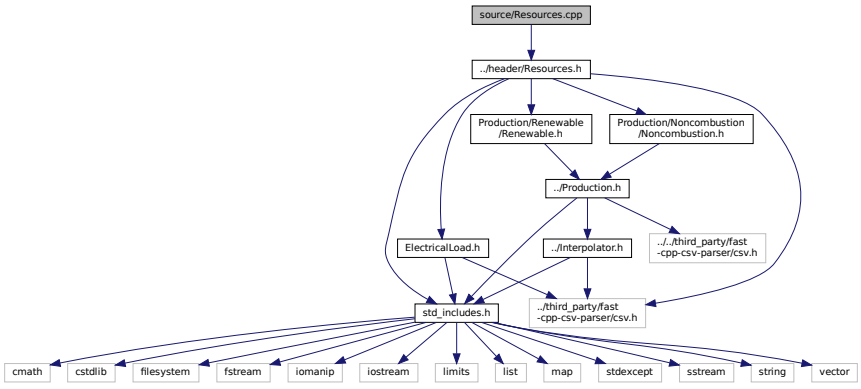
Implementation file for the Wind class.

A derived class of the Renewable branch of Production which models wind production.

5.53 source/Resources.cpp File Reference

Implementation file for the Resources class.

```
#include "../header/Resources.h"
```
Include dependency graph for Resources.cpp:



5.53.1 Detailed Description

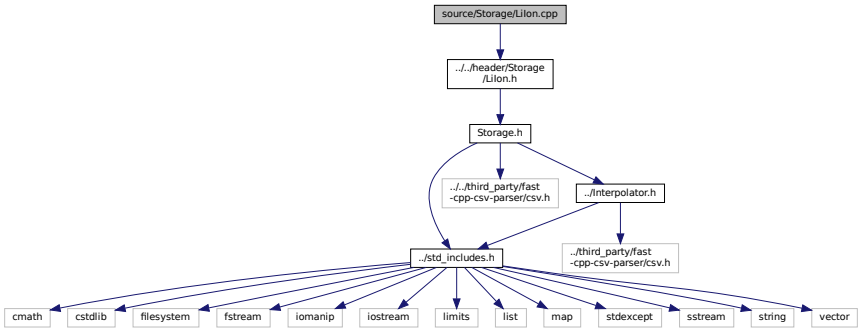
Implementation file for the Resources class.

A class which contains renewable resource data. Intended to serve as a component class of Model.

5.54 source/Storage/LiIon.cpp File Reference

Implementation file for the LiIon class.

`#include "../../header/Storage/LiIon.h"`
Include dependency graph for LiIon.cpp:



5.54.1 Detailed Description

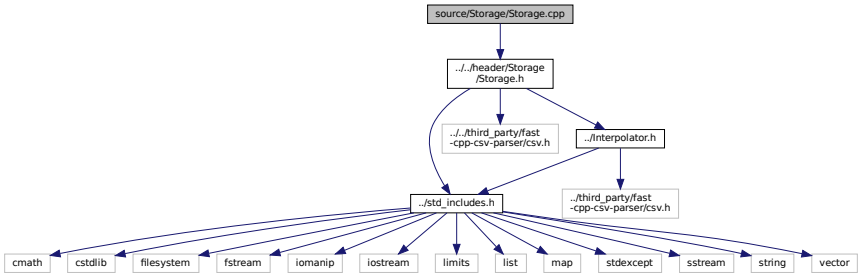
Implementation file for the LiIon class.

A derived class of Storage which models energy storage by way of lithium-ion batteries.

5.55 source/Storage/Storage.cpp File Reference

Implementation file for the Storage class.

`#include "../../header/Storage/Storage.h"`
Include dependency graph for Storage.cpp:



5.55.1 Detailed Description

Implementation file for the Storage class.

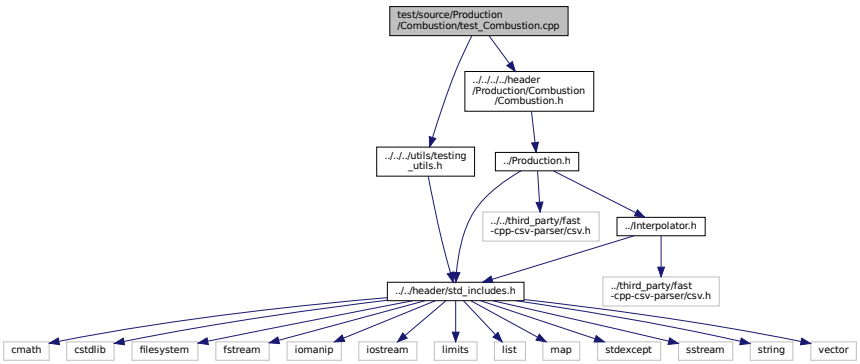
The base class of the Storage hierarchy. This hierarchy contains derived classes which model the storage of energy.

5.56 test/source/Production/Combustion/test_Combustion.cpp File Reference

Testing suite for Combustion class.

```
#include "../../../utils/testing_utils.h"
#include "../../../../header/Production/Combustion/Combustion.h"
```

Include dependency graph for test_Combustion.cpp:



Functions

- Combustion * testConstruct_Combustion (std::vector< double > *time_vec_hrs_ptr)

  A function to construct a Combustion object and spot check some post-construction attributes.
- int main (int argc, char **argv)

5.56.1 Detailed Description

Testing suite for Combustion class.

A suite of tests for the Combustion class.

5.56.2 Function Documentation

5.56.2.1 main()

```
int main (
              int argc,
              char ** argv )
147 {
148     #ifdef _WIN32
149         activateVirtualTerminal();
150     #endif  /* _WIN32 */
151
152     printGold("\tTesting Production <-- Combustion");
153
154     srand(time(NULL));
155
156
157     std::vector<double> time_vec_hrs (8760, 0);
158     for (size_t i = 0; i < time_vec_hrs.size(); i++) {
159         time_vec_hrs[i] = i;
160     }
161
162     Combustion* test_combustion_ptr = testConstruct_Combustion(&time_vec_hrs);
163
164
165     try {
166         //...
167     }
168
169
170     catch (...) {
171         delete test_combustion_ptr;
172
173         printGold(" ................. ");
174         printRed("FAIL");
175         std::cout « std::endl;
176         throw;
177     }
178
179
180     delete test_combustion_ptr;
181
182     printGold(" ................. ");
183     printGreen("PASS");
184     std::cout « std::endl;
185     return 0;
186
187 }   /* main() */
```

5.56.2.2 testConstruct_Combustion()

```
Combustion * testConstruct_Combustion (
              std::vector< double > * time_vec_hrs_ptr )
```

A function to construct a Combustion object and spot check some post-construction attributes.

Parameters

time_vec_hrs_ptr	A pointer to the vector containing the modelling time series.

Returns

A pointer to a test Combustion object.

```
65 {
66     CombustionInputs combustion_inputs;
67
68     Combustion* test_combustion_ptr = new Combustion(
69         8760,
70         1,
71         combustion_inputs,
```

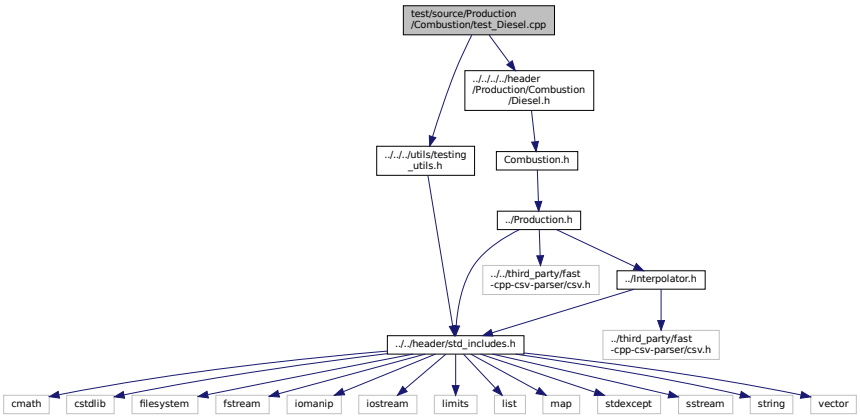
```
72          time_vec_hrs_ptr
73      );
74
75      testTruth(
76          not combustion_inputs.production_inputs.print_flag,
77          __FILE__,
78          __LINE__
79      );
80
81      testFloatEquals(
82          test_combustion_ptr->fuel_consumption_vec_L.size(),
83          8760,
84          __FILE__,
85          __LINE__
86      );
87
88      testFloatEquals(
89          test_combustion_ptr->fuel_cost_vec.size(),
90          8760,
91          __FILE__,
92          __LINE__
93      );
94
95      testFloatEquals(
96          test_combustion_ptr->CO2_emissions_vec_kg.size(),
97          8760,
98          __FILE__,
99          __LINE__
100     );
101
102     testFloatEquals(
103         test_combustion_ptr->CO_emissions_vec_kg.size(),
104         8760,
105         __FILE__,
106         __LINE__
107     );
108
109     testFloatEquals(
110         test_combustion_ptr->NOx_emissions_vec_kg.size(),
111         8760,
112         __FILE__,
113         __LINE__
114     );
115
116     testFloatEquals(
117         test_combustion_ptr->SOx_emissions_vec_kg.size(),
118         8760,
119         __FILE__,
120         __LINE__
121     );
122
123     testFloatEquals(
124         test_combustion_ptr->CH4_emissions_vec_kg.size(),
125         8760,
126         __FILE__,
127         __LINE__
128     );
129
130     testFloatEquals(
131         test_combustion_ptr->PM_emissions_vec_kg.size(),
132         8760,
133         __FILE__,
134         __LINE__
135     );
136
137     return test_combustion_ptr;
138 }   /* testConstruct_Combustion() */
```

5.57 test/source/Production/Combustion/test_Diesel.cpp File Reference

Testing suite for Diesel class.

```
#include "../../../utils/testing_utils.h"
#include "../../../../header/Production/Combustion/Diesel.h"
```

Include dependency graph for test_Diesel.cpp:



Functions

- Combustion * testConstruct_Diesel (std::vector< double > *time_vec_hrs_ptr)

  A function to construct a Diesel object and spot check some post-construction attributes.
- Combustion * testConstructLookup_Diesel (std::vector< double > *time_vec_hrs_ptr)

  A function to construct a Diesel object using fuel consumption lookup.
- void testBadConstruct_Diesel (std::vector< double > *time_vec_hrs_ptr)

  Function to test the trying to construct a Diesel object given bad inputs is being handled as expected.
- void testCapacityConstraint_Diesel (Combustion *test_diesel_ptr)

  Test to check that the installed capacity constraint is active and behaving as expected.
- void testMinimumLoadRatioConstraint_Diesel (Combustion *test_diesel_ptr)

  Test to check that the minimum load ratio constraint is active and behaving as expected.
- void testCommit_Diesel (Combustion *test_diesel_ptr)

  Function to test if the commit method is working as expected, by checking some post-call attributes of the test Diesel object.
- void testMinimumRuntimeConstraint_Diesel (Combustion *test_diesel_ptr)

  Function to check that the minimum runtime constraint is active and behaving as expected.
- void testFuelConsumptionEmissions_Diesel (Combustion *test_diesel_ptr)

  Function to test that post-commit fuel consumption and emissions are > 0 when the test Diesel object is running, and = 0 when it is not (as expected).
- void testEconomics_Diesel (Combustion *test_diesel_ptr)

  Function to test that the post-commit model economics for the test Diesel object are as expected (> 0 when running, = 0 when not).
- void testFuelLookup_Diesel (Combustion *test_diesel_lookup_ptr)

  Function to test that fuel consumption lookup (i.e., interpolation) is returning the expected values.
- int main (int argc, char **argv)

5.57.1 Detailed Description

Testing suite for Diesel class.

A suite of tests for the Diesel class.

5.57.2 Function Documentation

5.57.2.1 main()

```
int main (
              int argc,
              char ** argv )
730 {
731     #ifdef _WIN32
732         activateVirtualTerminal();
733     #endif  /* _WIN32 */
734
735     printGold("\tTesting Production <-- Combustion <-- Diesel");
736
737     srand(time(NULL));
738
739
740     std::vector<double> time_vec_hrs (8760, 0);
741     for (size_t i = 0; i < time_vec_hrs.size(); i++) {
742         time_vec_hrs[i] = i;
743     }
744
745
746     Combustion* test_diesel_ptr = testConstruct_Diesel(&time_vec_hrs);
747     Combustion* test_diesel_lookup_ptr = testConstructLookup_Diesel(&time_vec_hrs);
748
749     try {
750         testBadConstruct_Diesel(&time_vec_hrs);
751
752         testCapacityConstraint_Diesel(test_diesel_ptr);
753         testMinimumLoadRatioConstraint_Diesel(test_diesel_ptr);
754
755         testCommit_Diesel(test_diesel_ptr);
756
757         testMinimumRuntimeConstraint_Diesel(test_diesel_ptr);
758
759         testFuelConsumptionEmissions_Diesel(test_diesel_ptr);
760         testEconomics_Diesel(test_diesel_ptr);
761
762         testFuelLookup_Diesel(test_diesel_lookup_ptr);
763     }
764
765
766     catch (...) {
767         delete test_diesel_ptr;
768         delete test_diesel_lookup_ptr;
769
770         printGold(" ..... ");
771         printRed("FAIL");
772         std::cout « std::endl;
773         throw;
774     }
775
776
777     delete test_diesel_ptr;
778     delete test_diesel_lookup_ptr;
779
780     printGold(" ..... ");
781     printGreen("PASS");
782     std::cout « std::endl;
783     return 0;
784
785 }   /* main() */
```

5.57.2.2 testBadConstruct_Diesel()

```
void testBadConstruct_Diesel (
              std::vector< double > * time_vec_hrs_ptr )
```

Function to test the trying to construct a Diesel object given bad inputs is being handled as expected.

Parameters

time_vec_hrs_ptr	A pointer to the vector containing the modelling time series.

```
203 {
204     bool error_flag = true;
205 
206     try {
207         DieselInputs bad_diesel_inputs;
208         bad_diesel_inputs.fuel_cost_L = -1;
209 
210         Diesel bad_diesel(
211             8760,
212             1,
213             bad_diesel_inputs,
214             time_vec_hrs_ptr
215         );
216 
217         error_flag = false;
218     } catch (...) {
219         // Task failed successfully! =P
220     }
221     if (not error_flag) {
222         expectedErrorNotDetected(__FILE__, __LINE__);
223     }
224 
225     return;
226 }   /* testBadConstruct_Diesel() */
```

5.57.2.3 testCapacityConstraint_Diesel()

```
void testCapacityConstraint_Diesel (
            Combustion * test_diesel_ptr )
```

Test to check that the installed capacity constraint is active and behaving as expected.

Parameters

test_diesel_ptr	A Combustion pointer to the test Diesel object.

```
244 {
245     testFloatEquals(
246         test_diesel_ptr->requestProductionkW(0, 1, 2 * test_diesel_ptr->capacity_kW),
247         test_diesel_ptr->capacity_kW,
248         __FILE__,
249         __LINE__
250     );
251 
252     return;
253 }   /* testCapacityConstraint_Diesel() */
```

5.57.2.4 testCommit_Diesel()

```
void testCommit_Diesel (
            Combustion * test_diesel_ptr )
```

Function to test if the commit method is working as expected, by checking some post-call attributes of the test Diesel object.

Parameters

test_diesel_ptr	A Combustion pointer to the test Diesel object.

```
303 {
304     std::vector<double> dt_vec_hrs (48, 1);
305 
306     std::vector<double> load_vec_kW = {
307         1, 1, 0, 1, 0, 0, 1, 1, 1, 0, 1, 1,
308         1, 1, 1, 0, 0, 0, 0, 0, 0, 1, 1, 0,
309         1, 1, 1, 1, 1, 0, 1, 1, 1, 1, 0, 1,
310         1, 0, 0, 0, 1, 1, 1, 0, 1, 1, 0, 0
311     };
312 
313     double load_kW = 0;
314     double production_kW = 0;
315     double roll = 0;
316 
317     for (int i = 0; i < 48; i++) {
318         roll = (double)rand() / RAND_MAX;
319 
320         if (roll >= 0.95) {
321             roll = 1.25;
322         }
323 
324         load_vec_kW[i] *= roll * test_diesel_ptr->capacity_kW;
325         load_kW = load_vec_kW[i];
326 
327         production_kW = test_diesel_ptr->requestProductionkW(
328             i,
329             dt_vec_hrs[i],
330             load_kW
331         );
332 
333         load_kW = test_diesel_ptr->commit(
334             i,
335             dt_vec_hrs[i],
336             production_kW,
337             load_kW
338         );
339 
340         // load_kW <= load_vec_kW (i.e., after vs before)
341         testLessThanOrEqualTo(
342             load_kW,
343             load_vec_kW[i],
344             __FILE__,
345             __LINE__
346         );
347 
348         // production = dispatch + storage + curtailment
349         testFloatEquals(
350             test_diesel_ptr->production_vec_kW[i] -
351             test_diesel_ptr->dispatch_vec_kW[i] -
352             test_diesel_ptr->storage_vec_kW[i] -
353             test_diesel_ptr->curtailment_vec_kW[i],
354             0,
355             __FILE__,
356             __LINE__
357         );
358 
359         // capacity constraint
360         if (load_vec_kW[i] > test_diesel_ptr->capacity_kW) {
361             testFloatEquals(
362                 test_diesel_ptr->production_vec_kW[i],
363                 test_diesel_ptr->capacity_kW,
364                 __FILE__,
365                 __LINE__
366             );
367         }
368 
369         // minimum load ratio constraint
370         else if (
371             test_diesel_ptr->is_running and
372             test_diesel_ptr->production_vec_kW[i] > 0 and
373             load_vec_kW[i] <
374             ((Diesel*)test_diesel_ptr)->minimum_load_ratio * test_diesel_ptr->capacity_kW
375         ) {
376             testFloatEquals(
377                 test_diesel_ptr->production_vec_kW[i],
378                 ((Diesel*)test_diesel_ptr)->minimum_load_ratio *
379                     test_diesel_ptr->capacity_kW,
380                 __FILE__,
381                 __LINE__
382             );
383         }
384     }
```

```
385
386     return;
387 }   /* testCommit_Diesel() */
```

5.57.2.5 testConstruct_Diesel()

```
Combustion * testConstruct_Diesel (
             std::vector< double > * time_vec_hrs_ptr )
```

A function to construct a Diesel object and spot check some post-construction attributes.

Parameters

time_vec_hrs_ptr	A pointer to the vector containing the modelling time series.

Returns

A Combustion pointer to a test Diesel object.

```
65 {
66     DieselInputs diesel_inputs;
67
68     Combustion* test_diesel_ptr =  new Diesel(
69         8760,
70         1,
71         diesel_inputs,
72         time_vec_hrs_ptr
73     );
74
75     testTruth(
76         not diesel_inputs.combustion_inputs.production_inputs.print_flag,
77         __FILE__,
78         __LINE__
79     );
80
81     testFloatEquals(
82         test_diesel_ptr->type,
83         CombustionType :: DIESEL,
84         __FILE__,
85         __LINE__
86     );
87
88     testTruth(
89         test_diesel_ptr->type_str == "DIESEL",
90         __FILE__,
91         __LINE__
92     );
93
94     testFloatEquals(
95         test_diesel_ptr->linear_fuel_slope_LkWh,
96         0.265675,
97         __FILE__,
98         __LINE__
99     );
100
101     testFloatEquals(
102         test_diesel_ptr->linear_fuel_intercept_LkWh,
103         0.026676,
104         __FILE__,
105         __LINE__
106     );
107
108     testFloatEquals(
109         test_diesel_ptr->capital_cost,
110         94125.375446,
111         __FILE__,
112         __LINE__
113     );
114
115     testFloatEquals(
116         test_diesel_ptr->operation_maintenance_cost_kWh,
117         0.069905,
```

```
118         __FILE__,
119         __LINE__
120     );
121
122     testFloatEquals(
123         ((Diesel*)test_diesel_ptr)->minimum_load_ratio,
124         0.2,
125         __FILE__,
126         __LINE__
127     );
128
129     testFloatEquals(
130         ((Diesel*)test_diesel_ptr)->minimum_runtime_hrs,
131         4,
132         __FILE__,
133         __LINE__
134     );
135
136     testFloatEquals(
137         test_diesel_ptr->replace_running_hrs,
138         30000,
139         __FILE__,
140         __LINE__
141     );
142
143     testFloatEquals(
144         test_diesel_ptr->cycle_charging_setpoint,
145         0.85,
146         __FILE__,
147         __LINE__
148     );
149
150     return test_diesel_ptr;
151 }   /* testConstruct_Diesel() */
```

5.57.2.6 testConstructLookup_Diesel()

```
Combustion * testConstructLookup_Diesel (
              std::vector< double > * time_vec_hrs_ptr )
```

A function to construct a Diesel object using fuel consumption lookup.

Parameters

time_vec_hrs_ptr	A pointer to the vector containing the modelling time series.

Returns

A Combustion pointer to a test Diesel object.

```
170 {
171     DieselInputs diesel_inputs;
172
173     diesel_inputs.combustion_inputs.fuel_mode = FuelMode :: FUEL_MODE_LOOKUP;
174     diesel_inputs.combustion_inputs.path_2_fuel_interp_data =
175         "data/test/interpolation/diesel_fuel_curve.csv";
176
177     Combustion* test_diesel_lookup_ptr = new Diesel(
178         8760,
179         1,
180         diesel_inputs,
181         time_vec_hrs_ptr
182     );
183
184     return test_diesel_lookup_ptr;
185 }   /* testConstructLookup_Diesel() */
```

5.57.2.7 testEconomics_Diesel()

```
void testEconomics_Diesel (
            Combustion * test_diesel_ptr )
```

Function to test that the post-commit model economics for the test Diesel object are as expected ($>$ 0 when running, = 0 when not).

Parameters

test_diesel_ptr	A Combustion pointer to the test Diesel object.

```
607 {
608     std::vector<bool> expected_is_running_vec = {
609         1, 1, 1, 1, 0, 0, 1, 1, 1, 1, 1, 1,
610         1, 1, 1, 0, 0, 0, 0, 0, 0, 1, 1, 1,
611         1, 1, 1, 1, 1, 0, 1, 1, 1, 1, 0, 1,
612         1, 1, 1, 0, 1, 1, 1, 1, 1, 1, 0, 0
613     };
614
615     bool is_running = false;
616
617     for (int i = 0; i < 48; i++) {
618         is_running = test_diesel_ptr->is_running_vec[i];
619
620         testFloatEquals(
621             is_running,
622             expected_is_running_vec[i],
623             __FILE__,
624             __LINE__
625         );
626
627         // O&M, fuel consumption, and emissions > 0 whenever diesel is running
628         if (is_running) {
629             testGreaterThan(
630                 test_diesel_ptr->operation_maintenance_cost_vec[i],
631                 0,
632                 __FILE__,
633                 __LINE__
634             );
635         }
636
637         // O&M, fuel consumption, and emissions = 0 whenever diesel is not running
638         else {
639             testFloatEquals(
640                 test_diesel_ptr->operation_maintenance_cost_vec[i],
641                 0,
642                 __FILE__,
643                 __LINE__
644             );
645         }
646     }
647
648     return;
649 }   /* testEconomics_Diesel() */
```

5.57.2.8 testFuelConsumptionEmissions_Diesel()

```
void testFuelConsumptionEmissions_Diesel (
            Combustion * test_diesel_ptr )
```

Function to test that post-commit fuel consumption and emissions are $>$ 0 when the test Diesel object is running, and = 0 when it is not (as expected).

Parameters

test_diesel_ptr	A Combustion pointer to the test Diesel object.

```
449 {
450     std::vector<bool> expected_is_running_vec = {
451         1, 1, 1, 1, 0, 0, 1, 1, 1, 1, 1, 1,
452         1, 1, 1, 0, 0, 0, 0, 0, 0, 1, 1, 1,
453         1, 1, 1, 1, 1, 0, 1, 1, 1, 1, 0, 1,
454         1, 1, 1, 0, 1, 1, 1, 1, 1, 1, 0, 0
455     };
456 
457     bool is_running = false;
458 
459     for (int i = 0; i < 48; i++) {
460         is_running = test_diesel_ptr->is_running_vec[i];
461 
462         testFloatEquals(
463             is_running,
464             expected_is_running_vec[i],
465             __FILE__,
466             __LINE__
467         );
468 
469         // O&M, fuel consumption, and emissions > 0 whenever diesel is running
470         if (is_running) {
471             testGreaterThan(
472                 test_diesel_ptr->fuel_consumption_vec_L[i],
473                 0,
474                 __FILE__,
475                 __LINE__
476             );
477 
478             testGreaterThan(
479                 test_diesel_ptr->fuel_cost_vec[i],
480                 0,
481                 __FILE__,
482                 __LINE__
483             );
484 
485             testGreaterThan(
486                 test_diesel_ptr->CO2_emissions_vec_kg[i],
487                 0,
488                 __FILE__,
489                 __LINE__
490             );
491 
492             testGreaterThan(
493                 test_diesel_ptr->CO_emissions_vec_kg[i],
494                 0,
495                 __FILE__,
496                 __LINE__
497             );
498 
499             testGreaterThan(
500                 test_diesel_ptr->NOx_emissions_vec_kg[i],
501                 0,
502                 __FILE__,
503                 __LINE__
504             );
505 
506             testGreaterThan(
507                 test_diesel_ptr->SOx_emissions_vec_kg[i],
508                 0,
509                 __FILE__,
510                 __LINE__
511             );
512 
513             testGreaterThan(
514                 test_diesel_ptr->CH4_emissions_vec_kg[i],
515                 0,
516                 __FILE__,
517                 __LINE__
518             );
519 
520             testGreaterThan(
521                 test_diesel_ptr->PM_emissions_vec_kg[i],
522                 0,
523                 __FILE__,
524                 __LINE__
525             );
526         }
527 
528         // O&M, fuel consumption, and emissions = 0 whenever diesel is not running
529         else {
530             testFloatEquals(
531                 test_diesel_ptr->fuel_consumption_vec_L[i],
532                 0,
533                 __FILE__,
534                 __LINE__
535             );
```

```
536
537             testFloatEquals(
538                 test_diesel_ptr->fuel_cost_vec[i],
539                 0,
540                 __FILE__,
541                 __LINE__
542             );
543
544             testFloatEquals(
545                 test_diesel_ptr->CO2_emissions_vec_kg[i],
546                 0,
547                 __FILE__,
548                 __LINE__
549             );
550
551             testFloatEquals(
552                 test_diesel_ptr->CO_emissions_vec_kg[i],
553                 0,
554                 __FILE__,
555                 __LINE__
556             );
557
558             testFloatEquals(
559                 test_diesel_ptr->NOx_emissions_vec_kg[i],
560                 0,
561                 __FILE__,
562                 __LINE__
563             );
564
565             testFloatEquals(
566                 test_diesel_ptr->SOx_emissions_vec_kg[i],
567                 0,
568                 __FILE__,
569                 __LINE__
570             );
571
572             testFloatEquals(
573                 test_diesel_ptr->CH4_emissions_vec_kg[i],
574                 0,
575                 __FILE__,
576                 __LINE__
577             );
578
579             testFloatEquals(
580                 test_diesel_ptr->PM_emissions_vec_kg[i],
581                 0,
582                 __FILE__,
583                 __LINE__
584             );
585         }
586     }
587
588     return;
589 }   /* testFuelConsumptionEmissions_Diesel() */
```

5.57.2.9 testFuelLookup_Diesel()

```
void testFuelLookup_Diesel (
            Combustion * test_diesel_lookup_ptr )
```

Function to test that fuel consumption lookup (i.e., interpolation) is returning the expected values.

Parameters

test_diesel_lookup_ptr	A Combustion pointer to the test Diesel object using fuel consumption lookup.

```
668 {
669     std::vector<double> load_ratio_vec = {
670         0,
671         0.170812859791767,
672         0.322739274162545,
673         0.369750203682042,
674         0.443532869135929,
675         0.471567864244626,
676         0.536513734479662,
```

```
677         0.586125806988674,
678         0.601101175455075,
679         0.658356862575221,
680         0.70576929893201,
681         0.784069734739331,
682         0.805765927542453,
683         0.884747873186048,
684         0.930870496062112,
685         0.979415217694769,
686         1
687     };
688
689     std::vector<double> expected_fuel_consumption_vec_L = {
690         4.68079520372916,
691         8.35159603357656,
692         11.7422361561399,
693         12.9931187917615,
694         14.8786636301325,
695         15.5746957307243,
696         17.1419229487141,
697         18.3041866133728,
698         18.6530540913696,
699         19.9569217633299,
700         21.012354614584,
701         22.7142305879957,
702         23.1916726441968,
703         24.8602332554707,
704         25.8172124624032,
705         26.8256741279932,
706         27.254952
707     };
708
709     for (size_t i = 0; i < load_ratio_vec.size(); i++) {
710         testFloatEquals(
711             test_diesel_lookup_ptr->getFuelConsumptionL(
712                 1, load_ratio_vec[i] * test_diesel_lookup_ptr->capacity_kW
713             ),
714             expected_fuel_consumption_vec_L[i],
715             __FILE__,
716             __LINE__
717         );
718     }
719
720     return;
721 }   /* testFuelLookup_Diesel() */
```

5.57.2.10 testMinimumLoadRatioConstraint_Diesel()

```
void testMinimumLoadRatioConstraint_Diesel (
            Combustion * test_diesel_ptr )
```

Test to check that the minimum load ratio constraint is active and behaving as expected.

Parameters

test_diesel_ptr	A Combustion pointer to the test Diesel object.

```
271 {
272     testFloatEquals(
273         test_diesel_ptr->requestProductionkW(
274             0,
275             1,
276             0.5 * ((Diesel*)test_diesel_ptr)->minimum_load_ratio *
277                 test_diesel_ptr->capacity_kW
278         ),
279         ((Diesel*)test_diesel_ptr)->minimum_load_ratio * test_diesel_ptr->capacity_kW,
280         __FILE__,
281         __LINE__
282     );
283
284     return;
285 }   /* testMinimumLoadRatioConstraint_Diesel() */
```

5.57.2.11 testMinimumRuntimeConstraint_Diesel()

```
void testMinimumRuntimeConstraint_Diesel (
            Combustion * test_diesel_ptr )
```

Function to check that the minimum runtime constraint is active and behaving as expected.

Parameters

test_diesel_ptr	A Combustion pointer to the test Diesel object.

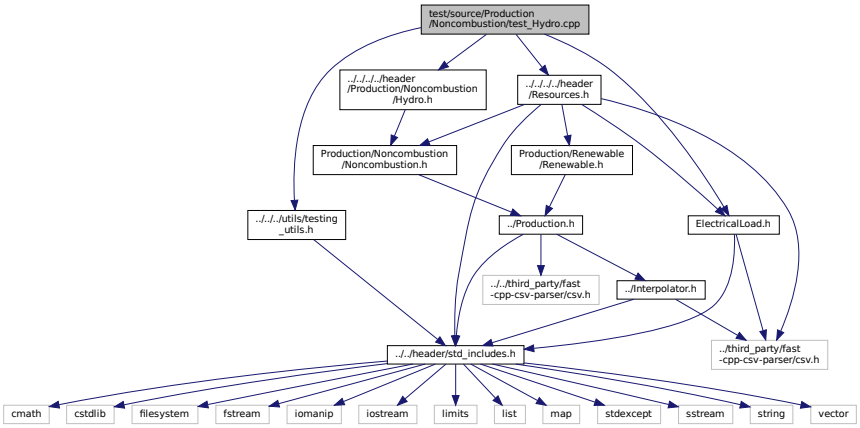
```
405 {
406     std::vector<double> load_vec_kW = {
407         1, 1, 0, 1, 0, 0, 1, 1, 1, 0, 1, 1,
408         1, 1, 1, 0, 0, 0, 0, 0, 0, 1, 1, 0,
409         1, 1, 1, 1, 1, 0, 1, 1, 1, 1, 0, 1,
410         1, 0, 0, 0, 1, 1, 1, 0, 1, 1, 0, 0
411     };
412
413     std::vector<bool> expected_is_running_vec = {
414         1, 1, 1, 1, 0, 0, 1, 1, 1, 1, 1, 1,
415         1, 1, 1, 0, 0, 0, 0, 0, 0, 1, 1, 1,
416         1, 1, 1, 1, 1, 0, 1, 1, 1, 1, 0, 1,
417         1, 1, 1, 0, 1, 1, 1, 1, 1, 1, 0, 0
418     };
419
420     for (int i = 0; i < 48; i++) {
421         testFloatEquals(
422             test_diesel_ptr->is_running_vec[i],
423             expected_is_running_vec[i],
424             __FILE__,
425             __LINE__
426         );
427     }
428
429     return;
430 }   /* testMinimumRuntimeConstraint_Diesel() */
```

5.58 test/source/Production/Noncombustion/test_Hydro.cpp File Reference

Testing suite for Hydro class.

```
#include "../../../utils/testing_utils.h"
#include "../../../../header/Resources.h"
#include "../../../../header/ElectricalLoad.h"
#include "../../../../header/Production/Noncombustion/Hydro.h"
```

Include dependency graph for test_Hydro.cpp:



Functions

- Noncombustion * testConstruct_Hydro (HydroInputs hydro_inputs, std::vector< double > *time_vec_hrs_↩ ptr)

  A function to construct a Hydro object and spot check some post-construction attributes.
- void testEfficiencyInterpolation_Hydro (Noncombustion *test_hydro_ptr)

  Function to test that the generator and turbine efficiency maps are being initialized as expected, and that efficiency interpolation is returning the expected values.
- void testCommit_Hydro (Noncombustion *test_hydro_ptr, Resources *test_resources_ptr)
- int main (int argc, char **argv)

5.58.1 Detailed Description

Testing suite for Hydro class.

A suite of tests for the Hydro class.

5.58.2 Function Documentation

5.58.2.1 main()

```
int main (
            int argc,
            char ** argv )
330 {
331     #ifdef _WIN32
332         activateVirtualTerminal();
333     #endif  /* _WIN32 */
334
335     printGold("\tTesting Production <-- Noncombustion <-- Hydro");
336
337     srand(time(NULL));
```

```
338
339
340     std::vector<double> time_vec_hrs (8760, 0);
341     for (size_t i = 0; i < time_vec_hrs.size(); i++) {
342         time_vec_hrs[i] = i;
343     }
344
345     std::string path_2_electrical_load_time_series =
346         "data/test/electrical_load/electrical_load_generic_peak-500kW_1yr_dt-1hr.csv";
347
348     ElectricalLoad* test_electrical_load_ptr =
349         new ElectricalLoad(path_2_electrical_load_time_series);
350
351     Resources* test_resources_ptr = new Resources();
352
353     HydroInputs hydro_inputs;
354     int hydro_resource_key = 0;
355
356     hydro_inputs.reservoir_capacity_m3 = 10000;
357     hydro_inputs.resource_key = hydro_resource_key;
358
359     Noncombustion* test_hydro_ptr = testConstruct_Hydro(hydro_inputs, &time_vec_hrs);
360
361     std::string path_2_hydro_resource_data =
362         "data/test/resources/hydro_inflow_peak-20000m3hr_1yr_dt-1hr.csv";
363
364     test_resources_ptr->addResource(
365         NoncombustionType::HYDRO,
366         path_2_hydro_resource_data,
367         hydro_resource_key,
368         test_electrical_load_ptr
369     );
370
371
372     try {
373         testEfficiencyInterpolation_Hydro(test_hydro_ptr);
374         testCommit_Hydro(test_hydro_ptr, test_resources_ptr);
375     }
376
377
378     catch (...) {
379         delete test_electrical_load_ptr;
380         delete test_resources_ptr;
381         delete test_hydro_ptr;
382
383         printGold(" ... ");
384         printRed("FAIL");
385         std::cout « std::endl;
386         throw;
387     }
388
389
390     delete test_electrical_load_ptr;
391     delete test_resources_ptr;
392     delete test_hydro_ptr;
393
394     printGold(" ... ");
395     printGreen("PASS");
396     std::cout « std::endl;
397     return 0;
398
399 }   /* main() */
```

5.58.2.2 testCommit_Hydro()

```
void testCommit_Hydro (
             Noncombustion * test_hydro_ptr,
             Resources * test_resources_ptr )
247 {
248     double load_kW = 100 * (double)rand() / RAND_MAX;
249     double production_kW = 0;
250
251     for (int i = 0; i < 8760; i++) {
252         production_kW = test_hydro_ptr->requestProductionkW(
253             i,
254             1,
255             load_kW,
256             test_resources_ptr->resource_map_1D[test_hydro_ptr->resource_key][i]
257         );
```

```
258
259         load_kW = test_hydro_ptr->commit(
260             i,
261             1,
262             production_kW,
263             load_kW,
264             test_resources_ptr->resource_map_1D[test_hydro_ptr->resource_key][i]
265         );
266
267         testGreaterThanOrEqualTo(
268             test_hydro_ptr->production_vec_kW[i],
269             0,
270             __FILE__,
271             __LINE__
272         );
273
274         testLessThanOrEqualTo(
275             test_hydro_ptr->production_vec_kW[i],
276             test_hydro_ptr->capacity_kW,
277             __FILE__,
278             __LINE__
279         );
280
281         testFloatEquals(
282             test_hydro_ptr->production_vec_kW[i] -
283             test_hydro_ptr->dispatch_vec_kW[i] -
284             test_hydro_ptr->curtailment_vec_kW[i] -
285             test_hydro_ptr->storage_vec_kW[i],
286             0,
287             __FILE__,
288             __LINE__
289         );
290
291         testGreaterThanOrEqualTo(
292             ((Hydro*)test_hydro_ptr)->turbine_flow_vec_m3hr[i],
293             0,
294             __FILE__,
295             __LINE__
296         );
297
298         testLessThanOrEqualTo(
299             ((Hydro*)test_hydro_ptr)->turbine_flow_vec_m3hr[i],
300             ((Hydro*)test_hydro_ptr)->maximum_flow_m3hr,
301             __FILE__,
302             __LINE__
303         );
304
305         testGreaterThanOrEqualTo(
306             ((Hydro*)test_hydro_ptr)->stored_volume_vec_m3[i],
307             0,
308             __FILE__,
309             __LINE__
310         );
311
312         testLessThanOrEqualTo(
313             ((Hydro*)test_hydro_ptr)->stored_volume_vec_m3[i],
314             ((Hydro*)test_hydro_ptr)->reservoir_capacity_m3,
315             __FILE__,
316             __LINE__
317         );
318     }
319
320     return;
321 }   /* testCommit_Hydro() */
```

5.58.2.3 testConstruct_Hydro()

```
Hydro *Noncombustion * testConstruct_Hydro (
            HydroInputs hydro_inputs,
            std::vector< double > * time_vec_hrs_ptr )
```

A function to construct a Hydro object and spot check some post-construction attributes.

Returns

A Noncombustion pointer to a test Hydro object.

```
72 {
73     Noncombustion* test_hydro_ptr =  new Hydro(
74         8760,
75         1,
76         hydro_inputs,
77         time_vec_hrs_ptr
78     );
79 
80     testTruth(
81         not hydro_inputs.noncombustion_inputs.production_inputs.print_flag,
82         __FILE__,
83         __LINE__
84     );
85 
86     testFloatEquals(
87         test_hydro_ptr->n_points,
88         8760,
89         __FILE__,
90         __LINE__
91     );
92 
93     testFloatEquals(
94         test_hydro_ptr->type,
95         NoncombustionType :: HYDRO,
96         __FILE__,
97         __LINE__
98     );
99 
100     testTruth(
101         test_hydro_ptr->type_str == "HYDRO",
102         __FILE__,
103         __LINE__
104     );
105 
106     testFloatEquals(
107         ((Hydro*)test_hydro_ptr)->turbine_type,
108         HydroTurbineType :: HYDRO_TURBINE_PELTON,
109         __FILE__,
110         __LINE__
111     );
112 
113     testFloatEquals(
114         ((Hydro*)test_hydro_ptr)->reservoir_capacity_m3,
115         10000,
116         __FILE__,
117         __LINE__
118     );
119 
120     return test_hydro_ptr;
121 }   /* testConstruct_Hydro() */
```

5.58.2.4 testEfficiencyInterpolation_Hydro()

```
void testEfficiencyInterpolation_Hydro (
            Noncombustion * test_hydro_ptr )
```

Function to test that the generator and turbine efficiency maps are being initialized as expected, and that efficiency interpolation is returning the expected values.

Parameters

test_hydro_ptr	A Noncombustion pointer to the test Hydro object.

```
140 {
141     std::vector<double> expected_gen_power_ratios = {
142         0,   0.1, 0.2,  0.3, 0.4, 0.5,
143         0.6, 0.7, 0.75, 0.8, 0.9, 1
144     };
145 
146     std::vector<double> expected_gen_efficiencies = {
```

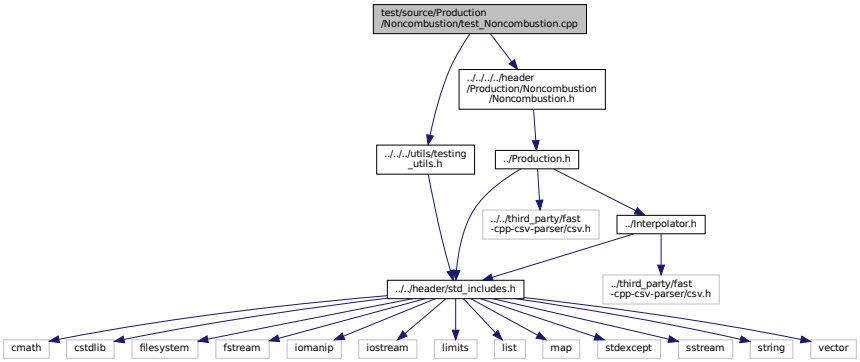
```
147         0.000, 0.800, 0.900, 0.913,
148         0.925, 0.943, 0.947, 0.950,
149         0.953, 0.954, 0.956, 0.958
150     };
151 
152     double query = 0;
153     for (size_t i = 0; i < expected_gen_power_ratios.size(); i++) {
154         testFloatEquals(
155             test_hydro_ptr->interpolator.interp_map_1D[
156                 HydroInterpKeys :: GENERATOR_EFFICIENCY_INTERP_KEY
157             ].x_vec[i],
158             expected_gen_power_ratios[i],
159             __FILE__,
160             __LINE__
161         );
162 
163         testFloatEquals(
164             test_hydro_ptr->interpolator.interp_map_1D[
165                 HydroInterpKeys :: GENERATOR_EFFICIENCY_INTERP_KEY
166             ].y_vec[i],
167             expected_gen_efficiencies[i],
168             __FILE__,
169             __LINE__
170         );
171 
172         if (i < expected_gen_power_ratios.size() - 1) {
173             query = expected_gen_power_ratios[i] + ((double)rand() / RAND_MAX) *
174                 (expected_gen_power_ratios[i + 1] - expected_gen_power_ratios[i]);
175 
176             test_hydro_ptr->interpolator.interp1D(
177                 HydroInterpKeys :: GENERATOR_EFFICIENCY_INTERP_KEY,
178                 query
179             );
180         }
181     }
182 
183     std::vector<double> expected_turb_power_ratios = {
184         0,   0.1, 0.2, 0.3, 0.4,
185         0.5, 0.6, 0.7, 0.8, 0.9,
186         1
187     };
188 
189     std::vector<double> expected_turb_efficiencies = {
190         0.000, 0.780, 0.855, 0.875, 0.890,
191         0.900, 0.908, 0.913, 0.918, 0.908,
192         0.880
193     };
194 
195     for (size_t i = 0; i < expected_turb_power_ratios.size(); i++) {
196         testFloatEquals(
197             test_hydro_ptr->interpolator.interp_map_1D[
198                 HydroInterpKeys :: TURBINE_EFFICIENCY_INTERP_KEY
199             ].x_vec[i],
200             expected_turb_power_ratios[i],
201             __FILE__,
202             __LINE__
203         );
204 
205         testFloatEquals(
206             test_hydro_ptr->interpolator.interp_map_1D[
207                 HydroInterpKeys :: TURBINE_EFFICIENCY_INTERP_KEY
208             ].y_vec[i],
209             expected_turb_efficiencies[i],
210             __FILE__,
211             __LINE__
212         );
213 
214         if (i < expected_turb_power_ratios.size() - 1) {
215             query = expected_turb_power_ratios[i] + ((double)rand() / RAND_MAX) *
216                 (expected_turb_power_ratios[i + 1] - expected_turb_power_ratios[i]);
217 
218             test_hydro_ptr->interpolator.interp1D(
219                 HydroInterpKeys :: TURBINE_EFFICIENCY_INTERP_KEY,
220                 query
221             );
222         }
223     }
224 
225     return;
226 }   /* testEfficiencyInterpolation_Hydro() */
```

5.59 test/source/Production/Noncombustion/test_Noncombustion.cpp File Reference

Testing suite for Noncombustion class.

```
#include "../../../utils/testing_utils.h"
#include "../../../../header/Production/Noncombustion/Noncombustion.h"
```

Include dependency graph for test_Noncombustion.cpp:



Functions

- Noncombustion * testConstruct_Noncombustion (std::vector< double > *time_vec_hrs_ptr)

  A function to construct a Noncombustion object and spot check some post-construction attributes.
- int main (int argc, char **argv)

5.59.1 Detailed Description

Testing suite for Noncombustion class.

A suite of tests for the Noncombustion class.

5.59.2 Function Documentation

5.59.2.1 main()

```
int main (
              int argc,
              char ** argv )
99 {
100     #ifdef _WIN32
101         activateVirtualTerminal();
102     #endif  /* _WIN32 */
103
104     printGold("\tTesting Production <-- Noncombustion");
105
106     srand(time(NULL));
107
108
109     std::vector<double> time_vec_hrs (8760, 0);
110     for (size_t i = 0; i < time_vec_hrs.size(); i++) {
111         time_vec_hrs[i] = i;
112     }
113
114     Noncombustion* test_noncombustion_ptr = testConstruct_Noncombustion(&time_vec_hrs);
115
116
117     try {
118         //...
119     }
120
121
122     catch (...) {
123         delete test_noncombustion_ptr;
124
125         printGold(" ..... ");
126         printRed("FAIL");
127         std::cout << std::endl;
128         throw;
129     }
130
131
132     delete test_noncombustion_ptr;
133
134     printGold(" ..... ");
135     printGreen("PASS");
136     std::cout << std::endl;
137     return 0;
138
139 }   /* main() */
```

5.59.2.2 testConstruct_Noncombustion()

```
Noncombustion * testConstruct_Noncombustion (
              std::vector< double > * time_vec_hrs_ptr )
```

A function to construct a Noncombustion object and spot check some post-construction attributes.

Parameters

time_vec_hrs_ptr	A pointer to the vector containing the modelling time series.

Returns

A pointer to a test Noncombustion object.

```
65 {
66     NoncombustionInputs noncombustion_inputs;
67
68     Noncombustion* test_noncombustion_ptr =
69         new Noncombustion(
70             8760,
71             1,
```

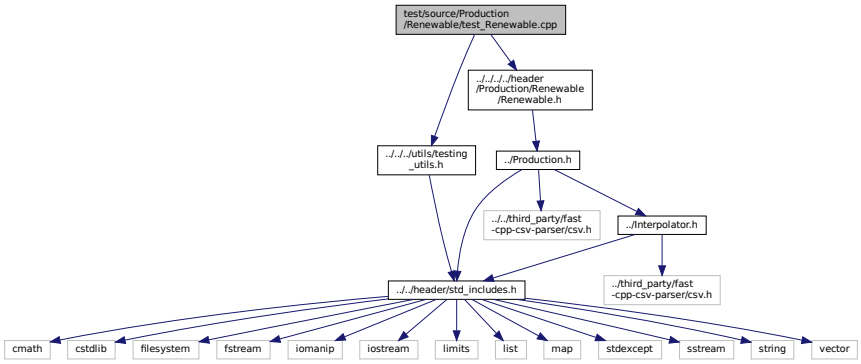
```
72              noncombustion_inputs,
73              time_vec_hrs_ptr
74          );
75
76      testTruth(
77          not noncombustion_inputs.production_inputs.print_flag,
78          __FILE__,
79          __LINE__
80      );
81
82      testFloatEquals(
83          test_noncombustion_ptr->n_points,
84          8760,
85          __FILE__,
86          __LINE__
87      );
88
89      return test_noncombustion_ptr;
90  }   /* testConstruct_Noncombustion() */
```

5.60 test/source/Production/Renewable/test_Renewable.cpp File Reference

Testing suite for Renewable class.

```
#include "../../../utils/testing_utils.h"
#include "../../../../header/Production/Renewable/Renewable.h"
```

Include dependency graph for test_Renewable.cpp:



Functions

- Renewable * testConstruct_Renewable (std::vector< double > *time_vec_hrs_ptr)

  A function to construct a Renewable object and spot check some post-construction attributes.
- int main (int argc, char **argv)

5.60.1 Detailed Description

Testing suite for Renewable class.

A suite of tests for the Renewable class.

5.60.2 Function Documentation

5.60.2.1 main()

```
int main (
              int argc,
              char ** argv )
```

```
98 {
99     #ifdef _WIN32
100         activateVirtualTerminal();
101     #endif  /* _WIN32 */
102
103     printGold("\tTesting Production <-- Renewable");
104
105     srand(time(NULL));
106
107
108     std::vector<double> time_vec_hrs (8760, 0);
109     for (size_t i = 0; i < time_vec_hrs.size(); i++) {
110         time_vec_hrs[i] = i;
111     }
112
113     Renewable* test_renewable_ptr = testConstruct_Renewable(&time_vec_hrs);
114
115
116     try {
117         //...
118     }
119
120
121     catch (...) {
122         delete test_renewable_ptr;
123
124         printGold(" .................. ");
125         printRed("FAIL");
126         std::cout << std::endl;
127         throw;
128     }
129
130
131     delete test_renewable_ptr;
132
133     printGold(" .................. ");
134     printGreen("PASS");
135     std::cout << std::endl;
136     return 0;
137
138 }   /* main() */
```

5.60.2.2 testConstruct_Renewable()

```
Renewable * testConstruct_Renewable (
              std::vector< double > * time_vec_hrs_ptr )
```

A function to construct a Renewable object and spot check some post-construction attributes.

Parameters

time_vec_hrs_ptr	A pointer to the vector containing the modelling time series.

Returns

A pointer to a test Renewable object.

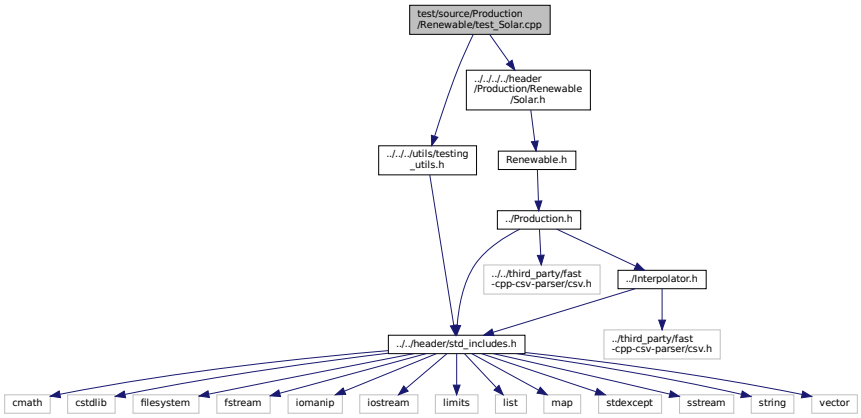
```
65 {
66     RenewableInputs renewable_inputs;
67
68     Renewable* test_renewable_ptr = new Renewable(
69         8760,
70         1,
71         renewable_inputs,
72         time_vec_hrs_ptr
73     );
74
75     testTruth(
76         not renewable_inputs.production_inputs.print_flag,
77         __FILE__,
78         __LINE__
79     );
80
81     testFloatEquals(
82         test_renewable_ptr->n_points,
83         8760,
84         __FILE__,
85         __LINE__
86     );
87
88     return test_renewable_ptr;
89 }   /* testConstruct_Renewable() */
```

5.61 test/source/Production/Renewable/test_Solar.cpp File Reference

Testing suite for Solar class.

```
#include "../../../utils/testing_utils.h"
#include "../../../../header/Production/Renewable/Solar.h"
```

Include dependency graph for test_Solar.cpp:



Functions

- Renewable * testConstruct_Solar (std::vector< double > *time_vec_hrs_ptr)

  A function to construct a Solar object and spot check some post-construction attributes.
- void testBadConstruct_Solar (std::vector< double > *time_vec_hrs_ptr)

  Function to test the trying to construct a Solar object given bad inputs is being handled as expected.
- void testProductionOverride_Solar (std::string path_2_normalized_production_time_series, std::vector< double > *time_vec_hrs_ptr)

Function to test that normalized production data is being read in correctly, and that the associated production override feature is behaving as expected.

- void testDetailed_Solar (void)
- void testProductionConstraint_Solar (Renewable *test_solar_ptr)

  Function to test that the production constraint is active and behaving as expected.
- void testCommit_Solar (Renewable *test_solar_ptr)

  Function to test if the commit method is working as expected, by checking some post-call attributes of the test Solar object. Uses a randomized resource input.
- void testEconomics_Solar (Renewable *test_solar_ptr)
- int main (int argc, char **argv)

5.61.1 Detailed Description

Testing suite for Solar class.

A suite of tests for the Solar class.

5.61.2 Function Documentation

5.61.2.1 main()

```
int main (
              int argc,
              char ** argv )
```

```
666 {
667     #ifdef _WIN32
668         activateVirtualTerminal();
669     #endif  /* _WIN32 */
670 
671     printGold("\tTesting Production <-- Renewable <-- Solar");
672 
673     srand(time(NULL));
674 
675 
676     std::vector<double> time_vec_hrs (8760, 0);
677     for (size_t i = 0; i < time_vec_hrs.size(); i++) {
678         time_vec_hrs[i] = i;
679     }
680 
681     Renewable* test_solar_ptr = testConstruct_Solar(&time_vec_hrs);
682 
683 
684     try {
685         testBadConstruct_Solar(&time_vec_hrs);
686 
687         std::string path_2_normalized_production_time_series =
688             "data/test/normalized_production/normalized_solar_production.csv";
689 
690         testProductionOverride_Solar(
691             path_2_normalized_production_time_series,
692             &time_vec_hrs
693         );
694 
695         testDetailed_Solar();
696 
697         testProductionConstraint_Solar(test_solar_ptr);
698 
699         testCommit_Solar(test_solar_ptr);
700         testEconomics_Solar(test_solar_ptr);
701     }
702 
703 
704     catch (...) {
```

```
705         delete test_solar_ptr;
706
707         printGold(" ....... ");
708         printRed("FAIL");
709         std::cout « std::endl;
710         throw;
711     }
712
713
714     delete test_solar_ptr;
715
716     printGold(" ....... ");
717     printGreen("PASS");
718     std::cout « std::endl;
719     return 0;
720
721 }   /* main() */
```

5.61.2.2 testBadConstruct_Solar()

```
void testBadConstruct_Solar (
             std::vector< double > * time_vec_hrs_ptr )
```

Function to test the trying to construct a Solar object given bad inputs is being handled as expected.

Parameters

time_vec_hrs_ptr	A pointer to the vector containing the modelling time series.

```
134 {
135     bool error_flag = true;
136
137     try {
138         SolarInputs bad_solar_inputs;
139         bad_solar_inputs.derating = -1;
140
141         Solar bad_solar(8760, 1, bad_solar_inputs, time_vec_hrs_ptr);
142
143         error_flag = false;
144     } catch (...) {
145         // Task failed successfully! =P
146     }
147     if (not error_flag) {
148         expectedErrorNotDetected(__FILE__, __LINE__);
149     }
150
151     return;
152 }   /* testBadConstruct_Solar() */
```

5.61.2.3 testCommit_Solar()

```
void testCommit_Solar (
             Renewable * test_solar_ptr )
```

Function to test if the commit method is working as expected, by checking some post-call attributes of the test Solar object. Uses a randomized resource input.

Parameters

test_solar_ptr	A Renewable pointer to the test Solar object.

```
515 {
516     std::vector<double> dt_vec_hrs (48, 1);
517
518     std::vector<double> load_vec_kW = {
519         1, 1, 0, 1, 0, 0, 1, 1, 1, 0, 1, 1,
520         1, 1, 1, 0, 0, 0, 0, 0, 0, 1, 1, 0,
521         1, 1, 1, 1, 1, 0, 1, 1, 1, 1, 0, 1,
522         1, 0, 0, 0, 1, 1, 1, 0, 1, 1, 0, 0
523     };
524
525     double load_kW = 0;
526     double production_kW = 0;
527     double roll = 0;
528     double solar_resource_kWm2 = 0;
529
530     for (int i = 0; i < 48; i++) {
531         roll = (double)rand() / RAND_MAX;
532
533         solar_resource_kWm2 = roll;
534
535         roll = (double)rand() / RAND_MAX;
536
537         if (roll <= 0.1) {
538             solar_resource_kWm2 = 0;
539         }
540
541         else if (roll >= 0.95) {
542             solar_resource_kWm2 = 1.25;
543         }
544
545         roll = (double)rand() / RAND_MAX;
546
547         if (roll >= 0.95) {
548             roll = 1.25;
549         }
550
551         load_vec_kW[i] *= roll * test_solar_ptr->capacity_kW;
552         load_kW = load_vec_kW[i];
553
554         production_kW = test_solar_ptr->computeProductionkW(
555             i,
556             dt_vec_hrs[i],
557             solar_resource_kWm2
558         );
559
560         load_kW = test_solar_ptr->commit(
561             i,
562             dt_vec_hrs[i],
563             production_kW,
564             load_kW
565         );
566
567         // is running (or not) as expected
568         if (solar_resource_kWm2 > 0) {
569             testTruth(
570                 test_solar_ptr->is_running,
571                 __FILE__,
572                 __LINE__
573             );
574         }
575
576         else {
577             testTruth(
578                 not test_solar_ptr->is_running,
579                 __FILE__,
580                 __LINE__
581             );
582         }
583
584         // load_kW <= load_vec_kW (i.e., after vs before)
585         testLessThanOrEqualTo(
586             load_kW,
587             load_vec_kW[i],
588             __FILE__,
589             __LINE__
590         );
591
592         // production = dispatch + storage + curtailment
593         testFloatEquals(
594             test_solar_ptr->production_vec_kW[i] -
595             test_solar_ptr->dispatch_vec_kW[i] -
596             test_solar_ptr->storage_vec_kW[i] -
597             test_solar_ptr->curtailment_vec_kW[i],
598             0,
599             __FILE__,
600             __LINE__
601         );
```

```
602
603         // capacity constraint
604         if (solar_resource_kWm2 > 1) {
605             testFloatEquals(
606                 test_solar_ptr->production_vec_kW[i],
607                 test_solar_ptr->capacity_kW,
608                 __FILE__,
609                 __LINE__
610             );
611         }
612     }
613
614     return;
615 }   /* testCommit_Solar() */
```

5.61.2.4 testConstruct_Solar()

```
Renewable * testConstruct_Solar (
            std::vector< double > * time_vec_hrs_ptr )
```

A function to construct a Solar object and spot check some post-construction attributes.

Parameters

time_vec_hrs_ptr	A pointer to the vector containing the modelling time series.

Returns

A Renewable pointer to a test Solar object.

```
65 {
66     SolarInputs solar_inputs;
67
68     Renewable* test_solar_ptr = new Solar(
69         8760,
70         1,
71         solar_inputs,
72         time_vec_hrs_ptr
73     );
74
75     testTruth(
76         not solar_inputs.renewable_inputs.production_inputs.print_flag,
77         __FILE__,
78         __LINE__
79     );
80
81     testFloatEquals(
82         test_solar_ptr->n_points,
83         8760,
84         __FILE__,
85         __LINE__
86     );
87
88     testFloatEquals(
89         test_solar_ptr->type,
90         RenewableType :: SOLAR,
91         __FILE__,
92         __LINE__
93     );
94
95     testTruth(
96         test_solar_ptr->type_str == "SOLAR",
97         __FILE__,
98         __LINE__
99     );
100
101     testFloatEquals(
102         test_solar_ptr->capital_cost,
103         350118.723363,
104         __FILE__,
105         __LINE__
106     );
```

```
107
108     testFloatEquals(
109         test_solar_ptr->operation_maintenance_cost_kWh,
110         0.01,
111         __FILE__,
112         __LINE__
113     );
114
115     return test_solar_ptr;
116 }   /* testConstruct_Solar() */
```

5.61.2.5 testDetailed_Solar()

```
void testDetailed_Solar (
             void  )
286 {
287     // init time and solar resource vectors
288     std::vector<double> time_vec_hrs = {
289         0,
290         1,
291         2,
292         3,
293         4,
294         5,
295         6,
296         7,
297         8,
298         9,
299         10,
300         11,
301         12,
302         13,
303         14,
304         15,
305         16,
306         17,
307         18,
308         19,
309         20,
310         21,
311         22,
312         23
313     };
314
315     std::vector<double> solar_resource_vec_kWm2 = {
316         0,
317         0,
318         0,
319         0,
320         0,
321         0,
322         8.51702662684015E-05,
323         0.000348341567045,
324         0.00213793728593,
325         0.004099863613322,
326         0.000997135230553,
327         0.009534527624657,
328         0.022927996790616,
329         0.0136071715294,
330         0.002535134127751,
331         0.005206897515821,
332         0.005627658648597,
333         0.000701186722215,
334         0.00017119827089,
335         0,
336         0,
337         0,
338         0,
339         0
340     };
341
342     // init expected results (simple and detailed)
343     std::vector<double> expected_simple_production_vec_kW = {
344         0,
345         0,
346         0,
347         0,
348         0,
349         0,
```

```
350         0.00681362130147212,
351         0.0278673253636,
352         0.1710349828744,
353         0.32798908906576,
354         0.07977081844424,
355         0.7627622099725601,
356         1.83423974324928,
357         1.088573722352,
358         0.20281073022008,
359         0.41655180126568,
360         0.45021269188776,
361         0.0560949377772,
362         0.0136958616712,
363         0,
364         0,
365         0,
366         0,
367         0
368     };
369
370     std::vector<double> expected_detailed_production_vec_kW = {
371         0,
372         0,
373         0,
374         0,
375         0,
376         0,
377         0.007338124437333107,
378         0.03001323298400045,
379         0.1842098680357352,
380         0.3532627387497894,
381         0.085919752082476,
382         0.8215778242841695,
383         1.975723895381408,
384         1.17256966118828,
385         0.2184652818009985,
386         0.4487156859620408,
387         0.4849877212456633,
388         0.06042929047364313,
389         0.01475448450756636,
390         0,
391         0,
392         0,
393         0,
394         0
395     };
396
397     // init Solar (simple)
398     SolarInputs solar_inputs;
399
400     Solar test_solar_simple(
401         time_vec_hrs.size(),
402         1,
403         solar_inputs,
404         &time_vec_hrs
405     );
406
407     // init Solar (detailed)
408     solar_inputs.power_model = SolarPowerProductionModel :: SOLAR_POWER_DETAILED;
409
410     solar_inputs.julian_day = 8766;
411     solar_inputs.latitude_deg = 50;
412     solar_inputs.longitude_deg = -125;
413     solar_inputs.panel_azimuth_deg = 180;
414     solar_inputs.panel_tilt_deg = 30;
415     solar_inputs.albedo_ground_reflectance = 0.5;
416
417     Solar test_solar_detailed(
418         time_vec_hrs.size(),
419         1,
420         solar_inputs,
421         &time_vec_hrs
422     );
423
424     // test simple production
425     double production_kW = 0;
426
427     for (size_t i = 0; i < time_vec_hrs.size(); i++) {
428         production_kW = test_solar_simple.computeProductionkW(
429             i, 1, solar_resource_vec_kWm2[i]
430         );
431
432         test_solar_simple.commit(
433             i, 1, production_kW, 100
434         );
435
436         testFloatEquals(
```

```
437             production_kW,
438             expected_simple_production_vec_kW[i],
439             __FILE__,
440             __LINE__
441         );
442     }
443
444     // test detailed production
445     for (size_t i = 0; i < time_vec_hrs.size(); i++) {
446         production_kW = test_solar_detailed.computeProductionkW(
447             i, 1, solar_resource_vec_kWm2[i]
448         );
449
450         test_solar_detailed.commit(
451             i, 1, production_kW, 100
452         );
453
454         testFloatEquals(
455             production_kW,
456             expected_detailed_production_vec_kW[i],
457             __FILE__,
458             __LINE__
459         );
460     }
461
462 }   /* testDetailed_Solar() */
```

5.61.2.6 testEconomics_Solar()

```
void testEconomics_Solar (
              Renewable * test_solar_ptr )
633 {
634     for (int i = 0; i < 48; i++) {
635         // resource, O&M > 0 whenever solar is running (i.e., producing)
636         if (test_solar_ptr->is_running_vec[i]) {
637             testGreaterThan(
638                 test_solar_ptr->operation_maintenance_cost_vec[i],
639                 0,
640                 __FILE__,
641                 __LINE__
642             );
643         }
644
645         // resource, O&M = 0 whenever solar is not running (i.e., not producing)
646         else {
647             testFloatEquals(
648                 test_solar_ptr->operation_maintenance_cost_vec[i],
649                 0,
650                 __FILE__,
651                 __LINE__
652             );
653         }
654     }
655
656     return;
657 }   /* testEconomics_Solar() */
```

5.61.2.7 testProductionConstraint_Solar()

```
void testProductionConstraint_Solar (
              Renewable * test_solar_ptr )
```

Function to test that the production constraint is active and behaving as expected.

Parameters

test_solar_ptr	A Renewable pointer to the test Solar object.

```
480 {
481     testFloatEquals(
482         test_solar_ptr->computeProductionkW(0, 1, 2),
483         100,
484         __FILE__,
485         __LINE__
486     );
487
488     testFloatEquals(
489         test_solar_ptr->computeProductionkW(0, 1, -1),
490         0,
491         __FILE__,
492         __LINE__
493     );
494
495     return;
496 }   /* testProductionConstraint_Solar() */
```

5.61.2.8 testProductionOverride_Solar()

```
void testProductionOverride_Solar (
            std::string path_2_normalized_production_time_series,
            std::vector< double > * time_vec_hrs_ptr )
```

Function to test that normalized production data is being read in correctly, and that the associated production override feature is behaving as expected.

Parameters

path_2_normalized_production_time_series	A path (either relative or absolute) to the given normalized production time series data.
time_vec_hrs_ptr	A pointer to the vector containing the modelling time series.

```
179 {
180     SolarInputs solar_inputs;
181
182     solar_inputs.renewable_inputs.production_inputs.path_2_normalized_production_time_series =
183         path_2_normalized_production_time_series;
184
185     Solar test_solar_override(
186         time_vec_hrs_ptr->size(),
187         1,
188         solar_inputs,
189         time_vec_hrs_ptr
190     );
191
192
193     std::vector<double> expected_normalized_production_vec = {
194         0.916955708517556,
195         0.90947506148393,
196         0.38425267564517,
197         0.191510884037643,
198         0.803361391862077,
199         0.261511294927198,
200         0.221944653883198,
201         0.858495335855501,
202         0.0162863861443092,
203         0.774345409915512,
204         0.354898664149867,
205         0.11158009453439,
206         0.191670176408956,
207         0.0149072402795702,
208         0.30174228469322,
209         0.0815062957850151,
210         0.776404660266821,
211         0.207069187162109,
212         0.518926216750454,
213         0.148538109788597,
214         0.443035200791027,
215         0.62119079547209,
216         0.270792717524391,
217         0.761074879460849,
```

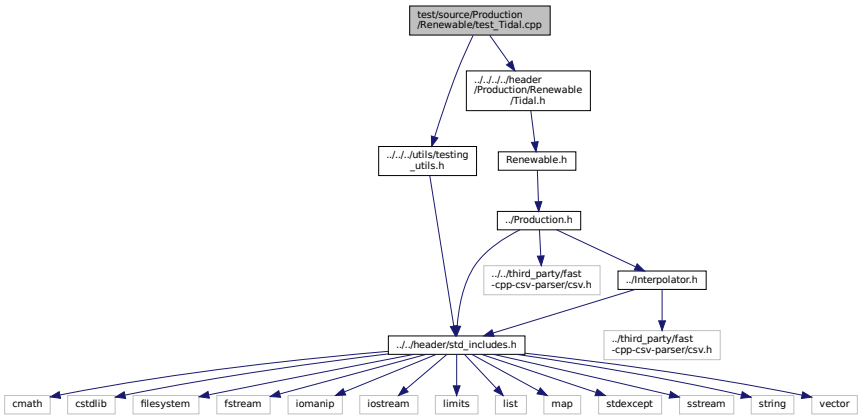
```
218         0.0545251308358993,
219         0.0895417089500092,
220         0.21787190761933,
221         0.834403724509682,
222         0.908807953036246,
223         0.815888965292123,
224         0.416663215314571,
225         0.523649705576525,
226         0.490890480401437,
227         0.28317138282312,
228         0.877382682055847,
229         0.14972090597986,
230         0.480161632646382,
231         0.0655830129932816,
232         0.41802666403448,
233         0.48692477737368,
234         0.275957323208066,
235         0.228651250718341,
236         0.574371311550247,
237         0.251872481275769,
238         0.802697508767121,
239         0.00130607304363551,
240         0.481240172488057,
241         0.702527508293784
242     };
243
244     for (size_t i = 0; i < expected_normalized_production_vec.size(); i++) {
245         testFloatEquals(
246             test_solar_override.normalized_production_vec[i],
247             expected_normalized_production_vec[i],
248             __FILE__,
249             __LINE__
250         );
251
252         testFloatEquals(
253             test_solar_override.computeProductionkW(i, rand(), rand()),
254             test_solar_override.capacity_kW * expected_normalized_production_vec[i],
255             __FILE__,
256             __LINE__
257         );
258     }
259
260     return;
261 }   /* testProductionOverride_Solar() */
```

5.62 test/source/Production/Renewable/test_Tidal.cpp File Reference

Testing suite for Tidal class.

```
#include "../../../utils/testing_utils.h"
#include "../../../../header/Production/Renewable/Tidal.h"
```

Include dependency graph for test_Tidal.cpp:



Functions

- Renewable * testConstruct_Tidal (std::vector< double > *time_vec_hrs_ptr)

  A function to construct a Tidal object and spot check some post-construction attributes.
- void testBadConstruct_Tidal (std::vector< double > *time_vec_hrs_ptr)

  Function to test the trying to construct a Tidal object given bad inputs is being handled as expected.
- void testProductionConstraint_Tidal (Renewable *test_tidal_ptr)

  Function to test that the production constraint is active and behaving as expected.
- void testCommit_Tidal (Renewable *test_tidal_ptr)

  Function to test if the commit method is working as expected, by checking some post-call attributes of the test Tidal object. Uses a randomized resource input.
- void testEconomics_Tidal (Renewable *test_tidal_ptr)
- int main (int argc, char **argv)

5.62.1 Detailed Description

Testing suite for Tidal class.

A suite of tests for the Tidal class.

5.62.2 Function Documentation

5.62.2.1 main()

```
int main (
              int argc,
              char ** argv )
352 {
353     #ifdef _WIN32
354         activateVirtualTerminal();
355     #endif  /* _WIN32 */
356
357     printGold("\tTesting Production <-- Renewable <-- Tidal");
358
359     srand(time(NULL));
360
361
362     std::vector<double> time_vec_hrs (8760, 0);
363     for (size_t i = 0; i < time_vec_hrs.size(); i++) {
364         time_vec_hrs[i] = i;
365     }
366
367     Renewable* test_tidal_ptr = testConstruct_Tidal(&time_vec_hrs);
368
369
370     try {
371         testBadConstruct_Tidal(&time_vec_hrs);
372
373         testProductionConstraint_Tidal(test_tidal_ptr);
374
375         testCommit_Tidal(test_tidal_ptr);
376         testEconomics_Tidal(test_tidal_ptr);
377     }
378
379
380     catch (...) {
381         delete test_tidal_ptr;
382
383         printGold(" ....... ");
384         printRed("FAIL");
385         std::cout << std::endl;
```

```
386         throw;
387     }
388
389
390     delete test_tidal_ptr;
391
392     printGold(" ....... ");
393     printGreen("PASS");
394     std::cout << std::endl;
395     return 0;
396
397 }   /* main() */
```

5.62.2.2 testBadConstruct_Tidal()

```
void testBadConstruct_Tidal (
            std::vector< double > * time_vec_hrs_ptr )
```

Function to test the trying to construct a Tidal object given bad inputs is being handled as expected.

Parameters

time_vec_hrs_ptr	A pointer to the vector containing the modelling time series.

```
129 {
130     bool error_flag = true;
131
132     try {
133         TidalInputs bad_tidal_inputs;
134         bad_tidal_inputs.design_speed_ms = -1;
135
136         Tidal bad_tidal(8760, 1, bad_tidal_inputs, time_vec_hrs_ptr);
137
138         error_flag = false;
139     } catch (...) {
140         // Task failed successfully! =P
141     }
142     if (not error_flag) {
143         expectedErrorNotDetected(__FILE__, __LINE__);
144     }
145
146     return;
147 }   /* testBadConstruct_Tidal() */
```

5.62.2.3 testCommit_Tidal()

```
void testCommit_Tidal (
            Renewable * test_tidal_ptr )
```

Function to test if the commit method is working as expected, by checking some post-call attributes of the test Tidal object. Uses a randomized resource input.

Parameters

test_tidal_ptr	A Renewable pointer to the test Tidal object.

```
211 {
212     std::vector<double> dt_vec_hrs (48, 1);
213
214     std::vector<double> load_vec_kW = {
215         1, 1, 0, 1, 0, 0, 1, 1, 1, 0, 1, 1,
216         1, 1, 1, 0, 0, 0, 0, 0, 0, 1, 1, 0,
```

```
217         1, 1, 1, 1, 1, 0, 1, 1, 1, 1, 0, 1,
218         1, 0, 0, 0, 1, 1, 1, 0, 1, 1, 0, 0
219     };
220
221     double load_kW = 0;
222     double production_kW = 0;
223     double roll = 0;
224     double tidal_resource_ms = 0;
225
226     for (int i = 0; i < 48; i++) {
227         roll = (double)rand() / RAND_MAX;
228
229         tidal_resource_ms = roll * ((Tidal*)test_tidal_ptr)->design_speed_ms;
230
231         roll = (double)rand() / RAND_MAX;
232
233         if (roll <= 0.1) {
234             tidal_resource_ms = 0;
235         }
236
237         else if (roll >= 0.95) {
238             tidal_resource_ms = 3 * ((Tidal*)test_tidal_ptr)->design_speed_ms;
239         }
240
241         roll = (double)rand() / RAND_MAX;
242
243         if (roll >= 0.95) {
244             roll = 1.25;
245         }
246
247         load_vec_kW[i] *= roll * test_tidal_ptr->capacity_kW;
248         load_kW = load_vec_kW[i];
249
250         production_kW = test_tidal_ptr->computeProductionkW(
251             i,
252             dt_vec_hrs[i],
253             tidal_resource_ms
254         );
255
256         load_kW = test_tidal_ptr->commit(
257             i,
258             dt_vec_hrs[i],
259             production_kW,
260             load_kW
261         );
262
263         // is running (or not) as expected
264         if (production_kW > 0) {
265             testTruth(
266                 test_tidal_ptr->is_running,
267                 __FILE__,
268                 __LINE__
269             );
270         }
271
272         else {
273             testTruth(
274                 not test_tidal_ptr->is_running,
275                 __FILE__,
276                 __LINE__
277             );
278         }
279
280         // load_kW <= load_vec_kW (i.e., after vs before)
281         testLessThanOrEqualTo(
282             load_kW,
283             load_vec_kW[i],
284             __FILE__,
285             __LINE__
286         );
287
288         // production = dispatch + storage + curtailment
289         testFloatEquals(
290             test_tidal_ptr->production_vec_kW[i] -
291             test_tidal_ptr->dispatch_vec_kW[i] -
292             test_tidal_ptr->storage_vec_kW[i] -
293             test_tidal_ptr->curtailment_vec_kW[i],
294             0,
295             __FILE__,
296             __LINE__
297         );
298     }
299
300     return;
301 }   /* testCommit_Tidal() */
```

5.62.2.4 testConstruct_Tidal()

```
Renewable * testConstruct_Tidal (
            std::vector< double > * time_vec_hrs_ptr )
```

A function to construct a Tidal object and spot check some post-construction attributes.

Parameters

time_vec_hrs_ptr	A pointer to the vector containing the modelling time series.

Returns

A Renewable pointer to a test Tidal object.

```
65 {
66     TidalInputs tidal_inputs;
67
68     Renewable* test_tidal_ptr = new Tidal(8760, 1, tidal_inputs, time_vec_hrs_ptr);
69
70     testTruth(
71         not tidal_inputs.renewable_inputs.production_inputs.print_flag,
72         __FILE__,
73         __LINE__
74     );
75
76     testFloatEquals(
77         test_tidal_ptr->n_points,
78         8760,
79         __FILE__,
80         __LINE__
81     );
82
83     testFloatEquals(
84         test_tidal_ptr->type,
85         RenewableType :: TIDAL,
86         __FILE__,
87         __LINE__
88     );
89
90     testTruth(
91         test_tidal_ptr->type_str == "TIDAL",
92         __FILE__,
93         __LINE__
94     );
95
96     testFloatEquals(
97         test_tidal_ptr->capital_cost,
98         500237.446725,
99         __FILE__,
100         __LINE__
101     );
102
103     testFloatEquals(
104         test_tidal_ptr->operation_maintenance_cost_kWh,
105         0.069905,
106         __FILE__,
107         __LINE__
108     );
109
110     return test_tidal_ptr;
111 }   /* testConstruct_Tidal() */
```

5.62.2.5 testEconomics_Tidal()

```
void testEconomics_Tidal (
            Renewable * test_tidal_ptr )
319 {
320     for (int i = 0; i < 48; i++) {
321         // resource, O&M > 0 whenever tidal is running (i.e., producing)
```

```
322         if (test_tidal_ptr->is_running_vec[i]) {
323             testGreaterThan(
324                 test_tidal_ptr->operation_maintenance_cost_vec[i],
325                 0,
326                 __FILE__,
327                 __LINE__
328             );
329         }
330 
331         // resource, O&M = 0 whenever tidal is not running (i.e., not producing)
332         else {
333             testFloatEquals(
334                 test_tidal_ptr->operation_maintenance_cost_vec[i],
335                 0,
336                 __FILE__,
337                 __LINE__
338             );
339         }
340     }
341 
342     return;
343 }   /* testEconomics_Tidal() */
```

5.62.2.6 testProductionConstraint_Tidal()

```
void testProductionConstraint_Tidal (
            Renewable * test_tidal_ptr )
```

Function to test that the production constraint is active and behaving as expected.

Parameters

test_tidal_ptr	A Renewable pointer to the test Tidal object.

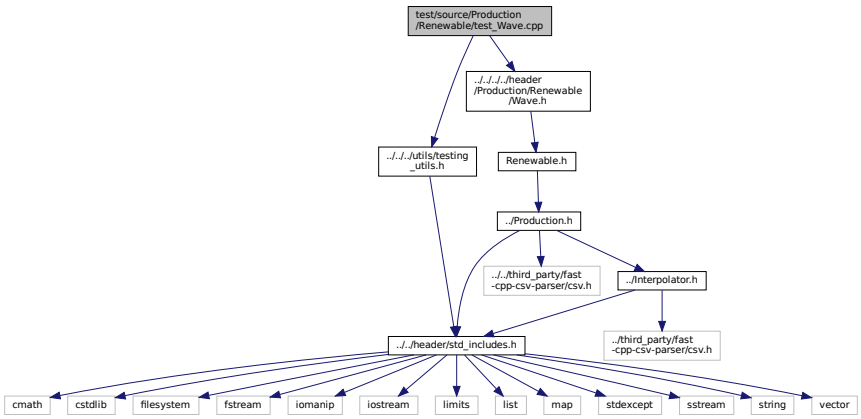
```
165 {
166     testFloatEquals(
167         test_tidal_ptr->computeProductionkW(0, 1, 1e6),
168         0,
169         __FILE__,
170         __LINE__
171     );
172 
173     testFloatEquals(
174         test_tidal_ptr->computeProductionkW(
175             0,
176             1,
177             ((Tidal*)test_tidal_ptr)->design_speed_ms
178         ),
179         test_tidal_ptr->capacity_kW,
180         __FILE__,
181         __LINE__
182     );
183 
184     testFloatEquals(
185         test_tidal_ptr->computeProductionkW(0, 1, -1),
186         0,
187         __FILE__,
188         __LINE__
189     );
190 
191     return;
192 }   /* testProductionConstraint_Tidal() */
```

5.63 test/source/Production/Renewable/test_Wave.cpp File Reference

Testing suite for Wave class.

```
#include "../../../utils/testing_utils.h"
#include "../../../../header/Production/Renewable/Wave.h"
```

Include dependency graph for test_Wave.cpp:



Functions

- Renewable ∗ testConstruct_Wave (std::vector< double > ∗time_vec_hrs_ptr)

  A function to construct a Wave object and spot check some post-construction attributes.
- Renewable ∗ testConstructLookup_Wave (std::vector< double > ∗time_vec_hrs_ptr)

  A function to construct a Wave object using production lookup.
- void testBadConstruct_Wave (std::vector< double > ∗time_vec_hrs_ptr)

  Function to test the trying to construct a Wave object given bad inputs is being handled as expected.
- void testProductionConstraint_Wave (Renewable ∗test_wave_ptr)

  Function to test that the production constraint is active and behaving as expected.
- void testCommit_Wave (Renewable ∗test_wave_ptr)

  Function to test if the commit method is working as expected, by checking some post-call attributes of the test Wave object. Uses a randomized resource input.
- void testEconomics_Wave (Renewable ∗test_wave_ptr)
- void testProductionLookup_Wave (Renewable ∗test_wave_lookup_ptr)

  Function to test that production lookup (i.e., interpolation) is returning the expected values.
- int main (int argc, char ∗∗argv)

5.63.1 Detailed Description

Testing suite for Wave class.

A suite of tests for the Wave class.

5.63.2 Function Documentation

5.63.2.1 main()

```
int main (
              int argc,
              char ** argv )
467 {
468     #ifdef _WIN32
469         activateVirtualTerminal();
470     #endif  /* _WIN32 */
471
472     printGold("\tTesting Production <-- Renewable <-- Wave");
473
474     srand(time(NULL));
475
476
477     std::vector<double> time_vec_hrs (8760, 0);
478     for (size_t i = 0; i < time_vec_hrs.size(); i++) {
479         time_vec_hrs[i] = i;
480     }
481
482     Renewable* test_wave_ptr = testConstruct_Wave(&time_vec_hrs);
483     Renewable* test_wave_lookup_ptr = testConstructLookup_Wave(&time_vec_hrs);
484
485
486     try {
487         testBadConstruct_Wave(&time_vec_hrs);
488
489         testProductionConstraint_Wave(test_wave_ptr);
490
491         testCommit_Wave(test_wave_ptr);
492         testEconomics_Wave(test_wave_ptr);
493
494         testProductionLookup_Wave(test_wave_lookup_ptr);
495     }
496
497
498     catch (...) {
499         delete test_wave_ptr;
500         delete test_wave_lookup_ptr;
501
502         printGold(" ........ ");
503         printRed("FAIL");
504         std::cout « std::endl;
505         throw;
506     }
507
508
509     delete test_wave_ptr;
510     delete test_wave_lookup_ptr;
511
512     printGold(" ........ ");
513     printGreen("PASS");
514     std::cout « std::endl;
515     return 0;
516
517 }   /* main() */
```

5.63.2.2 testBadConstruct_Wave()

```
void testBadConstruct_Wave (
              std::vector< double > * time_vec_hrs_ptr )
```

Function to test the trying to construct a Wave object given bad inputs is being handled as expected.

Parameters

time_vec_hrs_ptr	A pointer to the vector containing the modelling time series.

```
158 {
159     bool error_flag = true;
160
161     try {
```

```
162         WaveInputs bad_wave_inputs;
163         bad_wave_inputs.design_significant_wave_height_m = -1;
164
165         Wave bad_wave(8760, 1, bad_wave_inputs, time_vec_hrs_ptr);
166
167         error_flag = false;
168     } catch (...) {
169         // Task failed successfully! =P
170     }
171     if (not error_flag) {
172         expectedErrorNotDetected(__FILE__, __LINE__);
173     }
174
175     return;
176 }   /* testBadConstruct_Wave() */
```

5.63.2.3 testCommit_Wave()

```
void testCommit_Wave (
            Renewable * test_wave_ptr )
```

Function to test if the commit method is working as expected, by checking some post-call attributes of the test Wave object. Uses a randomized resource input.

Parameters

test_wave_ptr	A Renewable pointer to the test Wave object.

```
229 {
230     std::vector<double> dt_vec_hrs (48, 1);
231
232     std::vector<double> load_vec_kW = {
233         1, 1, 0, 1, 0, 0, 1, 1, 1, 0, 1, 1,
234         1, 1, 1, 0, 0, 0, 0, 0, 0, 1, 1, 0,
235         1, 1, 1, 1, 1, 0, 1, 1, 1, 1, 0, 1,
236         1, 0, 0, 0, 1, 1, 1, 0, 1, 1, 0, 0
237     };
238
239     double load_kW = 0;
240     double production_kW = 0;
241     double roll = 0;
242     double significant_wave_height_m = 0;
243     double energy_period_s = 0;
244
245     for (int i = 0; i < 48; i++) {
246         roll = (double)rand() / RAND_MAX;
247
248         if (roll <= 0.05) {
249             roll = 0;
250         }
251
252         significant_wave_height_m = roll *
253             ((Wave*)test_wave_ptr)->design_significant_wave_height_m;
254
255         roll = (double)rand() / RAND_MAX;
256
257         if (roll <= 0.05) {
258             roll = 0;
259         }
260
261         energy_period_s = roll * ((Wave*)test_wave_ptr)->design_energy_period_s;
262
263         roll = (double)rand() / RAND_MAX;
264
265         if (roll >= 0.95) {
266             roll = 1.25;
267         }
268
269         load_vec_kW[i] *= roll * test_wave_ptr->capacity_kW;
270         load_kW = load_vec_kW[i];
271
272         production_kW = test_wave_ptr->computeProductionkW(
273             i,
274             dt_vec_hrs[i],
```

```
275             significant_wave_height_m,
276             energy_period_s
277         );
278 
279         load_kW = test_wave_ptr->commit(
280             i,
281             dt_vec_hrs[i],
282             production_kW,
283             load_kW
284         );
285 
286         // is running (or not) as expected
287         if (production_kW > 0) {
288             testTruth(
289                 test_wave_ptr->is_running,
290                 __FILE__,
291                 __LINE__
292             );
293         }
294 
295         else {
296             testTruth(
297                 not test_wave_ptr->is_running,
298                 __FILE__,
299                 __LINE__
300             );
301         }
302 
303         // load_kW <= load_vec_kW (i.e., after vs before)
304         testLessThanOrEqualTo(
305             load_kW,
306             load_vec_kW[i],
307             __FILE__,
308             __LINE__
309         );
310 
311         // production = dispatch + storage + curtailment
312         testFloatEquals(
313             test_wave_ptr->production_vec_kW[i] -
314             test_wave_ptr->dispatch_vec_kW[i] -
315             test_wave_ptr->storage_vec_kW[i] -
316             test_wave_ptr->curtailment_vec_kW[i],
317             0,
318             __FILE__,
319             __LINE__
320         );
321     }
322 
323     return;
324 }   /* testCommit_Wave() */
```

5.63.2.4 testConstruct_Wave()

```
Renewable * testConstruct_Wave (
              std::vector< double > * time_vec_hrs_ptr )
```

A function to construct a Wave object and spot check some post-construction attributes.

Parameters

time_vec_hrs_ptr	A pointer to the vector containing the modelling time series.

Returns

A Renewable pointer to a test Wave object.

```
65 {
66     WaveInputs wave_inputs;
67 
68     Renewable* test_wave_ptr = new Wave(8760, 1, wave_inputs, time_vec_hrs_ptr);
69 
70     testTruth(
```

```
71          not wave_inputs.renewable_inputs.production_inputs.print_flag,
72          __FILE__,
73          __LINE__
74      );
75
76      testFloatEquals(
77          test_wave_ptr->n_points,
78          8760,
79          __FILE__,
80          __LINE__
81      );
82
83      testFloatEquals(
84          test_wave_ptr->type,
85          RenewableType :: WAVE,
86          __FILE__,
87          __LINE__
88      );
89
90      testTruth(
91          test_wave_ptr->type_str == "WAVE",
92          __FILE__,
93          __LINE__
94      );
95
96      testFloatEquals(
97          test_wave_ptr->capital_cost,
98          850831.063539,
99          __FILE__,
100          __LINE__
101      );
102
103      testFloatEquals(
104          test_wave_ptr->operation_maintenance_cost_kWh,
105          0.069905,
106          __FILE__,
107          __LINE__
108      );
109
110      return test_wave_ptr;
111  }   /* testConstruct_Wave() */
```

5.63.2.5 testConstructLookup_Wave()

```
Renewable * testConstructLookup_Wave (
            std::vector< double > * time_vec_hrs_ptr )
```

A function to construct a Wave object using production lookup.

Parameters

time_vec_hrs_ptr	A pointer to the vector containing the modelling time series.

Returns

A Renewable pointer to a test Wave object.

```
130 {
131     WaveInputs wave_inputs;
132
133     wave_inputs.power_model = WavePowerProductionModel :: WAVE_POWER_LOOKUP;
134     wave_inputs.path_2_normalized_performance_matrix =
135         "data/test/interpolation/wave_energy_converter_normalized_performance_matrix.csv";
136
137     Renewable* test_wave_lookup_ptr = new Wave(8760, 1, wave_inputs, time_vec_hrs_ptr);
138
139     return test_wave_lookup_ptr;
140 }   /* testConstructLookup_Wave() */
```

5.63.2.6 testEconomics_Wave()

```
void testEconomics_Wave (
              Renewable * test_wave_ptr )
342 {
343     for (int i = 0; i < 48; i++) {
344         // resource, O&M > 0 whenever wave is running (i.e., producing)
345         if (test_wave_ptr->is_running_vec[i]) {
346             testGreaterThan(
347                 test_wave_ptr->operation_maintenance_cost_vec[i],
348                 0,
349                 __FILE__,
350                 __LINE__
351             );
352         }
353 
354         // resource, O&M = 0 whenever wave is not running (i.e., not producing)
355         else {
356             testFloatEquals(
357                 test_wave_ptr->operation_maintenance_cost_vec[i],
358                 0,
359                 __FILE__,
360                 __LINE__
361             );
362         }
363     }
364 
365     return;
366 }   /* testEconomics_Wave() */
```

5.63.2.7 testProductionConstraint_Wave()

```
void testProductionConstraint_Wave (
              Renewable * test_wave_ptr )
```

Function to test that the production constraint is active and behaving as expected.

Parameters

test_wave_ptr	A Renewable pointer to the test Wave object.

```
194 {
195     testFloatEquals(
196         test_wave_ptr->computeProductionkW(0, 1, 0, rand()),
197         0,
198         __FILE__,
199         __LINE__
200     );
201 
202     testFloatEquals(
203         test_wave_ptr->computeProductionkW(0, 1, rand(), 0),
204         0,
205         __FILE__,
206         __LINE__
207     );
208 
209     return;
210 }   /* testProductionConstraint_Wave() */
```

5.63.2.8 testProductionLookup_Wave()

```
void testProductionLookup_Wave (
              Renewable * test_wave_lookup_ptr )
```

Function to test that production lookup (i.e., interpolation) is returning the expected values.

Parameters

test_wave_lookup_ptr	A Renewable pointer to the test Wave object using production lookup.

```
385 {
386     std::vector<double> significant_wave_height_vec_m = {
387         0.389211848822208,
388         0.836477431896843,
389         1.52738334015579,
390         1.92640601114508,
391         2.27297317532019,
392         2.87416589636605,
393         3.72275770908175,
394         3.95063175885536,
395         4.68097139867404,
396         4.97775020449812,
397         5.55184219980547,
398         6.06566629451658,
399         6.27927876785062,
400         6.96218133671013,
401         7.51754442460228
402     };
403
404     std::vector<double> energy_period_vec_s = {
405         5.45741899698926,
406         6.00101329139007,
407         7.50567689404182,
408         8.77681262912881,
409         9.45143678206774,
410         10.7767876462885,
411         11.4795760857165,
412         12.9430684577599,
413         13.303544885703,
414         14.5069863517863,
415         15.1487890438045,
416         16.086524049077,
417         17.176609978648,
418         18.4155153740256,
419         19.1704554940162
420     };
421
422     std::vector<std::vector<double>> expected_normalized_performance_matrix = {
423
      {0.0337204906738533,0.145056406036013,0.334677248806653,0.441674658936075,0.533295755691263,0.68807895676592,0.8996148
424
      {0.0310681846933292,0.135425896595439,0.324045598153363,0.430214268249038,0.520985043044784,0.673879556322479,0.882058
425
      {0.0237266281076604,0.108768742207538,0.294617294841705,0.398492020763049,0.486909112828702,0.63457575706117,0.8334608
426
      {0.0175245009938255,0.0862488504001753,0.269756343931147,0.371693152028768,0.458121859300634,0.601372013927032,0.79240
427
      {0.0142328739589644,0.0742969694833995,0.256562003243255,0.357470308928265,0.442843729679424,0.583749940636223,0.77061
428
      {0.0077662203173173,0.0508165832074184,0.230640709501637,0.329528443353471,0.41282867283787,0.549130026772199,0.727811
429
      {0.00433717405958826,0.0383657337957315,0.21689552996585,0.314711823368423,0.396912710109449,0.530772265145106,0.70511
430
      {0.000102358416923608,0.0210697053701168,0.188272456115393,0.283857573197153,0.363769179652786,0.492543912767949,0.657
431
      {0,0.0196038727057393,0.181222235960193,0.276257786480759,0.355605514643888,0.483127792688125,0.646203044346932,0.6855
432
      {0,0.0157252942367668,0.157685253727545,0.250886090139653,0.328351324840186,0.451692313207986,0.607334650020078,0.6442
433
      {0,0.0136568246246201,0.145132837191606,0.23735520935175,0.313816498778623,0.43492757979648,0.586605897674033,0.622265
434
      {0,0.0106345930466366,0.12679255826648,0.217585300741544,0.292579730277991,0.410432703770651,0.556319211544087,0.59010
435
      {0,0.00712134879261874,0.10547259059088,0.194603435839713,0.267892689267542,0.381958220518761,0.52111194060085,0.55272
436
      {0,0.00312847342058727,0.0812420026472571,0.168484067035528,0.239835352250276,0.349596376397684,0.481098142839729,0.510
437
      {0,0.00103256269522045,0.0673448574082101,0.152567953107312,0.222738316872545,0.329876344040866,0.456715311514779,0.484
438     };
439
440     for (size_t i = 0; i < energy_period_vec_s.size(); i++) {
441         for (size_t j = 0; j < significant_wave_height_vec_m.size(); j++) {
442             testFloatEquals(
443                 test_wave_lookup_ptr->computeProductionkW(
444                     0,
445                     1,
446                     significant_wave_height_vec_m[j],
447                     energy_period_vec_s[i]
448                 ),
449                 expected_normalized_performance_matrix[i][j] *
450                 test_wave_lookup_ptr->capacity_kW,
451                 __FILE__,
```

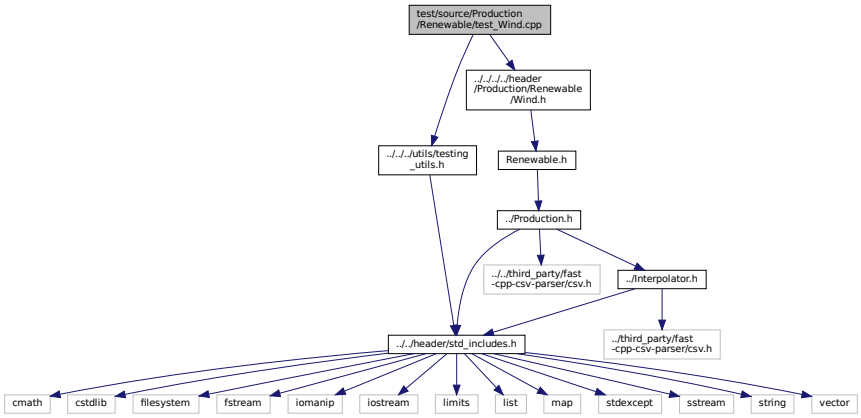
```
452                 __LINE__
453             );
454         }
455     }
456
457     return;
458 }   /* testProductionLookup_Wave() */
```

5.64 test/source/Production/Renewable/test_Wind.cpp File Reference

Testing suite for Wind class.

```
#include "../../../utils/testing_utils.h"
#include "../../../../header/Production/Renewable/Wind.h"
```

Include dependency graph for test_Wind.cpp:



Functions

- Renewable * testConstruct_Wind (std::vector< double > *time_vec_hrs_ptr)

  A function to construct a Wind object and spot check some post-construction attributes.
- void testBadConstruct_Wind (std::vector< double > *time_vec_hrs_ptr)

  Function to test the trying to construct a Wind object given bad inputs is being handled as expected.
- void testProductionConstraint_Wind (Renewable *test_wind_ptr)

  Function to test that the production constraint is active and behaving as expected.
- void testCommit_Wind (Renewable *test_wind_ptr)

  Function to test if the commit method is working as expected, by checking some post-call attributes of the test Wind object. Uses a randomized resource input.
- void testEconomics_Wind (Renewable *test_wind_ptr)
- int main (int argc, char **argv)

5.64.1 Detailed Description

Testing suite for Wind class.

A suite of tests for the Wind class.

5.64.2 Function Documentation

5.64.2.1 main()

```
int main (
              int argc,
              char ** argv )
```

```
352 {
353     #ifdef _WIN32
354         activateVirtualTerminal();
355     #endif  /* _WIN32 */
356
357     printGold("\tTesting Production <-- Renewable <-- Wind");
358
359     srand(time(NULL));
360
361
362     std::vector<double> time_vec_hrs (8760, 0);
363     for (size_t i = 0; i < time_vec_hrs.size(); i++) {
364         time_vec_hrs[i] = i;
365     }
366
367     Renewable* test_wind_ptr = testConstruct_Wind(&time_vec_hrs);
368
369
370     try {
371         testBadConstruct_Wind(&time_vec_hrs);
372
373         testProductionConstraint_Wind(test_wind_ptr);
374
375         testCommit_Wind(test_wind_ptr);
376         testEconomics_Wind(test_wind_ptr);
377     }
378
379
380     catch (...) {
381         delete test_wind_ptr;
382
383         printGold(" ........ ");
384         printRed("FAIL");
385         std::cout « std::endl;
386         throw;
387     }
388
389
390     delete test_wind_ptr;
391
392     printGold(" ........ ");
393     printGreen("PASS");
394     std::cout « std::endl;
395     return 0;
396
397 }   /* main() */
```

5.64.2.2 testBadConstruct_Wind()

```
void testBadConstruct_Wind (
              std::vector< double > * time_vec_hrs_ptr )
```

Function to test the trying to construct a Wind object given bad inputs is being handled as expected.

Parameters

time_vec_hrs_ptr	A pointer to the vector containing the modelling time series.

```
129 {
130     bool error_flag = true;
131 
132     try {
133         WindInputs bad_wind_inputs;
134         bad_wind_inputs.design_speed_ms = -1;
135 
136         Wind bad_wind(8760, 1, bad_wind_inputs, time_vec_hrs_ptr);
137 
138         error_flag = false;
139     } catch (...) {
140         // Task failed successfully! =P
141     }
142     if (not error_flag) {
143         expectedErrorNotDetected(__FILE__, __LINE__);
144     }
145 
146     return;
147 }   /* testBadConstruct_Wind() */
```

5.64.2.3 testCommit_Wind()

```
void testCommit_Wind (
            Renewable * test_wind_ptr )
```

Function to test if the commit method is working as expected, by checking some post-call attributes of the test Wind object. Uses a randomized resource input.

Parameters

test_wind_ptr	A Renewable pointer to the test Wind object.

```
211 {
212     std::vector<double> dt_vec_hrs (48, 1);
213 
214     std::vector<double> load_vec_kW = {
215         1, 1, 0, 1, 0, 0, 1, 1, 1, 0, 1, 1,
216         1, 1, 1, 0, 0, 0, 0, 0, 0, 1, 1, 0,
217         1, 1, 1, 1, 1, 0, 1, 1, 1, 1, 0, 1,
218         1, 0, 0, 0, 1, 1, 1, 0, 1, 1, 0, 0
219     };
220 
221     double load_kW = 0;
222     double production_kW = 0;
223     double roll = 0;
224     double wind_resource_ms = 0;
225 
226     for (int i = 0; i < 48; i++) {
227         roll = (double)rand() / RAND_MAX;
228 
229         wind_resource_ms = roll * ((Wind*)test_wind_ptr)->design_speed_ms;
230 
231         roll = (double)rand() / RAND_MAX;
232 
233         if (roll <= 0.1) {
234             wind_resource_ms = 0;
235         }
236 
237         else if (roll >= 0.95) {
238             wind_resource_ms = 3 * ((Wind*)test_wind_ptr)->design_speed_ms;
239         }
240 
241         roll = (double)rand() / RAND_MAX;
242 
243         if (roll >= 0.95) {
244             roll = 1.25;
245         }
246 
247         load_vec_kW[i] *= roll * test_wind_ptr->capacity_kW;
248         load_kW = load_vec_kW[i];
249 
250         production_kW = test_wind_ptr->computeProductionkW(
251             i,
252             dt_vec_hrs[i],
```

```
253             wind_resource_ms
254         );
255 
256         load_kW = test_wind_ptr->commit(
257             i,
258             dt_vec_hrs[i],
259             production_kW,
260             load_kW
261         );
262 
263         // is running (or not) as expected
264         if (production_kW > 0) {
265             testTruth(
266                 test_wind_ptr->is_running,
267                 __FILE__,
268                 __LINE__
269             );
270         }
271 
272         else {
273             testTruth(
274                 not test_wind_ptr->is_running,
275                 __FILE__,
276                 __LINE__
277             );
278         }
279 
280         // load_kW <= load_vec_kW (i.e., after vs before)
281         testLessThanOrEqualTo(
282             load_kW,
283             load_vec_kW[i],
284             __FILE__,
285             __LINE__
286         );
287 
288         // production = dispatch + storage + curtailment
289         testFloatEquals(
290             test_wind_ptr->production_vec_kW[i] -
291             test_wind_ptr->dispatch_vec_kW[i] -
292             test_wind_ptr->storage_vec_kW[i] -
293             test_wind_ptr->curtailment_vec_kW[i],
294             0,
295             __FILE__,
296             __LINE__
297         );
298     }
299 
300     return;
301 }   /* testCommit_Wind() */
```

5.64.2.4 testConstruct_Wind()

```
Renewable * testConstruct_Wind (
              std::vector< double > * time_vec_hrs_ptr )
```

A function to construct a Wind object and spot check some post-construction attributes.

Parameters

time_vec_hrs_ptr	A pointer to the vector containing the modelling time series.

Returns

A Renewable pointer to a test Wind object.

```
65 {
66     WindInputs wind_inputs;
67 
68     Renewable* test_wind_ptr = new Wind(8760, 1, wind_inputs, time_vec_hrs_ptr);
69 
70     testTruth(
71         not wind_inputs.renewable_inputs.production_inputs.print_flag,
```

```
72          __FILE__,
73          __LINE__
74      );
75
76      testFloatEquals(
77          test_wind_ptr->n_points,
78          8760,
79          __FILE__,
80          __LINE__
81      );
82
83      testFloatEquals(
84          test_wind_ptr->type,
85          RenewableType :: WIND,
86          __FILE__,
87          __LINE__
88      );
89
90      testTruth(
91          test_wind_ptr->type_str == "WIND",
92          __FILE__,
93          __LINE__
94      );
95
96      testFloatEquals(
97          test_wind_ptr->capital_cost,
98          450356.170088,
99          __FILE__,
100          __LINE__
101     );
102
103     testFloatEquals(
104         test_wind_ptr->operation_maintenance_cost_kWh,
105         0.034953,
106         __FILE__,
107         __LINE__
108     );
109
110     return test_wind_ptr;
111 }   /* testConstruct_Wind() */
```

5.64.2.5 testEconomics_Wind()

```
void testEconomics_Wind (
              Renewable * test_wind_ptr )
319 {
320     for (int i = 0; i < 48; i++) {
321         // resource, O&M > 0 whenever wind is running (i.e., producing)
322         if (test_wind_ptr->is_running_vec[i]) {
323             testGreaterThan(
324                 test_wind_ptr->operation_maintenance_cost_vec[i],
325                 0,
326                 __FILE__,
327                 __LINE__
328             );
329         }
330
331         // resource, O&M = 0 whenever wind is not running (i.e., not producing)
332         else {
333             testFloatEquals(
334                 test_wind_ptr->operation_maintenance_cost_vec[i],
335                 0,
336                 __FILE__,
337                 __LINE__
338             );
339         }
340     }
341
342     return;
343 }   /* testEconomics_Wind() */
```

5.64.2.6 testProductionConstraint_Wind()

```
void testProductionConstraint_Wind (
            Renewable * test_wind_ptr )
```

Function to test that the production constraint is active and behaving as expected.

Parameters

test_wind_ptr	A Renewable pointer to the test Wind object.

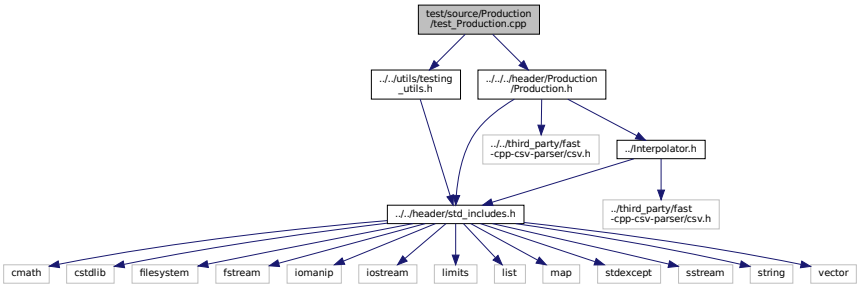
```
165 {
166     testFloatEquals(
167         test_wind_ptr->computeProductionkW(0, 1, 1e6),
168         0,
169         __FILE__,
170         __LINE__
171     );
172
173     testFloatEquals(
174         test_wind_ptr->computeProductionkW(
175             0,
176             1,
177             ((Wind*)test_wind_ptr)->design_speed_ms
178         ),
179         test_wind_ptr->capacity_kW,
180         __FILE__,
181         __LINE__
182     );
183
184     testFloatEquals(
185         test_wind_ptr->computeProductionkW(0, 1, -1),
186         0,
187         __FILE__,
188         __LINE__
189     );
190
191     return;
192 }   /* testProductionConstraint_Wind() */
```

5.65 test/source/Production/test_Production.cpp File Reference

Testing suite for Production class.

```
#include "../../utils/testing_utils.h"
#include "../../../header/Production/Production.h"
```

Include dependency graph for test_Production.cpp:



Functions

- Production * testConstruct_Production (std::vector< double > *time_vec_hrs_ptr)

  A function to construct a Production object and spot check some post-construction attributes.
- void testBadConstruct_Production (std::vector< double > *time_vec_hrs_ptr)

  Function to test the trying to construct a Production object given bad inputs is being handled as expected.
- int main (int argc, char **argv)

5.65.1 Detailed Description

Testing suite for Production class.

A suite of tests for the Production class.

5.65.2 Function Documentation

5.65.2.1 main()

```
int main (
              int argc,
              char ** argv )
```

```
203 {
204     #ifdef _WIN32
205         activateVirtualTerminal();
206     #endif  /* _WIN32 */
207
208     printGold("\tTesting Production");
209
210     srand(time(NULL));
211
212
213     std::vector<double> time_vec_hrs (8760, 0);
214     for (size_t i = 0; i < time_vec_hrs.size(); i++) {
215         time_vec_hrs[i] = i;
216     }
217
218     Production* test_production_ptr = testConstruct_Production(&time_vec_hrs);
219
220
221     try {
222         testBadConstruct_Production(&time_vec_hrs);
223     }
224
225
226     catch (...) {
227         delete test_production_ptr;
228
229         printGold(" ............................. ");
230         printRed("FAIL");
231         std::cout « std::endl;
232         throw;
233     }
234
235
236     delete test_production_ptr;
237
238     printGold(" ............................. ");
239     printGreen("PASS");
240     std::cout « std::endl;
241     return 0;
242
243 }   /* main() */
```

5.65.2.2 testBadConstruct_Production()

```
void testBadConstruct_Production (
            std::vector< double > * time_vec_hrs_ptr )
```

Function to test the trying to construct a Production object given bad inputs is being handled as expected.

Parameters

time_vec_hrs_ptr	A pointer to the vector containing the modelling time series.

```
177 {
178     bool error_flag = true;
179
180     try {
181         ProductionInputs production_inputs;
182
183         Production bad_production(0, 1, production_inputs, time_vec_hrs_ptr);
184
185         error_flag = false;
186     } catch (...) {
187         // Task failed successfully! =P
188     }
189     if (not error_flag) {
190         expectedErrorNotDetected(__FILE__, __LINE__);
191     }
192
193     return;
194 }   /* testBadConstruct_Production() */
```

5.65.2.3 testConstruct_Production()

```
Production * testConstruct_Production (
            std::vector< double > * time_vec_hrs_ptr )
```

A function to construct a Production object and spot check some post-construction attributes.

Parameters

time_vec_hrs_ptr	A pointer to the vector containing the modelling time series.

Returns

A pointer to a test Production object.

```
65 {
66     ProductionInputs production_inputs;
67
68     Production* test_production_ptr = new Production(
69         8760,
70         1,
71         production_inputs,
72         time_vec_hrs_ptr
73     );
74
75     testTruth(
76         not production_inputs.print_flag,
77         __FILE__,
78         __LINE__
79     );
80
81     testFloatEquals(
82         production_inputs.nominal_inflation_annual,
83         0.02,
84         __FILE__,
```

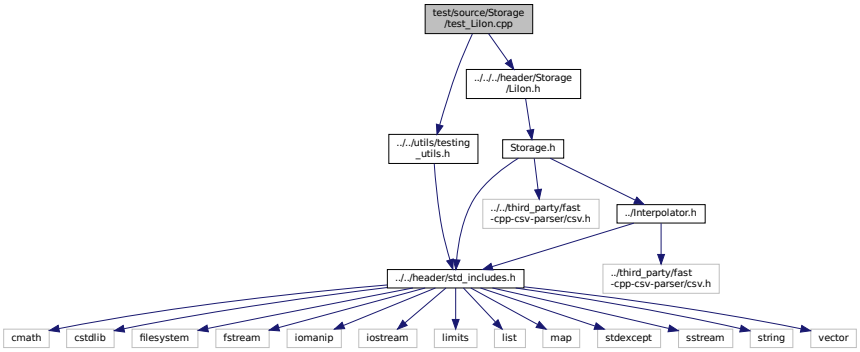
```
85          __LINE__
86      );
87
88      testFloatEquals(
89          production_inputs.nominal_discount_annual,
90          0.04,
91          __FILE__,
92          __LINE__
93      );
94
95      testFloatEquals(
96          test_production_ptr->n_points,
97          8760,
98          __FILE__,
99          __LINE__
100     );
101
102     testFloatEquals(
103         test_production_ptr->capacity_kW,
104         100,
105         __FILE__,
106         __LINE__
107     );
108
109     testFloatEquals(
110         test_production_ptr->real_discount_annual,
111         0.0196078431372549,
112         __FILE__,
113         __LINE__
114     );
115
116     testFloatEquals(
117         test_production_ptr->production_vec_kW.size(),
118         8760,
119         __FILE__,
120         __LINE__
121     );
122
123     testFloatEquals(
124         test_production_ptr->dispatch_vec_kW.size(),
125         8760,
126         __FILE__,
127         __LINE__
128     );
129
130     testFloatEquals(
131         test_production_ptr->storage_vec_kW.size(),
132         8760,
133         __FILE__,
134         __LINE__
135     );
136
137     testFloatEquals(
138         test_production_ptr->curtailment_vec_kW.size(),
139         8760,
140         __FILE__,
141         __LINE__
142     );
143
144     testFloatEquals(
145         test_production_ptr->capital_cost_vec.size(),
146         8760,
147         __FILE__,
148         __LINE__
149     );
150
151     testFloatEquals(
152         test_production_ptr->operation_maintenance_cost_vec.size(),
153         8760,
154         __FILE__,
155         __LINE__
156     );
157
158     return test_production_ptr;
159 }   /* testConstruct_Production() */
```

5.66 test/source/Storage/test_Lilon.cpp File Reference

Testing suite for Lilon class.

```
#include "../../utils/testing_utils.h"
#include "../../../header/Storage/LiIon.h"
```

Include dependency graph for test_LiIon.cpp:



Functions

- Storage * testConstruct_LiIon (void)

  A function to construct a LiIon object and spot check some post-construction attributes.
- void testBadConstruct_LiIon (void)

  Function to test the trying to construct a LiIon object given bad inputs is being handled as expected.
- void testCommitCharge_LiIon (Storage *test_liion_ptr)

  A function to test commitCharge() and ensure that its impact on acceptable and available power is as expected.
- void testCommitDischarge_LiIon (Storage *test_liion_ptr)

  A function to test commitDischarge() and ensure that its impact on acceptable and available power is as expected.
- int main (int argc, char **argv)

5.66.1 Detailed Description

Testing suite for LiIon class.

A suite of tests for the LiIon class.

5.66.2 Function Documentation

5.66.2.1 main()

```
int main (
              int argc,
              char ** argv )
331 {
332     #ifdef _WIN32
333         activateVirtualTerminal();
334     #endif  /* _WIN32 */
335
336     printGold("\tTesting Storage <-- LiIon");
337
338     srand(time(NULL));
339
340
341     Storage* test_liion_ptr = testConstruct_LiIon();
342
343
344     try {
345         testBadConstruct_LiIon();
346
347         testCommitCharge_LiIon(test_liion_ptr);
348         testCommitDischarge_LiIon(test_liion_ptr);
349     }
350
351
352     catch (...) {
353         delete test_liion_ptr;
354
355         printGold(" ......................... ");
356         printRed("FAIL");
357         std::cout « std::endl;
358         throw;
359     }
360
361
362     delete test_liion_ptr;
363
364     printGold(" ......................... ");
365     printGreen("PASS");
366     std::cout « std::endl;
367     return 0;
368
369 }   /* main() */
```

5.66.2.2 testBadConstruct_LiIon()

```
void testBadConstruct_LiIon (
              void  )
```

Function to test the trying to construct a LiIon object given bad inputs is being handled as expected.

```
174 {
175     bool error_flag = true;
176
177     try {
178         LiIonInputs bad_liion_inputs;
179         bad_liion_inputs.min_SOC = -1;
180
181         LiIon bad_liion(8760, 1, bad_liion_inputs);
182
183         error_flag = false;
184     } catch (...) {
185         // Task failed successfully! =P
186     }
187     if (not error_flag) {
188         expectedErrorNotDetected(__FILE__, __LINE__);
189     }
190
191     return;
192 }   /* testBadConstruct_LiIon() */
```

5.66.2.3 testCommitCharge_LiIon()

```
void testCommitCharge_LiIon (
            Storage * test_liion_ptr )
```

A function to test commitCharge() and ensure that its impact on acceptable and available power is as expected.

Parameters

test_liion_ptr	A Storage pointer to a test LiIon object.

```
210 {
211     double dt_hrs = 1;
212 
213     testFloatEquals(
214         test_liion_ptr->getAvailablekW(dt_hrs),
215         100,    // hits power capacity constraint
216         __FILE__,
217         __LINE__
218     );
219 
220     testFloatEquals(
221         test_liion_ptr->getAcceptablekW(dt_hrs),
222         100,    // hits power capacity constraint
223         __FILE__,
224         __LINE__
225     );
226 
227     test_liion_ptr->power_kW = 1e6; // as if a massive amount of power is already flowing in
228 
229     testFloatEquals(
230         test_liion_ptr->getAvailablekW(dt_hrs),
231         0,    // is already hitting power capacity constraint
232         __FILE__,
233         __LINE__
234     );
235 
236     testFloatEquals(
237         test_liion_ptr->getAcceptablekW(dt_hrs),
238         0,    // is already hitting power capacity constraint
239         __FILE__,
240         __LINE__
241     );
242 
243     test_liion_ptr->commitCharge(0, dt_hrs, 100);
244 
245     testFloatEquals(
246         test_liion_ptr->power_kW,
247         0,
248         __FILE__,
249         __LINE__
250     );
251 
252     return;
253 }   /* testCommitCharge_LiIon() */
```

5.66.2.4 testCommitDischarge_LiIon()

```
void testCommitDischarge_LiIon (
            Storage * test_liion_ptr )
```

A function to test commitDischarge() and ensure that its impact on acceptable and available power is as expected.

Parameters

test_liion_ptr	A Storage pointer to a test LiIon object.

```
271 {
```

```
272     double dt_hrs = 1;
273     double load_kW = 100;
274 
275     testFloatEquals(
276         test_liion_ptr->getAvailablekW(dt_hrs),
277         100,    // hits power capacity constraint
278         __FILE__,
279         __LINE__
280     );
281 
282     testFloatEquals(
283         test_liion_ptr->getAcceptablekW(dt_hrs),
284         100,    // hits power capacity constraint
285         __FILE__,
286         __LINE__
287     );
288 
289     test_liion_ptr->power_kW = 1e6; // as if a massive amount of power is already flowing out
290 
291     testFloatEquals(
292         test_liion_ptr->getAvailablekW(dt_hrs),
293         0,    // is already hitting power capacity constraint
294         __FILE__,
295         __LINE__
296     );
297 
298     testFloatEquals(
299         test_liion_ptr->getAcceptablekW(dt_hrs),
300         0,    // is already hitting power capacity constraint
301         __FILE__,
302         __LINE__
303     );
304 
305     load_kW = test_liion_ptr->commitDischarge(0, dt_hrs, 100, load_kW);
306 
307     testFloatEquals(
308         load_kW,
309         0,
310         __FILE__,
311         __LINE__
312     );
313 
314     testFloatEquals(
315         test_liion_ptr->power_kW,
316         0,
317         __FILE__,
318         __LINE__
319     );
320 
321     return;
322 }   /* testCommitDischarge_LiIon() */
```

5.66.2.5 testConstruct_LiIon()

```
Storage * testConstruct_LiIon (
            void  )
```

A function to construct a LiIon object and spot check some post-construction attributes.

Returns

A Storage pointer to a test LiIon object.

```
63 {
64     LiIonInputs liion_inputs;
65 
66     Storage* test_liion_ptr = new LiIon(8760, 1, liion_inputs);
67 
68     testTruth(
69         test_liion_ptr->type_str == "LIION",
70         __FILE__,
71         __LINE__
72     );
73 
74     testFloatEquals(
75         ((LiIon*)test_liion_ptr)->init_SOC,
```

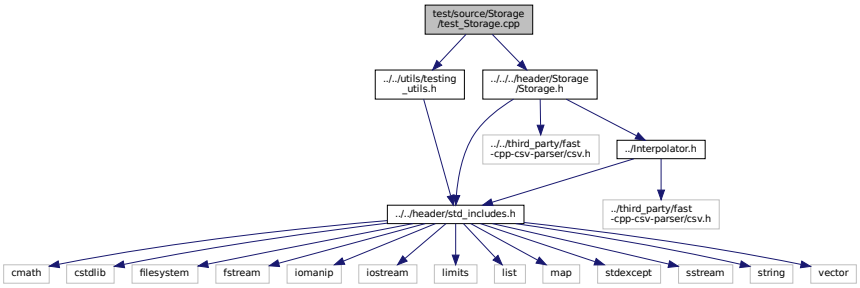
```
76          0.5,
77          __FILE__,
78          __LINE__
79      );
80
81      testFloatEquals(
82          ((LiIon*)test_liion_ptr)->min_SOC,
83          0.15,
84          __FILE__,
85          __LINE__
86      );
87
88      testFloatEquals(
89          ((LiIon*)test_liion_ptr)->hysteresis_SOC,
90          0.5,
91          __FILE__,
92          __LINE__
93      );
94
95      testFloatEquals(
96          ((LiIon*)test_liion_ptr)->max_SOC,
97          0.9,
98          __FILE__,
99          __LINE__
100     );
101
102     testFloatEquals(
103         ((LiIon*)test_liion_ptr)->charging_efficiency,
104         0.9,
105         __FILE__,
106         __LINE__
107     );
108
109     testFloatEquals(
110         ((LiIon*)test_liion_ptr)->discharging_efficiency,
111         0.9,
112         __FILE__,
113         __LINE__
114     );
115
116     testFloatEquals(
117         ((LiIon*)test_liion_ptr)->replace_SOH,
118         0.8,
119         __FILE__,
120         __LINE__
121     );
122
123     testFloatEquals(
124         ((LiIon*)test_liion_ptr)->power_kW,
125         0,
126         __FILE__,
127         __LINE__
128     );
129
130     testFloatEquals(
131         ((LiIon*)test_liion_ptr)->SOH_vec.size(),
132         8760,
133         __FILE__,
134         __LINE__
135     );
136
137     testTruth(
138         not ((LiIon*)test_liion_ptr)->power_degradation_flag,
139         __FILE__,
140         __LINE__
141     );
142
143     testFloatEquals(
144         test_liion_ptr->energy_capacity_kWh,
145         ((LiIon*)test_liion_ptr)->dynamic_energy_capacity_kWh,
146         __FILE__,
147         __LINE__
148     );
149
150     testFloatEquals(
151         test_liion_ptr->power_capacity_kW,
152         ((LiIon*)test_liion_ptr)->dynamic_power_capacity_kW,
153         __FILE__,
154         __LINE__
155     );
156
157     return test_liion_ptr;
158 }   /* testConstruct_LiIon() */
```

5.67 test/source/Storage/test_Storage.cpp File Reference

Testing suite for Storage class.

```
#include "../../utils/testing_utils.h"
#include "../../../header/Storage/Storage.h"
```

Include dependency graph for test_Storage.cpp:



Functions

- Storage * testConstruct_Storage (void)

  A function to construct a Storage object and spot check some post-construction attributes.
- void testBadConstruct_Storage (void)

  Function to test the trying to construct a Storage object given bad inputs is being handled as expected.
- int main (int argc, char **argv)

5.67.1 Detailed Description

Testing suite for Storage class.

A suite of tests for the Storage class.

5.67.2 Function Documentation

5.67.2.1 main()

```
int main (
            int argc,
            char ** argv )
161 {
162     #ifdef _WIN32
163         activateVirtualTerminal();
164     #endif  /* _WIN32 */
165
166     printGold("\tTesting Storage");
167
168     srand(time(NULL));
169
```

```
170
171     Storage* test_storage_ptr = testConstruct_Storage();
172
173
174     try {
175         testBadConstruct_Storage();
176     }
177
178
179     catch (...) {
180         delete test_storage_ptr;
181
182         printGold(" ................................. ");
183         printRed("FAIL");
184         std::cout << std::endl;
185         throw;
186     }
187
188
189     delete test_storage_ptr;
190
191     printGold(" ................................. ");
192     printGreen("PASS");
193     std::cout << std::endl;
194     return 0;
195
196 }   /* main() */
```

5.67.2.2 testBadConstruct_Storage()

```
void testBadConstruct_Storage (
             void  )
```

Function to test the trying to construct a Storage object given bad inputs is being handled as expected.

```
134 {
135     bool error_flag = true;
136
137     try {
138         StorageInputs bad_storage_inputs;
139         bad_storage_inputs.energy_capacity_kWh = 0;
140
141         Storage bad_storage(8760, 1, bad_storage_inputs);
142
143         error_flag = false;
144     } catch (...) {
145         // Task failed successfully! =P
146     }
147     if (not error_flag) {
148         expectedErrorNotDetected(__FILE__, __LINE__);
149     }
150
151     return;
152 }   /* testBadConstruct_Storage() */
```

5.67.2.3 testConstruct_Storage()

```
Storage * testConstruct_Storage (
             void  )
```

A function to construct a Storage object and spot check some post-construction attributes.

Returns

A Renewable pointer to a test Storage object.

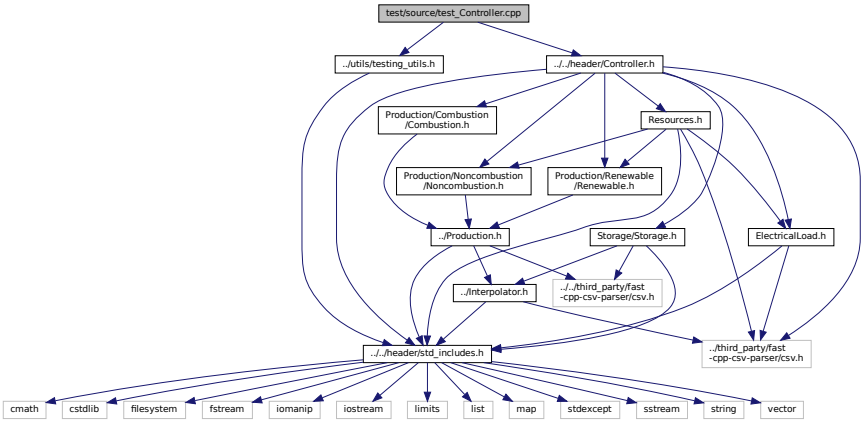
```
63 {
64     StorageInputs storage_inputs;
65
66     Storage* test_storage_ptr = new Storage(8760, 1, storage_inputs);
67
68     testFloatEquals(
69         test_storage_ptr->power_capacity_kW,
70         100,
71         __FILE__,
72         __LINE__
73     );
74
75     testFloatEquals(
76         test_storage_ptr->energy_capacity_kWh,
77         1000,
78         __FILE__,
79         __LINE__
80     );
81
82     testFloatEquals(
83         test_storage_ptr->charge_vec_kWh.size(),
84         8760,
85         __FILE__,
86         __LINE__
87     );
88
89     testFloatEquals(
90         test_storage_ptr->charging_power_vec_kW.size(),
91         8760,
92         __FILE__,
93         __LINE__
94     );
95
96     testFloatEquals(
97         test_storage_ptr->discharging_power_vec_kW.size(),
98         8760,
99         __FILE__,
100         __LINE__
101     );
102
103     testFloatEquals(
104         test_storage_ptr->capital_cost_vec.size(),
105         8760,
106         __FILE__,
107         __LINE__
108     );
109
110     testFloatEquals(
111         test_storage_ptr->operation_maintenance_cost_vec.size(),
112         8760,
113         __FILE__,
114         __LINE__
115     );
116
117     return test_storage_ptr;
118 }   /* testConstruct_Storage() */
```

5.68 test/source/test_Controller.cpp File Reference

Testing suite for Controller class.

```
#include "../utils/testing_utils.h"
#include "../../header/Controller.h"
```

Include dependency graph for test_Controller.cpp:



Functions

- Controller * testConstruct_Controller (void)

  A function to construct a Controller object.
- int main (int argc, char **argv)

5.68.1 Detailed Description

Testing suite for Controller class.

A suite of tests for the Controller class.

5.68.2 Function Documentation

5.68.2.1 main()

```
int main (
            int argc,
            char ** argv )
75 {
76     #ifdef _WIN32
77         activateVirtualTerminal();
78     #endif  /* _WIN32 */
79
80     printGold("\tTesting Controller");
81
82     srand(time(NULL));
83
84
85     Controller* test_controller_ptr = testConstruct_Controller();
86
87
88     try {
89         //...
90     }
```

```
91
92
93      catch (...) {
94          delete test_controller_ptr;
95
96          printGold(" ............................... ");
97          printRed("FAIL");
98          std::cout « std::endl;
99          throw;
100     }
101
102
103     delete test_controller_ptr;
104
105     printGold(" ............................... ");
106     printGreen("PASS");
107     std::cout « std::endl;
108     return 0;
109 }   /* main() */
```

5.68.2.2 testConstruct_Controller()

```
Controller * testConstruct_Controller (
             void  )
```

A function to construct a Controller object.

Returns

A pointer to a test Controller object.

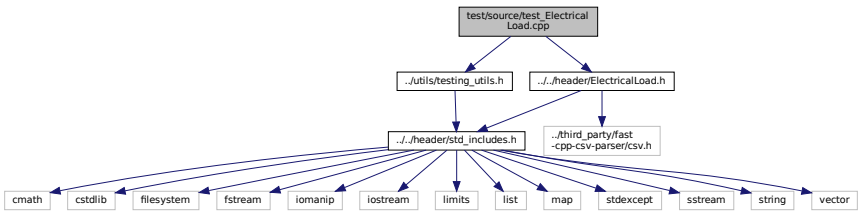
```
62 {
63     Controller* test_controller_ptr = new Controller();
64
65     return test_controller_ptr;
66 }   /* testConstruct_Controller() */
```

5.69 test/source/test_ElectricalLoad.cpp File Reference

Testing suite for ElectricalLoad class.

```
#include "../utils/testing_utils.h"
#include "../../header/ElectricalLoad.h"
```

Include dependency graph for test_ElectricalLoad.cpp:



Functions

- ElectricalLoad * testConstruct_ElectricalLoad (void)

  A function to construct an ElectricalLoad object.
- void testPostConstructionAttributes_ElectricalLoad (ElectricalLoad *test_electrical_load_ptr)

  A function to check the values of various post-construction attributes.
- void testDataRead_ElectricalLoad (ElectricalLoad *test_electrical_load_ptr)

  A function to check the values read into the test ElectricalLoad object.
- int main (int argc, char **argv)

5.69.1 Detailed Description

Testing suite for ElectricalLoad class.

A suite of tests for the ElectricalLoad class.

5.69.2 Function Documentation

5.69.2.1 main()

```
int main (
              int argc,
              char ** argv )
248 {
249     #ifdef _WIN32
250         activateVirtualTerminal();
251     #endif  /* _WIN32 */
252
253     printGold("\tTesting ElectricalLoad");
254
255     srand(time(NULL));
256
257
258     ElectricalLoad* test_electrical_load_ptr = testConstruct_ElectricalLoad();
259
260
261     try {
262         testPostConstructionAttributes_ElectricalLoad(test_electrical_load_ptr);
263         testDataRead_ElectricalLoad(test_electrical_load_ptr);
264     }
265
266
267     catch (...) {
268         delete test_electrical_load_ptr;
269
270         printGold(" ..... ");
271         printRed("FAIL");
272         std::cout << std::endl;
273         throw;
274     }
275
276
277     delete test_electrical_load_ptr;
278
279     printGold(" ..... ");
280     printGreen("PASS");
281     std::cout << std::endl;
282     return 0;
283 }   /* main() */
```

5.69.2.2 testConstruct_ElectricalLoad()

```
ElectricalLoad * testConstruct_ElectricalLoad (
            void  )
```

A function to construct an ElectricalLoad object.

Returns

A pointer to a test ElectricalLoad object.

```
62 {
63     std::string path_2_electrical_load_time_series =
64         "data/test/electrical_load/electrical_load_generic_peak-500kW_1yr_dt-1hr.csv";
65
66     ElectricalLoad* test_electrical_load_ptr =
67         new ElectricalLoad(path_2_electrical_load_time_series);
68
69     testTruth(
70         test_electrical_load_ptr->path_2_electrical_load_time_series ==
71         path_2_electrical_load_time_series,
72         __FILE__,
73         __LINE__
74     );
75
76     return test_electrical_load_ptr;
77 }   /* testConstruct_ElectricalLoad() */
```

5.69.2.3 testDataRead_ElectricalLoad()

```
void testDataRead_ElectricalLoad (
            ElectricalLoad * test_electrical_load_ptr )
```

A function to check the values read into the test ElectricalLoad object.

Parameters

test_electrical_load_ptr	A pointer to the test ElectricalLoad object.

```
153 {
154     std::vector<double> expected_dt_vec_hrs (48, 1);
155
156     std::vector<double> expected_time_vec_hrs = {
157          0,  1,  2,  3,  4,  5,  6,  7,  8,  9, 10, 11,
158         12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23,
159         24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35,
160         36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47
161     };
162
163     std::vector<double> expected_load_vec_kW = {
164         360.253836463674,
165         355.171277826775,
166         353.776453532298,
167         353.75405737934,
168         346.592867404975,
169         340.132411175118,
170         337.354867340578,
171         340.644115618736,
172         363.639028500678,
173         378.787797779238,
174         372.215798201712,
175         395.093925731298,
176         402.325427142659,
177         386.907725462306,
178         380.709170928091,
179         372.062070914977,
180         372.328646856954,
181         391.841444284136,
182         394.029351759596,
```

```
183         383.369407765254,
184         381.093099675206,
185         382.604158946193,
186         390.744843709034,
187         383.13949492437,
188         368.150393976985,
189         364.629744480226,
190         363.572736804082,
191         359.854924202248,
192         355.207590170267,
193         349.094656012401,
194         354.365935871597,
195         343.380608328546,
196         404.673065729266,
197         486.296896820126,
198         480.225974100847,
199         457.318764401085,
200         418.177339948609,
201         414.399018364126,
202         409.678420185754,
203         404.768766016563,
204         401.699589920585,
205         402.44339040654,
206         398.138372541906,
207         396.010498627646,
208         390.165117432277,
209         375.850429417013,
210         365.567100746484,
211         365.429624610923
212     };
213
214     for (int i = 0; i < 48; i++) {
215         testFloatEquals(
216             test_electrical_load_ptr->dt_vec_hrs[i],
217             expected_dt_vec_hrs[i],
218             __FILE__,
219             __LINE__
220         );
221
222         testFloatEquals(
223             test_electrical_load_ptr->time_vec_hrs[i],
224             expected_time_vec_hrs[i],
225             __FILE__,
226             __LINE__
227         );
228
229         testFloatEquals(
230             test_electrical_load_ptr->load_vec_kW[i],
231             expected_load_vec_kW[i],
232             __FILE__,
233             __LINE__
234         );
235
236     }
237
238     return;
239 }   /* testDataRead_ElectricalLoad() */
```

5.69.2.4 testPostConstructionAttributes_ElectricalLoad()

```
void testPostConstructionAttributes_ElectricalLoad (
            ElectricalLoad * test_electrical_load_ptr )
```

A function to check the values of various post-construction attributes.

Parameters

test_electrical_load_ptr	A pointer to the test ElectricalLoad object.

```
98 {
99     testFloatEquals(
100         test_electrical_load_ptr->n_points,
101         8760,
102         __FILE__,
103         __LINE__
```

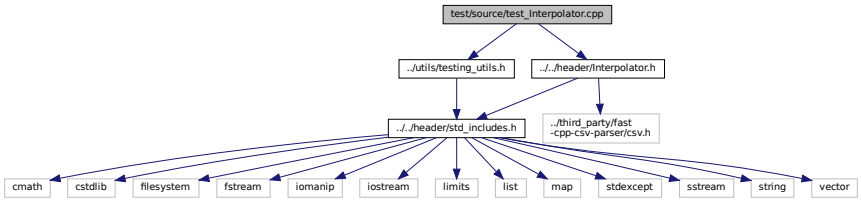
```
104     );
105
106     testFloatEquals(
107         test_electrical_load_ptr->n_years,
108         0.999886,
109         __FILE__,
110         __LINE__
111     );
112
113     testFloatEquals(
114         test_electrical_load_ptr->min_load_kW,
115         82.1211213927802,
116         __FILE__,
117         __LINE__
118     );
119
120     testFloatEquals(
121         test_electrical_load_ptr->mean_load_kW,
122         258.373472633202,
123         __FILE__,
124         __LINE__
125     );
126
127
128     testFloatEquals(
129         test_electrical_load_ptr->max_load_kW,
130         500,
131         __FILE__,
132         __LINE__
133     );
134
135     return;
136 }   /* testPostConstructionAttributes_ElectricalLoad() */
```

5.70 test/source/test_Interpolator.cpp File Reference

Testing suite for Interpolator class.

```
#include "../utils/testing_utils.h"
#include "../../header/Interpolator.h"
```

Include dependency graph for test_Interpolator.cpp:



Functions

- Interpolator * testConstruct_Interpolator (void)

  A function to construct an Interpolator object.
- void testDataRead1D_Interpolator (Interpolator *test_interpolator_ptr, int data_key_1D, std::string path_2↩ _data_1D)

  A function to check the 1D data values read into the Interpolator object.
- void testBadIndexing1D_Interpolator (Interpolator *test_interpolator_ptr, int data_key_bad)

  A function to check if bad key errors are being handled properly.
- void testInvalidInterpolation1D_Interpolator (Interpolator *test_interpolator_ptr, int data_key_1D)

  Function to check if attempting to interpolate outside the given 1D data domain is handled properly.

- void testInterpolation1D_Interpolator (Interpolator *test_interpolator_ptr, int data_key_1D)

  Function to check that the Interpolator object is returning the expected 1D interpolation values.
- void testDataRead2D_Interpolator (Interpolator *test_interpolator_ptr, int data_key_2D, std::string path_2_data_2D)

  A function to check the 2D data values read into the Interpolator object.
- void testInvalidInterpolation2D_Interpolator (Interpolator *test_interpolator_ptr, int data_key_2D)

  Function to check if attempting to interpolate outside the given 2D data domain is handled properly.
- void testInterpolation2D_Interpolator (Interpolator *test_interpolator_ptr, int data_key_2D)

  Function to check that the Interpolator object is returning the expected 2D interpolation values.
- int main (int argc, char **argv)

5.70.1 Detailed Description

Testing suite for Interpolator class.

A suite of tests for the Interpolator class.

5.70.2 Function Documentation

5.70.2.1 main()

```
int main (
            int argc,
            char ** argv )
725 {
726     #ifdef _WIN32
727         activateVirtualTerminal();
728     #endif  /* _WIN32 */
729 
730     printGold("\n\tTesting Interpolator");
731 
732     srand(time(NULL));
733 
734 
735     Interpolator* test_interpolator_ptr = testConstruct_Interpolator();
736 
737 
738     try {
739         int data_key_1D = 1;
740         std::string path_2_data_1D =
741             "data/test/interpolation/diesel_fuel_curve.csv";
742 
743         testDataRead1D_Interpolator(test_interpolator_ptr, data_key_1D, path_2_data_1D);
744         testBadIndexing1D_Interpolator(test_interpolator_ptr, -99);
745         testInvalidInterpolation1D_Interpolator(test_interpolator_ptr, data_key_1D);
746         testInterpolation1D_Interpolator(test_interpolator_ptr, data_key_1D);
747 
748 
749         int data_key_2D = 2;
750         std::string path_2_data_2D =
751             "data/test/interpolation/wave_energy_converter_normalized_performance_matrix.csv";
752 
753         testDataRead2D_Interpolator(test_interpolator_ptr, data_key_2D, path_2_data_2D);
754         testInvalidInterpolation2D_Interpolator(test_interpolator_ptr, data_key_2D);
755         testInterpolation2D_Interpolator(test_interpolator_ptr, data_key_2D);
756     }
757 
758 
759     catch (...) {
760         delete test_interpolator_ptr;
761 
762         printGold(" ............................. ");
```

```
763         printRed("FAIL");
764         std::cout « std::endl;
765         throw;
766     }
767
768
769     delete test_interpolator_ptr;
770
771     printGold(" ............................. ");
772     printGreen("PASS");
773     std::cout « std::endl;
774     return 0;
775 }   /* main() */
```

5.70.2.2 testBadIndexing1D_Interpolator()

```
void testBadIndexing1D_Interpolator (
             Interpolator * test_interpolator_ptr,
             int data_key_bad )
```

A function to check if bad key errors are being handled properly.

Parameters

test_interpolator_ptr	A pointer to the test Interpolator object.
data_key_bad	A key used to index into the Interpolator object.

```
212 {
213     bool error_flag = true;
214
215     try {
216         test_interpolator_ptr->interp1D(data_key_bad, 0);
217         error_flag = false;
218     } catch (...) {
219         // Task failed successfully! =P
220     }
221     if (not error_flag) {
222         expectedErrorNotDetected(__FILE__, __LINE__);
223     }
224
225     return;
226 }   /* testBadIndexing1D_Interpolator() */
```

5.70.2.3 testConstruct_Interpolator()

```
Interpolator * testConstruct_Interpolator (
             void  )
```

A function to construct an Interpolator object.

Returns

A pointer to a test Interpolator object.

```
62 {
63     Interpolator* test_interpolator_ptr = new Interpolator();
64
65     return test_interpolator_ptr;
66 }   /* testConstruct_Interpolator() */
```

5.70.2.4 testDataRead1D_Interpolator()

```
void testDataRead1D_Interpolator (
            Interpolator * test_interpolator_ptr,
            int data_key,
            std::string path_2_data_1D )
```

A function to check the 1D data values read into the Interpolator object.

Parameters

test_interpolator_ptr	A pointer to the test Interpolator object.
data_key_1D	A key used to index into the Interpolator object.
path_2_data_1D	A path (either relative or absolute) to the interpolation data.

```
95 {
96     test_interpolator_ptr->addData1D(data_key_1D, path_2_data_1D);
97
98     testTruth(
99         test_interpolator_ptr->path_map_1D[data_key_1D] == path_2_data_1D,
100         __FILE__,
101         __LINE__
102     );
103
104     testFloatEquals(
105         test_interpolator_ptr->interp_map_1D[data_key_1D].n_points,
106         16,
107         __FILE__,
108         __LINE__
109     );
110
111     testFloatEquals(
112         test_interpolator_ptr->interp_map_1D[data_key_1D].x_vec.size(),
113         16,
114         __FILE__,
115         __LINE__
116     );
117
118     std::vector<double> expected_x_vec = {
119         0,
120         0.3,
121         0.35,
122         0.4,
123         0.45,
124         0.5,
125         0.55,
126         0.6,
127         0.65,
128         0.7,
129         0.75,
130         0.8,
131         0.85,
132         0.9,
133         0.95,
134         1
135     };
136
137     std::vector<double> expected_y_vec = {
138         4.68079520372916,
139         11.1278522361839,
140         12.4787834830748,
141         13.7808847600209,
142         15.0417468303382,
143         16.277263,
144         17.4612831516442,
145         18.6279054806525,
146         19.7698039220515,
147         20.8893499214868,
148         21.955378,
149         23.0690535155297,
150         24.1323614374927,
151         25.1797231192866,
152         26.2122451458747,
153         27.254952
154     };
155
156     for (int i = 0; i < test_interpolator_ptr->interp_map_1D[data_key_1D].n_points; i++) {
157         testFloatEquals(
```

```
158             test_interpolator_ptr->interp_map_1D[data_key_1D].x_vec[i],
159             expected_x_vec[i],
160             __FILE__,
161             __LINE__
162         );
163 
164         testFloatEquals(
165             test_interpolator_ptr->interp_map_1D[data_key_1D].y_vec[i],
166             expected_y_vec[i],
167             __FILE__,
168             __LINE__
169         );
170     }
171 
172     testFloatEquals(
173         test_interpolator_ptr->interp_map_1D[data_key_1D].min_x,
174         expected_x_vec[0],
175         __FILE__,
176         __LINE__
177     );
178 
179     testFloatEquals(
180         test_interpolator_ptr->interp_map_1D[data_key_1D].max_x,
181         expected_x_vec[expected_x_vec.size() - 1],
182         __FILE__,
183         __LINE__
184     );
185 
186     return;
187 }   /* testDataRead1D_Interpolator() */
```

5.70.2.5 testDataRead2D_Interpolator()

```
void testDataRead2D_Interpolator (
              Interpolator * test_interpolator_ptr,
              int data_key,
              std::string path_2_data_2D )
```

A function to check the 2D data values read into the Interpolator object.

Parameters

test_interpolator_ptr	A pointer to the test Interpolator object.
data_key_2D	A key used to index into the Interpolator object.
path_2_data_2D	A path (either relative or absolute) to the interpolation data.

```
402 {
403     test_interpolator_ptr->addData2D(data_key_2D, path_2_data_2D);
404 
405     testTruth(
406         test_interpolator_ptr->path_map_2D[data_key_2D] == path_2_data_2D,
407         __FILE__,
408         __LINE__
409     );
410 
411     testFloatEquals(
412         test_interpolator_ptr->interp_map_2D[data_key_2D].n_rows,
413         16,
414         __FILE__,
415         __LINE__
416     );
417 
418     testFloatEquals(
419         test_interpolator_ptr->interp_map_2D[data_key_2D].n_cols,
420         16,
421         __FILE__,
422         __LINE__
423     );
424 
425     testFloatEquals(
426         test_interpolator_ptr->interp_map_2D[data_key_2D].x_vec.size(),
427         16,
```

```
428         __FILE__,
429         __LINE__
430     );
431 
432     testFloatEquals(
433         test_interpolator_ptr->interp_map_2D[data_key_2D].y_vec.size(),
434         16,
435         __FILE__,
436         __LINE__
437     );
438 
439     testFloatEquals(
440         test_interpolator_ptr->interp_map_2D[data_key_2D].z_matrix.size(),
441         16,
442         __FILE__,
443         __LINE__
444     );
445 
446     testFloatEquals(
447         test_interpolator_ptr->interp_map_2D[data_key_2D].z_matrix[0].size(),
448         16,
449         __FILE__,
450         __LINE__
451     );
452 
453     std::vector<double> expected_x_vec = {
454         0.25, 0.75, 1.25, 1.75, 2.25, 2.75, 3.25, 3.75, 4.25, 4.75, 5.25, 5.75, 6.25, 6.75, 7.25, 7.75
455     };
456 
457     std::vector <double> expected_y_vec = {
458         5,
459         6,
460         7,
461         8,
462         9,
463         10,
464         11,
465         12,
466         13,
467         14,
468         15,
469         16,
470         17,
471         18,
472         19,
473         20
474     };
475 
476     for (int i = 0; i < test_interpolator_ptr->interp_map_2D[data_key_2D].n_cols; i++) {
477         testFloatEquals(
478             test_interpolator_ptr->interp_map_2D[data_key_2D].x_vec[i],
479             expected_x_vec[i],
480             __FILE__,
481             __LINE__
482         );
483     }
484 
485     for (int i = 0; i < test_interpolator_ptr->interp_map_2D[data_key_2D].n_rows; i++) {
486         testFloatEquals(
487             test_interpolator_ptr->interp_map_2D[data_key_2D].y_vec[i],
488             expected_y_vec[i],
489             __FILE__,
490             __LINE__
491         );
492     }
493 
494     testFloatEquals(
495         test_interpolator_ptr->interp_map_2D[data_key_2D].min_x,
496         expected_x_vec[0],
497         __FILE__,
498         __LINE__
499     );
500 
501     testFloatEquals(
502         test_interpolator_ptr->interp_map_2D[data_key_2D].max_x,
503         expected_x_vec[expected_x_vec.size() - 1],
504         __FILE__,
505         __LINE__
506     );
507 
508     testFloatEquals(
509         test_interpolator_ptr->interp_map_2D[data_key_2D].min_y,
510         expected_y_vec[0],
511         __FILE__,
512         __LINE__
513     );
514 
```

```
515     testFloatEquals(
516         test_interpolator_ptr->interp_map_2D[data_key_2D].max_y,
517         expected_y_vec[expected_y_vec.size() - 1],
518         __FILE__,
519         __LINE__
520     );
521
522     std::vector<std::vector<double» expected_z_matrix = {
523         {0, 0.129128125, 0.268078125, 0.404253125, 0.537653125, 0.668278125, 0.796128125, 0.921203125,
      1, 1, 1, 0, 0, 0, 0},
524         {0, 0.11160375, 0.24944375, 0.38395375, 0.51513375, 0.64298375, 0.76750375, 0.88869375, 1, 1, 1,
      1, 1, 1, 1, 1},
525         {0, 0.094079375, 0.230809375, 0.363654375, 0.492614375, 0.617689375, 0.738879375, 0.856184375,
      0.969604375, 1, 1, 1, 1, 1, 1, 1},
526         {0, 0.076555, 0.212175, 0.343355, 0.470095, 0.592395, 0.710255, 0.823675, 0.932655, 1, 1, 1, 1,
      1, 1, 1},
527         {0, 0.059030625, 0.193540625, 0.323055625, 0.447575625, 0.567100625, 0.681630625, 0.791165625,
      0.895705625, 0.995250625, 1, 1, 1, 1, 1, 1},
528         {0, 0.04150625, 0.17490625, 0.30275625, 0.42505625, 0.54180625, 0.65300625, 0.75865625,
      0.85875625, 0.95330625, 1, 1, 1, 1, 1, 1},
529         {0, 0.023981875, 0.156271875, 0.282456875, 0.402536875, 0.516511875, 0.624381875, 0.726146875,
      0.821806875, 0.911361875, 0.994811875, 1, 1, 1, 1, 1},
530         {0, 0.0064575, 0.1376375, 0.2621575, 0.3800175, 0.4912175, 0.5957575, 0.6936375, 0.7848575,
      0.8694175, 0.9473175, 1, 1, 1, 1, 1},
531         {0, 0, 0.119003125, 0.241858125, 0.357498125, 0.465923125, 0.567133125, 0.661128125,
      0.747908125, 0.827473125, 0.899823125, 0.964958125, 1, 1, 1, 1},
532         {0, 0, 0.10036875, 0.22155875, 0.33497875, 0.44062875, 0.53850875, 0.62861875, 0.71095875,
      0.78552875, 0.85232875, 0.91135875, 0.96261875, 1, 1, 1},
533         {0, 0, 0.081734375, 0.201259375, 0.312459375, 0.415334375, 0.509884375, 0.596109375,
      0.674009375, 0.743584375, 0.804834375, 0.857759375, 0.902359375, 0.938634375, 0.966584375,
      0.986209375},
534         {0, 0, 0.0631, 0.18096, 0.28994, 0.39004, 0.48126, 0.5636, 0.63706, 0.70164, 0.75734, 0.80416,
      0.8421, 0.87116, 0.89134, 0.90264},
535         {0, 0, 0.044465625, 0.160660625, 0.267420625, 0.364745625, 0.452635625, 0.531090625,
      0.600110625, 0.659695625, 0.709845625, 0.750560625, 0.781840625, 0.803685624999999, 0.816095625,
      0.819070625},
536         {0, 0, 0.02583125, 0.14036125, 0.24490125, 0.33945125, 0.42401125, 0.49858125, 0.56316125,
      0.61775125, 0.66235125, 0.69696125, 0.72158125, 0.73621125, 0.74085125, 0.73550125},
537         {0, 0, 0.007196875, 0.120061875, 0.222381875, 0.314156875, 0.395386875, 0.466071875,
      0.526211875, 0.575806875, 0.614856875, 0.643361875, 0.661321875, 0.668736875, 0.665606875,
      0.651931875},
538         {0, 0, 0, 0.0997625, 0.1998625, 0.2888625, 0.3667625, 0.4335625, 0.4892625, 0.5338625,
      0.5673625, 0.5897625, 0.6010625, 0.6012625, 0.5903625, 0.5683625}
539     };
540
541     for (int i = 0; i < test_interpolator_ptr->interp_map_2D[data_key_2D].n_rows; i++) {
542         for (int j = 0; j < test_interpolator_ptr->interp_map_2D[data_key_2D].n_cols; j++) {
543             testFloatEquals(
544                 test_interpolator_ptr->interp_map_2D[data_key_2D].z_matrix[i][j],
545                 expected_z_matrix[i][j],
546                 __FILE__,
547                 __LINE__
548             );
549         }
550     }
551
552     return;
553 }   /* testDataRead2D_Interpolator() */
```

5.70.2.6 testInterpolation1D_Interpolator()

```
void testInterpolation1D_Interpolator (
            Interpolator * test_interpolator_ptr,
            int data_key_1D )
```

Function to check that the Interpolator object is returning the expected 1D interpolation values.

Parameters

test_interpolator_ptr	A pointer to the test Interpolator object.
data_key_1D	A key used to index into the Interpolator object.

```
322 {
323     std::vector<double> interp_x_vec = {
```

```
324         0,
325         0.170812859791767,
326         0.322739274162545,
327         0.369750203682042,
328         0.443532869135929,
329         0.471567864244626,
330         0.536513734479662,
331         0.586125806988674,
332         0.601101175455075,
333         0.658356862575221,
334         0.70576929893201,
335         0.784069734739331,
336         0.805765927542453,
337         0.884747873186048,
338         0.930870496062112,
339         0.979415217694769,
340         1
341     };
342
343     std::vector<double> expected_interp_y_vec = {
344         4.68079520372916,
345         8.35159603357656,
346         11.7422361561399,
347         12.9931187917615,
348         14.8786636301325,
349         15.5746957307243,
350         17.1419229487141,
351         18.3041866133728,
352         18.6530540913696,
353         19.9569217633299,
354         21.012354614584,
355         22.7142305879957,
356         23.1916726441968,
357         24.8602332554707,
358         25.8172124624032,
359         26.8256741279932,
360         27.254952
361     };
362
363     for (size_t i = 0; i < interp_x_vec.size(); i++) {
364         testFloatEquals(
365             test_interpolator_ptr->interp1D(data_key_1D, interp_x_vec[i]),
366             expected_interp_y_vec[i],
367             __FILE__,
368             __LINE__
369         );
370     }
371
372     return;
373 }   /* testInterpolation1D_Interpolator() */
```

5.70.2.7 testInterpolation2D_Interpolator()

```
void testInterpolation2D_Interpolator (
            Interpolator * test_interpolator_ptr,
            int data_key_2D )
```

Function to check that the Interpolator object is returning the expected 2D interpolation values.

Parameters

test_interpolator_ptr	A pointer to the test Interpolator object.
data_key_2D	A key used to index into the Interpolator object.

```
649 {
650     std::vector<double> interp_x_vec = {
651         0.389211848822208,
652         0.836477431896843,
653         1.52738334015579,
654         1.92640601114508,
655         2.27297317532019,
656         2.87416589636605,
657         3.72275770908175,
658         3.95063175885536,
```

```
659         4.68097139867404,
660         4.97775020449812,
661         5.55184219980547,
662         6.06566629451658,
663         6.27927876785062,
664         6.96218133671013,
665         7.51754442460228
666     };
667
668     std::vector<double> interp_y_vec = {
669         5.45741899698926,
670         6.00101329139007,
671         7.50567689404182,
672         8.77681262912881,
673         9.45143678206774,
674         10.7767876462885,
675         11.4795760857165,
676         12.9430684577599,
677         13.303544885703,
678         14.5069863517863,
679         15.1487890438045,
680         16.086524049077,
681         17.176609978648,
682         18.4155153740256,
683         19.1704554940162
684     };
685
686     std::vector<std::vector<double> expected_interp_z_matrix = {
687
      {0.0337204906738533,0.145056406036013,0.334677248806653,0.441674658936075,0.533295755691263,0.68807895676592,0.8996148
688
      {0.0310681846933292,0.135425896595439,0.324045598153363,0.430214268249038,0.520985043044784,0.673879556322479,0.882058
689
      {0.0237266281076604,0.108768742207538,0.294617294841705,0.398492020763049,0.486909112828702,0.63457575706117,0.8334608
690
      {0.0175245009938255,0.0862488504001753,0.269756343931147,0.371693152028768,0.458121859300634,0.601372013927032,0.79240
691
      {0.0142328739589644,0.0742969694833995,0.256562003243255,0.357470308928265,0.442843729679424,0.583749940636223,0.77061
692
      {0.0077662203173173,0.0508165832074184,0.230640709501637,0.329528443353471,0.41282867283787,0.549130026772199,0.727811
693
      {0.00433717405958826,0.0383657337957315,0.21689552996585,0.314711823368423,0.396912710109449,0.530772265145106,0.70511
694
      {0.000102358416923608,0.0210697053701168,0.188272456115393,0.283857573197153,0.363769179652786,0.492543912767949,0.657
695
      {0,0.0196038727057393,0.181222235960193,0.276257786480759,0.355605514643888,0.483127792688125,0.646203044346932,0.6855
696
      {0,0.0157252942367668,0.157685253727545,0.250886090139653,0.328351324840186,0.451692313207986,0.607334650020078,0.6442
697
      {0,0.0136568246246201,0.145132837191606,0.23735520935175,0.313816498778623,0.43492757979648,0.586605897674033,0.622265
698
      {0,0.0106345930466366,0.12679255826648,0.217585300741544,0.292579730277991,0.410432703770651,0.556319211544087,0.59010
699
      {0,0.00712134879261874,0.10547259059088,0.194603435839713,0.267892689267542,0.381958220518761,0.52111194060085,0.55272
700
      {0,0.00312847342058727,0.0812420026472571,0.168484067035528,0.239835352250276,0.349596376397684,0.481098142839729,0.510
701
      {0,0.00103256269522045,0.0673448574082101,0.152567953107312,0.222738316872545,0.329876344040866,0.456715311514779,0.484
702     };
703
704     for (size_t i = 0; i < interp_y_vec.size(); i++) {
705         for (size_t j = 0; j < interp_x_vec.size(); j++) {
706             testFloatEquals(
707                 test_interpolator_ptr->interp2D(data_key_2D, interp_x_vec[j], interp_y_vec[i]),
708                 expected_interp_z_matrix[i][j],
709                 __FILE__,
710                 __LINE__
711             );
712         }
713     }
714
715     return;
716 }   /* testInterpolation2D_Interpolator() */
```

5.70.2.8 testInvalidInterpolation1D_Interpolator()

```
void testInvalidInterpolation1D_Interpolator (
            Interpolator * test_interpolator_ptr,
            int data_key_1D )
```

Function to check if attempting to interpolate outside the given 1D data domain is handled properly.

Parameters

test_interpolator_ptr	A pointer to the test Interpolator object.
data_key_1D	A key used to index into the Interpolator object.

```
252 {
253     bool error_flag = true;
254 
255     try {
256         test_interpolator_ptr->interp1D(data_key_1D, -1);
257         error_flag = false;
258     } catch (...) {
259         // Task failed successfully! =P
260     }
261     if (not error_flag) {
262         expectedErrorNotDetected(__FILE__, __LINE__);
263     }
264 
265     try {
266         test_interpolator_ptr->interp1D(data_key_1D, 2);
267         error_flag = false;
268     } catch (...) {
269         // Task failed successfully! =P
270     }
271     if (not error_flag) {
272         expectedErrorNotDetected(__FILE__, __LINE__);
273     }
274 
275     try {
276         test_interpolator_ptr->interp1D(data_key_1D, 0 - FLOAT_TOLERANCE);
277         error_flag = false;
278     } catch (...) {
279         // Task failed successfully! =P
280     }
281     if (not error_flag) {
282         expectedErrorNotDetected(__FILE__, __LINE__);
283     }
284 
285     try {
286         test_interpolator_ptr->interp1D(data_key_1D, 1 + FLOAT_TOLERANCE);
287         error_flag = false;
288     } catch (...) {
289         // Task failed successfully! =P
290     }
291     if (not error_flag) {
292         expectedErrorNotDetected(__FILE__, __LINE__);
293     }
294 
295     return;
296 }   /* testInvalidInterpolation1D_Interpolator() */
```

5.70.2.9 testInvalidInterpolation2D_Interpolator()

```
void testInvalidInterpolation2D_Interpolator (
             Interpolator * test_interpolator_ptr,
             int data_key_2D )
```

Function to check if attempting to interpolate outside the given 2D data domain is handled properly.

Parameters

test_interpolator_ptr	A pointer to the test Interpolator object.
data_key_2D	A key used to index into the Interpolator object.

```
579 {
580     bool error_flag = true;
581 
582     try {
583         test_interpolator_ptr->interp2D(data_key_2D, -1, 6);
584         error_flag = false;
585     } catch (...) {
```

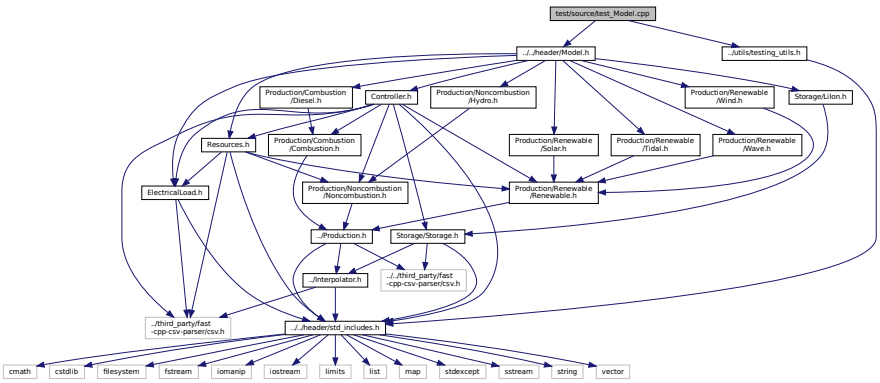
```
586         // Task failed successfully! =P
587     }
588     if (not error_flag) {
589         expectedErrorNotDetected(__FILE__, __LINE__);
590     }
591
592     try {
593         test_interpolator_ptr->interp2D(data_key_2D, 99, 6);
594         error_flag = false;
595     } catch (...) {
596         // Task failed successfully! =P
597     }
598     if (not error_flag) {
599         expectedErrorNotDetected(__FILE__, __LINE__);
600     }
601
602     try {
603         test_interpolator_ptr->interp2D(data_key_2D, 0.75, -1);
604         error_flag = false;
605     } catch (...) {
606         // Task failed successfully! =P
607     }
608     if (not error_flag) {
609         expectedErrorNotDetected(__FILE__, __LINE__);
610     }
611
612     try {
613         test_interpolator_ptr->interp2D(data_key_2D, 0.75, 99);
614         error_flag = false;
615     } catch (...) {
616         // Task failed successfully! =P
617     }
618     if (not error_flag) {
619         expectedErrorNotDetected(__FILE__, __LINE__);
620     }
621
622     return;
623 }   /* testInvalidInterpolation2D_Interpolator() */
```

5.71 test/source/test_Model.cpp File Reference

Testing suite for Model class.

```
#include "../utils/testing_utils.h"
#include "../../header/Model.h"
```

Include dependency graph for test_Model.cpp:



Functions

- Model * testConstruct_Model (ModelInputs test_model_inputs)
- void testBadConstruct_Model (void)

Function to check if passing bad ModelInputs to the Model constructor is handled appropriately.

- void testPostConstructionAttributes_Model (Model *test_model_ptr)

  A function to check the values of various post-construction attributes.

- void testElectricalLoadData_Model (Model *test_model_ptr)

  Function to check the values read into the ElectricalLoad component of the test Model object.

- void testAddSolarResource_Model (Model *test_model_ptr, std::string path_2_solar_resource_data, int solar_resource_key)

  Function to test adding a solar resource and then check the values read into the Resources component of the test Model object.

- void testAddTidalResource_Model (Model *test_model_ptr, std::string path_2_tidal_resource_data, int tidal_resource_key)

  Function to test adding a tidal resource and then check the values read into the Resources component of the test Model object.

- void testAddWaveResource_Model (Model *test_model_ptr, std::string path_2_wave_resource_data, int wave_resource_key)

  Function to test adding a wave resource and then check the values read into the Resources component of the test Model object.

- void testAddWindResource_Model (Model *test_model_ptr, std::string path_2_wind_resource_data, int wind_resource_key)

  Function to test adding a wind resource and then check the values read into the Resources component of the test Model object.

- void testAddHydroResource_Model (Model *test_model_ptr, std::string path_2_hydro_resource_data, int hydro_resource_key)

  Function to test adding a hydro resource and then check the values read into the Resources component of the test Model object.

- void testAddHydro_Model (Model *test_model_ptr, int hydro_resource_key)

  Function to test adding a hydroelectric asset to the test Model object, and then spot check some post-add attributes.

- void testAddDiesel_Model (Model *test_model_ptr)

  Function to test adding a suite of diesel generators to the test Model object, and then spot check some post-add attributes.

- void testAddSolar_Model (Model *test_model_ptr, int solar_resource_key)

  Function to test adding a solar PV array to the test Model object and then spot check some post-add attributes.

- void testAddSolar_productionOverride_Model (Model *test_model_ptr, std::string path_2_normalized_production_time_series)

  Function to test adding a solar PV array to the test Model object using the production override feature, and then spot check some post-add attributes.

- void testAddTidal_Model (Model *test_model_ptr, int tidal_resource_key)

  Function to test adding a tidal turbine to the test Model object and then spot check some post-add attributes.

- void testAddWave_Model (Model *test_model_ptr, int wave_resource_key)

  Function to test adding a wave energy converter to the test Model object and then spot check some post-add attributes.

- void testAddWind_Model (Model *test_model_ptr, int wind_resource_key)

  Function to test adding a wind turbine to the test Model object and then spot check some post-add attributes.

- void testAddLiIon_Model (Model *test_model_ptr)

  Function to test adding a lithium ion battery energy storage system to the test Model object and then spot check some post-add attributes.

- void testLoadBalance_Model (Model *test_model_ptr)

  Function to check that the post-run load data is as expected. That is, the added renewable, production, and storage assets are handled by the Controller as expected.

- void testEconomics_Model (Model *test_model_ptr)

  Function to check that the modelled economic metrics are > 0.

- void testFuelConsumptionEmissions_Model (Model *test_model_ptr)

  Function to check that the modelled fuel consumption and emissions are > 0.

- int main (int argc, char **argv)

5.71.1 Detailed Description

Testing suite for Model class.

A suite of tests for the Model class.

5.71.2 Function Documentation

5.71.2.1 main()

```
int main (
              int argc,
              char ** argv )
1490 {
1491     #ifdef _WIN32
1492         activateVirtualTerminal();
1493     #endif  /* _WIN32 */
1494
1495     printGold("\tTesting Model");
1496     std::cout « std::flush;
1497
1498     srand(time(NULL));
1499
1500
1501     std::string path_2_electrical_load_time_series =
1502         "data/test/electrical_load/electrical_load_generic_peak-500kW_1yr_dt-1hr.csv";
1503
1504     ModelInputs test_model_inputs;
1505     test_model_inputs.path_2_electrical_load_time_series =
1506         path_2_electrical_load_time_series;
1507
1508     Model* test_model_ptr = testConstruct_Model(test_model_inputs);
1509
1510
1511     try {
1512         testBadConstruct_Model();
1513         testPostConstructionAttributes_Model(test_model_ptr);
1514         testElectricalLoadData_Model(test_model_ptr);
1515
1516
1517         int solar_resource_key = 0;
1518         std::string path_2_solar_resource_data =
1519             "data/test/resources/solar_GHI_peak-1kWm2_1yr_dt-1hr.csv";
1520
1521         testAddSolarResource_Model(
1522             test_model_ptr,
1523             path_2_solar_resource_data,
1524             solar_resource_key
1525         );
1526
1527
1528         int tidal_resource_key = 1;
1529         std::string path_2_tidal_resource_data =
1530             "data/test/resources/tidal_speed_peak-3ms_1yr_dt-1hr.csv";
1531
1532         testAddTidalResource_Model(
1533             test_model_ptr,
1534             path_2_tidal_resource_data,
1535             tidal_resource_key
1536         );
1537
1538
1539         int wave_resource_key = 2;
1540         std::string path_2_wave_resource_data =
1541             "data/test/resources/waves_H_s_peak-8m_T_e_peak-15s_1yr_dt-1hr.csv";
1542
1543         testAddWaveResource_Model(
1544             test_model_ptr,
1545             path_2_wave_resource_data,
1546             wave_resource_key
1547         );
1548
```

```
1549
1550         int wind_resource_key = 3;
1551         std::string path_2_wind_resource_data =
1552             "data/test/resources/wind_speed_peak-25ms_1yr_dt-1hr.csv";
1553
1554         testAddWindResource_Model(
1555             test_model_ptr,
1556             path_2_wind_resource_data,
1557             wind_resource_key
1558         );
1559
1560
1561         int hydro_resource_key = 4;
1562         std::string path_2_hydro_resource_data =
1563             "data/test/resources/hydro_inflow_peak-20000m3hr_1yr_dt-1hr.csv";
1564
1565         testAddHydroResource_Model(
1566             test_model_ptr,
1567             path_2_hydro_resource_data,
1568             hydro_resource_key
1569         );
1570
1571
1572         std::string path_2_normalized_production_time_series =
1573                 "data/test/normalized_production/normalized_solar_production.csv";
1574
1575         // looping solely for the sake of profiling (also tests reset(), which is
1576         // needed for wrapping PGMcpp in an optimizer)
1577         for (int i = 0; i < 1000; i++) {
1578             test_model_ptr->reset();
1579
1580
1581             testAddHydro_Model(test_model_ptr, hydro_resource_key);
1582             testAddDiesel_Model(test_model_ptr);
1583             testAddSolar_Model(test_model_ptr, solar_resource_key);
1584
1585             testAddSolar_productionOverride_Model(
1586                 test_model_ptr,
1587                 path_2_normalized_production_time_series
1588             );
1589
1590             testAddTidal_Model(test_model_ptr, tidal_resource_key);
1591             testAddWave_Model(test_model_ptr, wave_resource_key);
1592             testAddWind_Model(test_model_ptr, wind_resource_key);
1593
1594
1595             test_model_ptr->run();
1596         }
1597
1598
1599         testLoadBalance_Model(test_model_ptr);
1600         testEconomics_Model(test_model_ptr);
1601         testFuelConsumptionEmissions_Model(test_model_ptr);
1602
1603         test_model_ptr->writeResults("test/test_results/");
1604     }
1605
1606
1607     catch (...) {
1608         delete test_model_ptr;
1609
1610         printGold(" ..................................... ");
1611         printRed("FAIL");
1612         std::cout « std::endl;
1613         throw;
1614     }
1615
1616
1617     delete test_model_ptr;
1618
1619     printGold(" ..................................... ");
1620     printGreen("PASS");
1621     std::cout « std::endl;
1622     return 0;
1623 }   /* main() */
```

5.71.2.2 testAddDiesel_Model()

```
void testAddDiesel_Model (
             Model * test_model_ptr )
```

Function to test adding a suite of diesel generators to the test Model object, and then spot check some post-add attributes.

Parameters

test_model_ptr	A pointer to the test Model object.

```
918 {
919     DieselInputs diesel_inputs;
920     diesel_inputs.combustion_inputs.production_inputs.capacity_kW = 100;
921     diesel_inputs.combustion_inputs.production_inputs.is_sunk = true;
922 
923     test_model_ptr->addDiesel(diesel_inputs);
924 
925     testFloatEquals(
926         test_model_ptr->combustion_ptr_vec.size(),
927         1,
928         __FILE__,
929         __LINE__
930     );
931 
932     testFloatEquals(
933         test_model_ptr->combustion_ptr_vec[0]->type,
934         CombustionType :: DIESEL,
935         __FILE__,
936         __LINE__
937     );
938 
939     diesel_inputs.combustion_inputs.production_inputs.capacity_kW = 150;
940 
941     test_model_ptr->addDiesel(diesel_inputs);
942 
943     diesel_inputs.combustion_inputs.production_inputs.capacity_kW = 250;
944 
945     test_model_ptr->addDiesel(diesel_inputs);
946 
947     testFloatEquals(
948         test_model_ptr->combustion_ptr_vec.size(),
949         3,
950         __FILE__,
951         __LINE__
952     );
953 
954     std::vector<int> expected_diesel_capacity_vec_kW = {100, 150, 250};
955 
956     for (int i = 0; i < 3; i++) {
957         testFloatEquals(
958             test_model_ptr->combustion_ptr_vec[i]->capacity_kW,
959             expected_diesel_capacity_vec_kW[i],
960             __FILE__,
961             __LINE__
962         );
963     }
964 
965     diesel_inputs.combustion_inputs.production_inputs.capacity_kW = 100;
966 
967     for (int i = 0; i < 2 * ((double)rand() / RAND_MAX); i++) {
968         test_model_ptr->addDiesel(diesel_inputs);
969     }
970 
971     return;
972 }   /* testAddDiesel_Model() */
```

5.71.2.3 testAddHydro_Model()

```
void testAddHydro_Model (
             Model * test_model_ptr,
             int hydro_resource_key )
```

Function to test adding a hydroelectric asset to the test Model object, and then spot check some post-add attributes.

Parameters

test_model_ptr	A pointer to the test Model object.
hydro_resource_key	A key used to index into the Resources component of the test Model object.

```
868 {
869     HydroInputs hydro_inputs;
870     hydro_inputs.noncombustion_inputs.production_inputs.capacity_kW = 300;
871     hydro_inputs.reservoir_capacity_m3 = 100000;
872     hydro_inputs.init_reservoir_state = 0.5;
873     hydro_inputs.noncombustion_inputs.production_inputs.is_sunk = true;
874     hydro_inputs.resource_key = hydro_resource_key;
875 
876     test_model_ptr->addHydro(hydro_inputs);
877 
878     testFloatEquals(
879         test_model_ptr->noncombustion_ptr_vec.size(),
880         1,
881         __FILE__,
882         __LINE__
883     );
884 
885     testFloatEquals(
886         test_model_ptr->noncombustion_ptr_vec[0]->type,
887         NoncombustionType :: HYDRO,
888         __FILE__,
889         __LINE__
890     );
891 
892     testFloatEquals(
893         test_model_ptr->noncombustion_ptr_vec[0]->resource_key,
894         hydro_resource_key,
895         __FILE__,
896         __LINE__
897     );
898 
899     return;
900 }   /* testAddHydro_Model() */
```

5.71.2.4 testAddHydroResource_Model()

```
void testAddHydroResource_Model (
             Model * test_model_ptr,
             std::string path_2_hydro_resource_data,
             int hydro_resource_key )
```

Function to test adding a hydro resource and then check the values read into the Resources component of the test Model object.

Parameters

test_model_ptr	A pointer to the test Model object.
path_2_hydro_resource_data	A path (either relative or absolute) to the hydro resource data.
hydro_resource_key	A key used to index into the Resources component of the test Model object.

```
773 {
774     test_model_ptr->addResource(
775         NoncombustionType :: HYDRO,
776         path_2_hydro_resource_data,
777         hydro_resource_key
778     );
779 
780     std::vector<double> expected_hydro_resource_vec_ms = {
781         2167.91531556942,
782         2046.58261560569,
783         2007.85941123153,
784         2000.11477247929,
785         1917.50527264453,
786         1963.97311577093,
```

```
787         1908.46985899809,
788         1886.5267112678,
789         1965.26388854254,
790         1953.64692935289,
791         2084.01504296306,
792         2272.46796101188,
793         2520.29645627096,
794         2715.203242423,
795         2720.36633563203,
796         3130.83228077221,
797         3289.59741021591,
798         3981.45195965772,
799         5295.45929491303,
800         7084.47124360523,
801         7709.20557708454,
802         7436.85238642936,
803         7235.49173429668,
804         6710.14695517339,
805         6015.71085806577,
806         5279.97001316337,
807         4877.24870889801,
808         4421.60569340303,
809         3919.49483690424,
810         3498.70270322341,
811         3274.10813058883,
812         3147.61233529349,
813         2904.94693324343,
814         2805.55738101,
815         2418.32535637171,
816         2398.96375630723,
817         2260.85100182222,
818         2157.58912702878,
819         2019.47637254377,
820         1913.63295220712,
821         1863.29279076589,
822         1748.41395678279,
823         1695.49224555317,
824         1599.97501375715,
825         1559.96103873397,
826         1505.74855473274,
827         1438.62833664765,
828         1384.41585476901
829     };
830
831     for (size_t i = 0; i < expected_hydro_resource_vec_ms.size(); i++) {
832         testFloatEquals(
833             test_model_ptr->resources.resource_map_1D[hydro_resource_key][i],
834             expected_hydro_resource_vec_ms[i],
835             __FILE__,
836             __LINE__
837         );
838     }
839
840     return;
841 }   /* testAddHydroResource_Model() */
```

5.71.2.5 testAddLiIon_Model()

```
void testAddLiIon_Model (
              Model * test_model_ptr )
```

Function to test adding a lithium ion battery energy storage system to the test Model object and then spot check some post-add attributes.

Parameters

test_model_ptr	A pointer to the test Model object.

```
1244 {
1245     LiIonInputs liion_inputs;
1246
1247     test_model_ptr->addLiIon(liion_inputs);
1248
1249     testFloatEquals(
```

```
1250         test_model_ptr->storage_ptr_vec.size(),
1251         1,
1252         __FILE__,
1253         __LINE__
1254     );
1255
1256     testFloatEquals(
1257         test_model_ptr->storage_ptr_vec[0]->type,
1258         StorageType :: LIION,
1259         __FILE__,
1260         __LINE__
1261     );
1262
1263     return;
1264 }   /* testAddLiIon_Model() */
```

5.71.2.6 testAddSolar_Model()

```
void testAddSolar_Model (
             Model * test_model_ptr,
             int solar_resource_key )
```

Function to test adding a solar PV array to the test Model object and then spot check some post-add attributes.

Parameters

test_model_ptr	A pointer to the test Model object.
solar_resource_key	A key used to index into the Resources component of the test Model object.

```
999 {
1000     SolarInputs solar_inputs;
1001     solar_inputs.resource_key = solar_resource_key;
1002
1003     test_model_ptr->addSolar(solar_inputs);
1004
1005     testFloatEquals(
1006         test_model_ptr->renewable_ptr_vec.size(),
1007         1,
1008         __FILE__,
1009         __LINE__
1010     );
1011
1012     testFloatEquals(
1013         test_model_ptr->renewable_ptr_vec[0]->type,
1014         RenewableType :: SOLAR,
1015         __FILE__,
1016         __LINE__
1017     );
1018
1019     return;
1020 }   /* testAddSolar_Model() */
```

5.71.2.7 testAddSolar_productionOverride_Model()

```
void testAddSolar_productionOverride_Model (
             Model * test_model_ptr,
             std::string path_2_normalized_production_time_series )
```

Function to test adding a solar PV array to the test Model object using the production override feature, and then spot check some post-add attributes.

Parameters

test_model_ptr	A pointer to the test Model object.
path_2_normalized_production_time_series	A path (either relative or absolute) to the given normalized production time series data.

```
1047 {
1048     SolarInputs solar_inputs;
1049     solar_inputs.renewable_inputs.production_inputs.path_2_normalized_production_time_series =
1050         path_2_normalized_production_time_series;
1051 
1052     test_model_ptr->addSolar(solar_inputs);
1053 
1054     testFloatEquals(
1055         test_model_ptr->renewable_ptr_vec.size(),
1056         2,
1057         __FILE__,
1058         __LINE__
1059     );
1060 
1061     testFloatEquals(
1062         test_model_ptr->renewable_ptr_vec[1]->type,
1063         RenewableType :: SOLAR,
1064         __FILE__,
1065         __LINE__
1066     );
1067 
1068     testTruth(
1069         test_model_ptr->renewable_ptr_vec[1]->normalized_production_series_given,
1070         __FILE__,
1071         __LINE__
1072     );
1073 
1074     testTruth(
1075         test_model_ptr->renewable_ptr_vec[1]->path_2_normalized_production_time_series ==
1076         path_2_normalized_production_time_series,
1077         __FILE__,
1078         __LINE__
1079     );
1080 
1081     return;
1082 }   /* testAddSolar_productionOverride_Model() */
```

5.71.2.8 testAddSolarResource_Model()

```
void testAddSolarResource_Model (
             Model * test_model_ptr,
             std::string path_2_solar_resource_data,
             int solar_resource_key )
```

Function to test adding a solar resource and then check the values read into the Resources component of the test Model object.

Parameters

test_model_ptr	A pointer to the test Model object.
path_2_solar_resource_data	A path (either relative or absolute) to the solar resource data.
solar_resource_key	A key used to index into the Resources component of the test Model object.

```
315 {
316     test_model_ptr->addResource(
317         RenewableType :: SOLAR,
318         path_2_solar_resource_data,
319         solar_resource_key
320     );
321 
322     std::vector<double> expected_solar_resource_vec_kWm2 = {
323         0,
```

```
324         0,
325         0,
326         0,
327         0,
328         0,
329         8.51702662684015E-05,
330         0.000348341567045,
331         0.00213793728593,
332         0.004099863613322,
333         0.000997135230553,
334         0.009534527624657,
335         0.022927996790616,
336         0.0136071715294,
337         0.002535134127751,
338         0.005206897515821,
339         0.005627658648597,
340         0.000701186722215,
341         0.00017119827089,
342         0,
343         0,
344         0,
345         0,
346         0,
347         0,
348         0,
349         0,
350         0,
351         0,
352         0,
353         0,
354         0.000141055102242,
355         0.00084525014743,
356         0.024893647822702,
357         0.091245556190749,
358         0.158722176731637,
359         0.152859680515876,
360         0.149922903895116,
361         0.13049996570866,
362         0.03081254222795,
363         0.001218928911125,
364         0.000206092647423,
365         0,
366         0,
367         0,
368         0,
369         0,
370         0
371     };
372
373     for (size_t i = 0; i < expected_solar_resource_vec_kWm2.size(); i++) {
374         testFloatEquals(
375             test_model_ptr->resources.resource_map_1D[solar_resource_key][i],
376             expected_solar_resource_vec_kWm2[i],
377             __FILE__,
378             __LINE__
379         );
380     }
381
382     return;
383 }   /* testAddSolarResource_Model() */
```

5.71.2.9 testAddTidal_Model()

```
void testAddTidal_Model (
              Model * test_model_ptr,
              int tidal_resource_key )
```

Function to test adding a tidal turbine to the test Model object and then spot check some post-add attributes.

Parameters

test_model_ptr	A pointer to the test Model object.
tidal_resource_key	A key used to index into the Resources component of the test Model object.

```
1109 {
1110     TidalInputs tidal_inputs;
1111     tidal_inputs.resource_key = tidal_resource_key;
1112 
1113     test_model_ptr->addTidal(tidal_inputs);
1114 
1115     testFloatEquals(
1116         test_model_ptr->renewable_ptr_vec.size(),
1117         3,
1118         __FILE__,
1119         __LINE__
1120     );
1121 
1122     testFloatEquals(
1123         test_model_ptr->renewable_ptr_vec[2]->type,
1124         RenewableType :: TIDAL,
1125         __FILE__,
1126         __LINE__
1127     );
1128 
1129     return;
1130 }   /* testAddTidal_Model() */
```

5.71.2.10 testAddTidalResource_Model()

```
void testAddTidalResource_Model (
              Model * test_model_ptr,
              std::string path_2_tidal_resource_data,
              int tidal_resource_key )
```

Function to test adding a tidal resource and then check the values read into the Resources component of the test Model object.

Parameters

test_model_ptr	A pointer to the test Model object.
path_2_tidal_resource_data	A path (either relative or absolute) to the tidal resource data.
tidal_resource_key	A key used to index into the Resources component of the test Model object.

```
415 {
416     test_model_ptr->addResource(
417         RenewableType :: TIDAL,
418         path_2_tidal_resource_data,
419         tidal_resource_key
420     );
421 
422     std::vector<double> expected_tidal_resource_vec_ms = {
423         0.347439913040533,
424         0.770545522195602,
425         0.731352084836198,
426         0.293389814389542,
427         0.209959110813115,
428         0.610609623896497,
429         1.78067162013604,
430         2.53522775118089,
431         2.75966627832024,
432         2.52101111143895,
433         2.05389330201031,
434         1.3461515862445,
435         0.28909254878384,
436         0.897754086048563,
437         1.71406453837407,
438         1.85047408742869,
439         1.71507908595979,
440         1.33540349705416,
441         0.434586143463003,
442         0.500623815700637,
443         1.37172172646733,
444         1.68294125491228,
445         1.56101300975417,
446         1.04925834219412,
447         0.211395463930223,
```

```
448         1.03720048903385,
449         1.85059536356448,
450         1.85203242794517,
451         1.4091471616277,
452         0.767776539039899,
453         0.251464906990961,
454         1.47018469375652,
455         2.36260493698197,
456         2.46653750048625,
457         2.12851908739291,
458         1.62783753197988,
459         0.734594890957439,
460         0.441886297300355,
461         1.6574418350918,
462         2.0684558286637,
463         1.87717416992136,
464         1.58871262337931,
465         1.03451227609235,
466         0.193371305159817,
467         0.976400122458815,
468         1.6583227369707,
469         1.76690616570953,
470         1.54801328553115
471     };
472
473     for (size_t i = 0; i < expected_tidal_resource_vec_ms.size(); i++) {
474         testFloatEquals(
475             test_model_ptr->resources.resource_map_1D[tidal_resource_key][i],
476             expected_tidal_resource_vec_ms[i],
477             __FILE__,
478             __LINE__
479         );
480     }
481
482     return;
483 }   /* testAddTidalResource_Model() */
```

5.71.2.11 testAddWave_Model()

```
void testAddWave_Model (
              Model * test_model_ptr,
              int wave_resource_key )
```

Function to test adding a wave energy converter to the test Model object and then spot check some post-add attributes.

Parameters

test_model_ptr	A pointer to the test Model object.
wave_resource_key	A key used to index into the Resources component of the test Model object.

```
1157 {
1158     WaveInputs wave_inputs;
1159     wave_inputs.resource_key = wave_resource_key;
1160
1161     test_model_ptr->addWave(wave_inputs);
1162
1163     testFloatEquals(
1164         test_model_ptr->renewable_ptr_vec.size(),
1165         4,
1166         __FILE__,
1167         __LINE__
1168     );
1169
1170     testFloatEquals(
1171         test_model_ptr->renewable_ptr_vec[3]->type,
1172         RenewableType :: WAVE,
1173         __FILE__,
1174         __LINE__
1175     );
1176
1177     return;
1178 }   /* testAddWave_Model() */
```

5.71.2.12 testAddWaveResource_Model()

```
void testAddWaveResource_Model (
            Model * test_model_ptr,
            std::string path_2_wave_resource_data,
            int wave_resource_key )
```

Function to test adding a wave resource and then check the values read into the Resources component of the test Model object.

Parameters

test_model_ptr	A pointer to the test Model object.
path_2_wave_resource_data	A path (either relative or absolute) to the wave resource data.
wave_resource_key	A key used to index into the Resources component of the test Model object.

```
515 {
516     test_model_ptr->addResource(
517         RenewableType :: WAVE,
518         path_2_wave_resource_data,
519         wave_resource_key
520     );
521
522     std::vector<double> expected_significant_wave_height_vec_m = {
523         4.26175222125028,
524         4.25020976167872,
525         4.25656524330349,
526         4.27193854786718,
527         4.28744955711233,
528         4.29421815278154,
529         4.2839937266082,
530         4.25716982457976,
531         4.22419391611483,
532         4.19588925217606,
533         4.17338788587412,
534         4.14672746914214,
535         4.10560041173665,
536         4.05074966447193,
537         3.9953696962433,
538         3.95316976150866,
539         3.92771018142378,
540         3.91129562488595,
541         3.89558312094911,
542         3.87861093931749,
543         3.86538307240754,
544         3.86108961027929,
545         3.86459448853189,
546         3.86796474016882,
547         3.86357412779993,
548         3.85554872014731,
549         3.86044266668675,
550         3.89445961915999,
551         3.95554798115731,
552         4.02265508610476,
553         4.07419587011404,
554         4.10314247143958,
555         4.11738045085928,
556         4.12554995596708,
557         4.12923992001675,
558         4.1229292327442,
559         4.10123955307441,
560         4.06748827895363,
561         4.0336230651344,
562         4.01134236393876,
563         4.00136570034559,
564         3.99368787690411,
565         3.97820924247644,
566         3.95369335178055,
567         3.92742545608532,
568         3.90683362771686,
569         3.89331520944006,
570         3.88256045801583
571     };
```

```
572
573     std::vector<double> expected_energy_period_vec_s = {
574         10.4456008226821,
575         10.4614151137651,
576         10.4462827795433,
577         10.4127692097884,
578         10.3734397942723,
579         10.3408599227669,
580         10.32637292093,
581         10.3245412676322,
582         10.310409818185,
583         10.2589529840966,
584         10.1728100603103,
585         10.0862908658929,
586         10.03480243813,
587         10.023673635806,
588         10.0243418565116,
589         10.0063487117653,
590         9.96050302286607,
591         9.9011999635568,
592         9.84451822125472,
593         9.79726875879626,
594         9.75614594835158,
595         9.7173447961368,
596         9.68342904390577,
597         9.66380508567062,
598         9.6674009575699,
599         9.68927134575103,
600         9.70979984863046,
601         9.70967357906908,
602         9.68983025704562,
603         9.6722855524805,
604         9.67973599910003,
605         9.71977125328293,
606         9.78450442291421,
607         9.86532355233449,
608         9.96158937600019,
609         10.0807018356507,
610         10.2291022504937,
611         10.39458528356,
612         10.5464393581004,
613         10.6553277500484,
614         10.7245553190084,
615         10.7893127285064,
616         10.8846512240849,
617         11.0148158739075,
618         11.1544325654719,
619         11.2772785848343,
620         11.3744362756187,
621         11.4533643503183
622     };
623
624     for (size_t i = 0; i < expected_energy_period_vec_s.size(); i++) {
625         testFloatEquals(
626             test_model_ptr->resources.resource_map_2D[wave_resource_key][i][0],
627             expected_significant_wave_height_vec_m[i],
628             __FILE__,
629             __LINE__
630         );
631
632         testFloatEquals(
633             test_model_ptr->resources.resource_map_2D[wave_resource_key][i][1],
634             expected_energy_period_vec_s[i],
635             __FILE__,
636             __LINE__
637         );
638     }
639
640     return;
641 }   /* testAddWaveResource_Model() */
```

5.71.2.13 testAddWind_Model()

```
void testAddWind_Model (
            Model * test_model_ptr,
            int wind_resource_key )
```

Function to test adding a wind turbine to the test Model object and then spot check some post-add attributes.

Parameters

test_model_ptr	A pointer to the test Model object.
wind_resource_key	A key used to index into the Resources component of the test Model object.

```
1205 {
1206     WindInputs wind_inputs;
1207     wind_inputs.resource_key = wind_resource_key;
1208 
1209     test_model_ptr->addWind(wind_inputs);
1210 
1211     testFloatEquals(
1212         test_model_ptr->renewable_ptr_vec.size(),
1213         5,
1214         __FILE__,
1215         __LINE__
1216     );
1217 
1218     testFloatEquals(
1219         test_model_ptr->renewable_ptr_vec[4]->type,
1220         RenewableType :: WIND,
1221         __FILE__,
1222         __LINE__
1223     );
1224 
1225     return;
1226 }   /* testAddWind_Model() */
```

5.71.2.14 testAddWindResource_Model()

```
void testAddWindResource_Model (
              Model * test_model_ptr,
              std::string path_2_wind_resource_data,
              int wind_resource_key )
```

Function to test adding a wind resource and then check the values read into the Resources component of the test Model object.

Parameters

test_model_ptr	A pointer to the test Model object.
path_2_wind_resource_data	A path (either relative or absolute) to the wind resource data.
wind_resource_key	A key used to index into the Resources component of the test Model object.

```
673 {
674     test_model_ptr->addResource(
675         RenewableType :: WIND,
676         path_2_wind_resource_data,
677         wind_resource_key
678     );
679 
680     std::vector<double> expected_wind_resource_vec_ms = {
681         6.88566688469997,
682         5.02177105466549,
683         3.74211715899568,
684         5.67169579985362,
685         4.90670669971858,
686         4.29586955031368,
687         7.41155377205065,
688         10.2243290476943,
689         13.1258696725555,
690         13.7016198628274,
691         16.2481482330233,
692         16.5096744355418,
693         13.4354482206162,
694         14.0129230731609,
695         14.5554549260515,
696         13.4454539065912,
697         13.3447169512094,
```

```
698         11.7372615098554,
699         12.7200070078013,
700         10.6421127908149,
701         6.09869498990661,
702         5.66355596602321,
703         4.97316966910831,
704         3.48937138360567,
705         2.15917470979169,
706         1.29061103587027,
707         3.43475751425219,
708         4.11706326260927,
709         4.28905275747408,
710         5.75850263196241,
711         8.98293663055264,
712         11.7069822941315,
713         12.4031987075858,
714         15.4096570910089,
715         16.6210843829552,
716         13.3421219142573,
717         15.2112831900548,
718         18.350864533037,
719         15.8751799822971,
720         15.3921198799796,
721         15.9729192868434,
722         12.4728950178772,
723         10.177050481096,
724         10.7342247355551,
725         8.98846695631389,
726         4.14671169124739,
727         3.17256452697149,
728         3.40036336968628
729     };
730
731     for (size_t i = 0; i < expected_wind_resource_vec_ms.size(); i++) {
732         testFloatEquals(
733             test_model_ptr->resources.resource_map_1D[wind_resource_key][i],
734             expected_wind_resource_vec_ms[i],
735             __FILE__,
736             __LINE__
737         );
738     }
739
740     return;
741 }   /* testAddWindResource_Model() */
```

5.71.2.15 testBadConstruct_Model()

```
void testBadConstruct_Model (
             void  )
```

Function to check if passing bad ModelInputs to the Model constructor is handled appropriately.

```
91 {
92     bool error_flag = true;
93
94     try {
95         ModelInputs bad_model_inputs;   // path_2_electrical_load_time_series left empty
96
97         Model bad_model(bad_model_inputs);
98
99         error_flag = false;
100     } catch (...) {
101         // Task failed successfully! =P
102     }
103     if (not error_flag) {
104         expectedErrorNotDetected(__FILE__, __LINE__);
105     }
106
107     try {
108         ModelInputs bad_model_inputs;
109         bad_model_inputs.path_2_electrical_load_time_series =
110             "data/test/electrical_load/bad_path_";
111         bad_model_inputs.path_2_electrical_load_time_series += std::to_string(rand());
112         bad_model_inputs.path_2_electrical_load_time_series += ".csv";
113
114         Model bad_model(bad_model_inputs);
115
116         error_flag = false;
117     } catch (...) {
```

```
118         // Task failed successfully! =P
119     }
120     if (not error_flag) {
121         expectedErrorNotDetected(__FILE__, __LINE__);
122     }
123
124     return;
125 }
```

5.71.2.16 testConstruct_Model()

```
Model* testConstruct_Model (
            ModelInputs test_model_inputs )
64 {
65     Model* test_model_ptr = new Model(test_model_inputs);
66
67     testTruth(
68         test_model_ptr->electrical_load.path_2_electrical_load_time_series ==
69         test_model_inputs.path_2_electrical_load_time_series,
70         __FILE__,
71         __LINE__
72     );
73
74     return test_model_ptr;
75 }   /* testConstruct_Model() */
```

5.71.2.17 testEconomics_Model()

```
void testEconomics_Model (
            Model * test_model_ptr )
```

Function to check that the modelled economic metrics are > 0.

Parameters

test_model_ptr	A pointer to the test Model object.

```
1397 {
1398     testGreaterThan(
1399         test_model_ptr->net_present_cost,
1400         0,
1401         __FILE__,
1402         __LINE__
1403     );
1404
1405     testGreaterThan(
1406         test_model_ptr->levellized_cost_of_energy_kWh,
1407         0,
1408         __FILE__,
1409         __LINE__
1410     );
1411
1412     return;
1413 }   /* testEconomics_Model() */
```

5.71.2.18 testElectricalLoadData_Model()

```
void testElectricalLoadData_Model (
            Model * test_model_ptr )
```

Function to check the values read into the ElectricalLoad component of the test Model object.

Parameters

test_model_ptr	A pointer to the test Model object.

```
198 {
199     std::vector<double> expected_dt_vec_hrs (48, 1);
200 
201     std::vector<double> expected_time_vec_hrs = {
202          0,  1,  2,  3,  4,  5,  6,  7,  8,  9, 10, 11,
203         12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23,
204         24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35,
205         36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47
206     };
207 
208     std::vector<double> expected_load_vec_kW = {
209         360.253836463674,
210         355.171277826775,
211         353.776453532298,
212         353.75405737934,
213         346.592867404975,
214         340.132411175118,
215         337.354867340578,
216         340.644115618736,
217         363.639028500678,
218         378.787797779238,
219         372.215798201712,
220         395.093925731298,
221         402.325427142659,
222         386.907725462306,
223         380.709170928091,
224         372.062070914977,
225         372.328646856954,
226         391.841444284136,
227         394.029351759596,
228         383.369407765254,
229         381.093099675206,
230         382.604158946193,
231         390.744843709034,
232         383.13949492437,
233         368.150393976985,
234         364.629744480226,
235         363.572736804082,
236         359.854924202248,
237         355.207590170267,
238         349.094656012401,
239         354.365935871597,
240         343.380608328546,
241         404.673065729266,
242         486.296896820126,
243         480.225974100847,
244         457.318764401085,
245         418.177339948609,
246         414.399018364126,
247         409.678420185754,
248         404.768766016563,
249         401.699589920585,
250         402.44339040654,
251         398.138372541906,
252         396.010498627646,
253         390.165117432277,
254         375.850429417013,
255         365.567100746484,
256         365.429624610923
257     };
258 
259     for (int i = 0; i < 48; i++) {
260         testFloatEquals(
261             test_model_ptr->electrical_load.dt_vec_hrs[i],
262             expected_dt_vec_hrs[i],
263             __FILE__,
264             __LINE__
265         );
266 
267         testFloatEquals(
268             test_model_ptr->electrical_load.time_vec_hrs[i],
269             expected_time_vec_hrs[i],
270             __FILE__,
271             __LINE__
272         );
273 
274         testFloatEquals(
275             test_model_ptr->electrical_load.load_vec_kW[i],
276             expected_load_vec_kW[i],
277             __FILE__,
278             __LINE__
279         );
```

```
280     }
281
282     return;
283 }   /* testElectricalLoadData_Model() */
```

5.71.2.19 testFuelConsumptionEmissions_Model()

```
void testFuelConsumptionEmissions_Model (
            Model * test_model_ptr )
```

Function to check that the modelled fuel consumption and emissions are > 0.

Parameters

test_model_ptr	A pointer to the test Model object.

```
1430 {
1431     testGreaterThan(
1432         test_model_ptr->total_fuel_consumed_L,
1433         0,
1434         __FILE__,
1435         __LINE__
1436     );
1437
1438     testGreaterThan(
1439         test_model_ptr->total_emissions.CO2_kg,
1440         0,
1441         __FILE__,
1442         __LINE__
1443     );
1444
1445     testGreaterThan(
1446         test_model_ptr->total_emissions.CO_kg,
1447         0,
1448         __FILE__,
1449         __LINE__
1450     );
1451
1452     testGreaterThan(
1453         test_model_ptr->total_emissions.NOx_kg,
1454         0,
1455         __FILE__,
1456         __LINE__
1457     );
1458
1459     testGreaterThan(
1460         test_model_ptr->total_emissions.SOx_kg,
1461         0,
1462         __FILE__,
1463         __LINE__
1464     );
1465
1466     testGreaterThan(
1467         test_model_ptr->total_emissions.CH4_kg,
1468         0,
1469         __FILE__,
1470         __LINE__
1471     );
1472
1473     testGreaterThan(
1474         test_model_ptr->total_emissions.PM_kg,
1475         0,
1476         __FILE__,
1477         __LINE__
1478     );
1479
1480     return;
1481 }   /* testFuelConsumptionEmissions_Model() */
```

5.71.2.20 testLoadBalance_Model()

```
void testLoadBalance_Model (
            Model * test_model_ptr )
```

Function to check that the post-run load data is as expected. That is, the added renewable, production, and storage assets are handled by the Controller as expected.

Parameters

test_model_ptr	A pointer to the test Model object.

```
1283 {
1284     double net_load_kW = 0;
1285 
1286     Combustion* combustion_ptr;
1287     Noncombustion* noncombustion_ptr;
1288     Renewable* renewable_ptr;
1289     Storage* storage_ptr;
1290 
1291     for (int i = 0; i < test_model_ptr->electrical_load.n_points; i++) {
1292         net_load_kW = test_model_ptr->controller.net_load_vec_kW[i];
1293 
1294         testLessThanOrEqualTo(
1295             test_model_ptr->controller.net_load_vec_kW[i],
1296             test_model_ptr->electrical_load.max_load_kW,
1297             __FILE__,
1298             __LINE__
1299         );
1300 
1301         for (size_t j = 0; j < test_model_ptr->combustion_ptr_vec.size(); j++) {
1302             combustion_ptr = test_model_ptr->combustion_ptr_vec[j];
1303 
1304             testFloatEquals(
1305                 combustion_ptr->production_vec_kW[i] -
1306                 combustion_ptr->dispatch_vec_kW[i] -
1307                 combustion_ptr->curtailment_vec_kW[i] -
1308                 combustion_ptr->storage_vec_kW[i],
1309                 0,
1310                 __FILE__,
1311                 __LINE__
1312             );
1313 
1314             net_load_kW -= combustion_ptr->production_vec_kW[i];
1315         }
1316 
1317         for (size_t j = 0; j < test_model_ptr->noncombustion_ptr_vec.size(); j++) {
1318             noncombustion_ptr = test_model_ptr->noncombustion_ptr_vec[j];
1319 
1320             testFloatEquals(
1321                 noncombustion_ptr->production_vec_kW[i] -
1322                 noncombustion_ptr->dispatch_vec_kW[i] -
1323                 noncombustion_ptr->curtailment_vec_kW[i] -
1324                 noncombustion_ptr->storage_vec_kW[i],
1325                 0,
1326                 __FILE__,
1327                 __LINE__
1328             );
1329 
1330             net_load_kW -= noncombustion_ptr->production_vec_kW[i];
1331         }
1332 
1333         for (size_t j = 0; j < test_model_ptr->renewable_ptr_vec.size(); j++) {
1334             renewable_ptr = test_model_ptr->renewable_ptr_vec[j];
1335 
1336             testFloatEquals(
1337                 renewable_ptr->production_vec_kW[i] -
1338                 renewable_ptr->dispatch_vec_kW[i] -
1339                 renewable_ptr->curtailment_vec_kW[i] -
1340                 renewable_ptr->storage_vec_kW[i],
1341                 0,
1342                 __FILE__,
1343                 __LINE__
1344             );
1345 
1346             net_load_kW -= renewable_ptr->production_vec_kW[i];
1347         }
1348 
1349         for (size_t j = 0; j < test_model_ptr->storage_ptr_vec.size(); j++) {
1350             storage_ptr = test_model_ptr->storage_ptr_vec[j];
```

```
1351
1352             testTruth(
1353                 not (
1354                     storage_ptr->charging_power_vec_kW[i] > 0 and
1355                     storage_ptr->discharging_power_vec_kW[i] > 0
1356                 ),
1357                 __FILE__,
1358                 __LINE__
1359             );
1360
1361             net_load_kW -= storage_ptr->discharging_power_vec_kW[i];
1362         }
1363
1364         testLessThanOrEqualTo(
1365             net_load_kW,
1366             0,
1367             __FILE__,
1368             __LINE__
1369         );
1370     }
1371
1372     testFloatEquals(
1373         test_model_ptr->total_dispatch_discharge_kWh,
1374         2263351.62026685,
1375         __FILE__,
1376         __LINE__
1377     );
1378
1379     return;
1380 }   /* testLoadBalance_Model() */
```

5.71.2.21 testPostConstructionAttributes_Model()

```
void testPostConstructionAttributes_Model (
            Model * test_model_ptr )
```

A function to check the values of various post-construction attributes.

Parameters

test_model_ptr	A pointer to the test Model object.

```
142 {
143     testFloatEquals(
144         test_model_ptr->electrical_load.n_points,
145         8760,
146         __FILE__,
147         __LINE__
148     );
149
150     testFloatEquals(
151         test_model_ptr->electrical_load.n_years,
152         0.999886,
153         __FILE__,
154         __LINE__
155     );
156
157     testFloatEquals(
158         test_model_ptr->electrical_load.min_load_kW,
159         82.1211213927802,
160         __FILE__,
161         __LINE__
162     );
163
164     testFloatEquals(
165         test_model_ptr->electrical_load.mean_load_kW,
166         258.373472633202,
167         __FILE__,
168         __LINE__
169     );
170
171
172     testFloatEquals(
173         test_model_ptr->electrical_load.max_load_kW,
174         500,
```

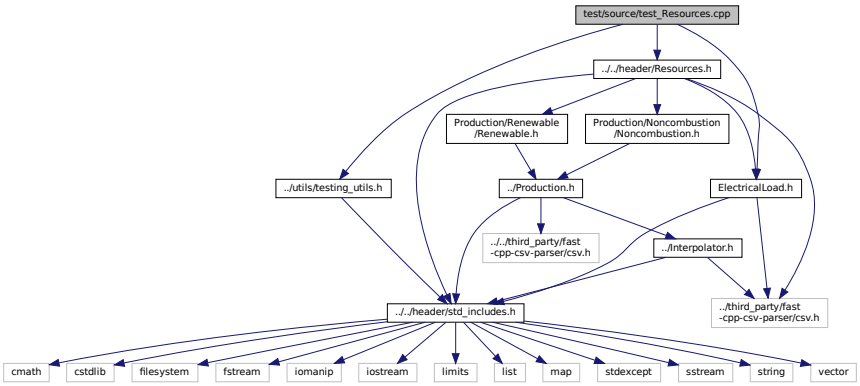
```
175         __FILE__,
176         __LINE__
177     );
178 
179     return;
180 }   /* testPostConstructionAttributes_Model() */
```

5.72 test/source/test_Resources.cpp File Reference

Testing suite for Resources class.

```
#include "../utils/testing_utils.h"
#include "../../header/Resources.h"
#include "../../header/ElectricalLoad.h"
```

Include dependency graph for test_Resources.cpp:



Functions

- Resources * testConstruct_Resources (void)

  A function to construct a Resources object and spot check some post-construction attributes.
- void testAddSolarResource_Resources (Resources *test_resources_ptr, ElectricalLoad *test_electrical_load_ptr, std::string path_2_solar_resource_data, int solar_resource_key)

  Function to test adding a solar resource and then check the values read into the test Resources object.
- void testBadAdd_Resources (Resources *test_resources_ptr, ElectricalLoad *test_electrical_load_ptr, std::string path_2_solar_resource_data, int solar_resource_key)

  Function to test that trying to add bad resource data is being handled as expected.
- void testAddTidalResource_Resources (Resources *test_resources_ptr, ElectricalLoad *test_electrical_load_ptr, std::string path_2_tidal_resource_data, int tidal_resource_key)

  Function to test adding a tidal resource and then check the values read into the test Resources object.
- void testAddWaveResource_Resources (Resources *test_resources_ptr, ElectricalLoad *test_electrical_load_ptr, std::string path_2_wave_resource_data, int wave_resource_key)

  Function to test adding a wave resource and then check the values read into the test Resources object.
- void testAddWindResource_Resources (Resources *test_resources_ptr, ElectricalLoad *test_electrical_load_ptr, std::string path_2_wind_resource_data, int wind_resource_key)

  Function to test adding a wind resource and then check the values read into the test Resources object.
- void testAddHydroResource_Resources (Resources *test_resources_ptr, ElectricalLoad *test_electrical_load_ptr, std::string path_2_hydro_resource_data, int hydro_resource_key)

  Function to test adding a hydro resource and then check the values read into the test Resources object.
- int main (int argc, char **argv)

5.72.1 Detailed Description

Testing suite for Resources class.

A suite of tests for the Resources class.

5.72.2 Function Documentation

5.72.2.1 main()

```
int main (
              int argc,
              char ** argv )
```

```
783 {
784     #ifdef _WIN32
785         activateVirtualTerminal();
786     #endif  /* _WIN32 */
787 
788     printGold("\tTesting Resources");
789 
790     srand(time(NULL));
791 
792 
793     std::string path_2_electrical_load_time_series =
794         "data/test/electrical_load/electrical_load_generic_peak-500kW_1yr_dt-1hr.csv";
795 
796     ElectricalLoad* test_electrical_load_ptr =
797         new ElectricalLoad(path_2_electrical_load_time_series);
798 
799     Resources* test_resources_ptr = testConstruct_Resources();
800 
801 
802     try {
803         int solar_resource_key = 0;
804         std::string path_2_solar_resource_data =
805             "data/test/resources/solar_GHI_peak-1kWm2_1yr_dt-1hr.csv";
806 
807         testAddSolarResource_Resources(
808             test_resources_ptr,
809             test_electrical_load_ptr,
810             path_2_solar_resource_data,
811             solar_resource_key
812         );
813 
814         testBadAdd_Resources(
815             test_resources_ptr,
816             test_electrical_load_ptr,
817             path_2_solar_resource_data,
818             solar_resource_key
819         );
820 
821 
822         int tidal_resource_key = 1;
823         std::string path_2_tidal_resource_data =
824             "data/test/resources/tidal_speed_peak-3ms_1yr_dt-1hr.csv";
825 
826         testAddTidalResource_Resources(
827             test_resources_ptr,
828             test_electrical_load_ptr,
829             path_2_tidal_resource_data,
830             tidal_resource_key
831         );
832 
833 
834         int wave_resource_key = 2;
835         std::string path_2_wave_resource_data =
836             "data/test/resources/waves_H_s_peak-8m_T_e_peak-15s_1yr_dt-1hr.csv";
837 
838         testAddWaveResource_Resources(
839             test_resources_ptr,
840             test_electrical_load_ptr,
841             path_2_wave_resource_data,
```

```
842             wave_resource_key
843         );
844
845
846         int wind_resource_key = 3;
847         std::string path_2_wind_resource_data =
848             "data/test/resources/wind_speed_peak-25ms_1yr_dt-1hr.csv";
849
850         testAddWindResource_Resources(
851             test_resources_ptr,
852             test_electrical_load_ptr,
853             path_2_wind_resource_data,
854             wind_resource_key
855         );
856
857
858         int hydro_resource_key = 4;
859         std::string path_2_hydro_resource_data =
860             "data/test/resources/hydro_inflow_peak-20000m3hr_1yr_dt-1hr.csv";
861
862         testAddHydroResource_Resources(
863             test_resources_ptr,
864             test_electrical_load_ptr,
865             path_2_hydro_resource_data,
866             hydro_resource_key
867         );
868     }
869
870
871     catch (...) {
872         delete test_electrical_load_ptr;
873         delete test_resources_ptr;
874
875         printGold(" ............................... ");
876         printRed("FAIL");
877         std::cout << std::endl;
878         throw;
879     }
880
881
882     delete test_electrical_load_ptr;
883     delete test_resources_ptr;
884
885     printGold(" ............................... ");
886     printGreen("PASS");
887     std::cout << std::endl;
888     return 0;
889 }   /* main() */
```

5.72.2.2 testAddHydroResource_Resources()

```
void testAddHydroResource_Resources (
              Resources * test_resources_ptr,
              ElectricalLoad * test_electrical_load_ptr,
              std::string path_2_hydro_resource_data,
              int hydro_resource_key )
```

Function to test adding a hydro resource and then check the values read into the test Resources object.

Parameters

test_resources_ptr	A pointer to the test Resources object.
test_electrical_load_ptr	A pointer to the test ElectricalLoad object.
path_2_hydro_resource_data	A path (either relative or absolute) to the hydro resource data.
hydro_resource_key	A key used to index into the Resources component of the test Resources object.

```
705 {
706     test_resources_ptr->addResource(
707         NoncombustionType::HYDRO,
708         path_2_hydro_resource_data,
709         hydro_resource_key,
```

```
710         test_electrical_load_ptr
711     );
712 
713     std::vector<double> expected_hydro_resource_vec_m3hr = {
714         2167.91531556942,
715         2046.58261560569,
716         2007.85941123153,
717         2000.11477247929,
718         1917.50527264453,
719         1963.97311577093,
720         1908.46985899809,
721         1886.5267112678,
722         1965.26388854254,
723         1953.64692935289,
724         2084.01504296306,
725         2272.46796101188,
726         2520.29645627096,
727         2715.203242423,
728         2720.36633563203,
729         3130.83228077221,
730         3289.59741021591,
731         3981.45195965772,
732         5295.45929491303,
733         7084.47124360523,
734         7709.20557708454,
735         7436.85238642936,
736         7235.49173429668,
737         6710.14695517339,
738         6015.71085806577,
739         5279.97001316337,
740         4877.24870889801,
741         4421.60569340303,
742         3919.49483690424,
743         3498.70270322341,
744         3274.10813058883,
745         3147.61233529349,
746         2904.94693324343,
747         2805.55738101,
748         2418.32535637171,
749         2398.96375630723,
750         2260.85100182222,
751         2157.58912702878,
752         2019.47637254377,
753         1913.63295220712,
754         1863.29279076589,
755         1748.41395678279,
756         1695.49224555317,
757         1599.97501375715,
758         1559.96103873397,
759         1505.74855473274,
760         1438.62833664765,
761         1384.41585476901
762     };
763 
764     for (size_t i = 0; i < expected_hydro_resource_vec_m3hr.size(); i++) {
765         testFloatEquals(
766             test_resources_ptr->resource_map_1D[hydro_resource_key][i],
767             expected_hydro_resource_vec_m3hr[i],
768             __FILE__,
769             __LINE__
770         );
771     }
772 
773     return;
774 }   /* testAddHydroResource_Resources() */
```

5.72.2.3 testAddSolarResource_Resources()

```
void testAddSolarResource_Resources (
            Resources * test_resources_ptr,
            ElectricalLoad * test_electrical_load_ptr,
            std::string path_2_solar_resource_data,
            int solar_resource_key )
```

Function to test adding a solar resource and then check the values read into the test Resources object.

Parameters

test_resources_ptr	A pointer to the test Resources object.
test_electrical_load_ptr	A pointer to the test ElectricalLoad object.
path_2_solar_resource_data	A path (either relative or absolute) to the solar resource data.
solar_resource_key	A key used to index into the Resources component of the test Resources object.

```
132 {
133     test_resources_ptr->addResource(
134         RenewableType::SOLAR,
135         path_2_solar_resource_data,
136         solar_resource_key,
137         test_electrical_load_ptr
138     );
139 
140     std::vector<double> expected_solar_resource_vec_kWm2 = {
141         0,
142         0,
143         0,
144         0,
145         0,
146         0,
147         8.51702662684015E-05,
148         0.000348341567045,
149         0.00213793728593,
150         0.004099863613322,
151         0.000997135230553,
152         0.009534527624657,
153         0.022927996790616,
154         0.0136071715294,
155         0.002535134127751,
156         0.005206897515821,
157         0.005627658648597,
158         0.000701186722215,
159         0.00017119827089,
160         0,
161         0,
162         0,
163         0,
164         0,
165         0,
166         0,
167         0,
168         0,
169         0,
170         0,
171         0,
172         0.000141055102242,
173         0.00084525014743,
174         0.024893647822702,
175         0.091245556190749,
176         0.158722176731637,
177         0.152859680515876,
178         0.149922903895116,
179         0.13049996570866,
180         0.03081254222795,
181         0.001218928911125,
182         0.000206092647423,
183         0,
184         0,
185         0,
186         0,
187         0,
188         0
189     };
190 
191     for (size_t i = 0; i < expected_solar_resource_vec_kWm2.size(); i++) {
192         testFloatEquals(
193             test_resources_ptr->resource_map_1D[solar_resource_key][i],
194             expected_solar_resource_vec_kWm2[i],
195             __FILE__,
196             __LINE__
197         );
198     }
199 
200     return;
201 }   /* testAddSolarResource_Resources() */
```

5.72.2.4 testAddTidalResource_Resources()

```
void testAddTidalResource_Resources (
            Resources * test_resources_ptr,
            ElectricalLoad * test_electrical_load_ptr,
            std::string path_2_tidal_resource_data,
            int tidal_resource_key )
```

Function to test adding a tidal resource and then check the values read into the test Resources object.

Parameters

test_resources_ptr	A pointer to the test Resources object.
test_electrical_load_ptr	A pointer to the test ElectricalLoad object.
path_2_tidal_resource_data	A path (either relative or absolute) to the tidal resource data.
tidal_resource_key	A key used to index into the Resources component of the test Resources object.

```
332 {
333     test_resources_ptr->addResource(
334         RenewableType::TIDAL,
335         path_2_tidal_resource_data,
336         tidal_resource_key,
337         test_electrical_load_ptr
338     );
339 
340     std::vector<double> expected_tidal_resource_vec_ms = {
341         0.347439913040533,
342         0.770545522195602,
343         0.731352084836198,
344         0.293389814389542,
345         0.209959110813115,
346         0.610609623896497,
347         1.78067162013604,
348         2.53522775118089,
349         2.75966627832024,
350         2.52101111143895,
351         2.05389330201031,
352         1.3461515862445,
353         0.28909254878384,
354         0.897754086048563,
355         1.71406453837407,
356         1.85047408742869,
357         1.71507908595979,
358         1.33540349705416,
359         0.434586143463003,
360         0.500623815700637,
361         1.37172172646733,
362         1.68294125491228,
363         1.56101300975417,
364         1.04925834219412,
365         0.211395463930223,
366         1.03720048903385,
367         1.85059536356448,
368         1.85203242794517,
369         1.4091471616277,
370         0.767776539039899,
371         0.251464906990961,
372         1.47018469375652,
373         2.36260493698197,
374         2.46653750048625,
375         2.12851908739291,
376         1.62783753197988,
377         0.734594890957439,
378         0.441886297300355,
379         1.6574418350918,
380         2.0684558286637,
381         1.87717416992136,
382         1.58871262337931,
383         1.03451227609235,
384         0.193371305159817,
385         0.976400122458815,
386         1.6583227369707,
387         1.76690616570953,
388         1.54801328553115
389     };
390 
391     for (size_t i = 0; i < expected_tidal_resource_vec_ms.size(); i++) {
```

```
392         testFloatEquals(
393             test_resources_ptr->resource_map_1D[tidal_resource_key][i],
394             expected_tidal_resource_vec_ms[i],
395             __FILE__,
396             __LINE__
397         );
398     }
399 
400     return;
401 }   /* testAddTidalResource_Resources() */
```

5.72.2.5 testAddWaveResource_Resources()

```
void testAddWaveResource_Resources (
              Resources * test_resources_ptr,
              ElectricalLoad * test_electrical_load_ptr,
              std::string path_2_wave_resource_data,
              int wave_resource_key )
```

Function to test adding a wave resource and then check the values read into the test Resources object.

Parameters

test_resources_ptr	A pointer to the test Resources object.
test_electrical_load_ptr	A pointer to the test ElectricalLoad object.
path_2_wave_resource_data	A path (either relative or absolute) to the wave resource data.
wave_resource_key	A key used to index into the Resources component of the test Resources object.

```
437 {
438     test_resources_ptr->addResource(
439         RenewableType::WAVE,
440         path_2_wave_resource_data,
441         wave_resource_key,
442         test_electrical_load_ptr
443     );
444 
445     std::vector<double> expected_significant_wave_height_vec_m = {
446         4.26175222125028,
447         4.25020976167872,
448         4.25656524330349,
449         4.27193854786718,
450         4.28744955711233,
451         4.29421815278154,
452         4.2839937266082,
453         4.25716982457976,
454         4.22419391611483,
455         4.19588925217606,
456         4.17338788587412,
457         4.14672746914214,
458         4.10560041173665,
459         4.05074966447193,
460         3.9953696962433,
461         3.95316976150866,
462         3.92771018142378,
463         3.91129562488595,
464         3.89558312094911,
465         3.87861093931749,
466         3.86538307240754,
467         3.86108961027929,
468         3.86459448853189,
469         3.86796474016882,
470         3.86357412779993,
471         3.85554872014731,
472         3.86044266668675,
473         3.89445961915999,
474         3.95554798115731,
475         4.02265508610476,
476         4.07419587011404,
477         4.10314247143958,
478         4.11738045085928,
479         4.12554995596708,
```

```
480         4.12923992001675,
481         4.1229292327442,
482         4.10123955307441,
483         4.06748827895363,
484         4.0336230651344,
485         4.01134236393876,
486         4.00136570034559,
487         3.99368787690411,
488         3.97820924247644,
489         3.95369335178055,
490         3.92742545608532,
491         3.90683362771686,
492         3.89331520944006,
493         3.88256045801583
494     };
495
496     std::vector<double> expected_energy_period_vec_s = {
497         10.4456008226821,
498         10.4614151137651,
499         10.4462827795433,
500         10.4127692097884,
501         10.3734397942723,
502         10.3408599227669,
503         10.32637292093,
504         10.3245412676322,
505         10.310409818185,
506         10.2589529840966,
507         10.1728100603103,
508         10.0862908658929,
509         10.03480243813,
510         10.023673635806,
511         10.0243418565116,
512         10.0063487117653,
513         9.96050302286607,
514         9.9011999635568,
515         9.84451822125472,
516         9.79726875879626,
517         9.75614594835158,
518         9.7173447961368,
519         9.68342904390577,
520         9.66380508567062,
521         9.6674009575699,
522         9.68927134575103,
523         9.70979984863046,
524         9.70967357906908,
525         9.68983025704562,
526         9.6722855524805,
527         9.67973599910003,
528         9.71977125328293,
529         9.78450442291421,
530         9.86532355233449,
531         9.96158937600019,
532         10.0807018356507,
533         10.2291022504937,
534         10.39458528356,
535         10.5464393581004,
536         10.6553277500484,
537         10.7245553190084,
538         10.7893127285064,
539         10.8846512240849,
540         11.0148158739075,
541         11.1544325654719,
542         11.2772785848343,
543         11.3744362756187,
544         11.4533643503183
545     };
546
547     for (size_t i = 0; i < expected_significant_wave_height_vec_m.size(); i++) {
548         testFloatEquals(
549             test_resources_ptr->resource_map_2D[wave_resource_key][i][0],
550             expected_significant_wave_height_vec_m[i],
551             __FILE__,
552             __LINE__
553         );
554
555         testFloatEquals(
556             test_resources_ptr->resource_map_2D[wave_resource_key][i][1],
557             expected_energy_period_vec_s[i],
558             __FILE__,
559             __LINE__
560         );
561     }
562
563     return;
564 }   /* testAddWaveResource_Resources() */
```

5.72.2.6 testAddWindResource_Resources()

```
void testAddWindResource_Resources (
            Resources * test_resources_ptr,
            ElectricalLoad * test_electrical_load_ptr,
            std::string path_2_wind_resource_data,
            int wind_resource_key )
```

Function to test adding a wind resource and then check the values read into the test Resources object.

Parameters

test_resources_ptr	A pointer to the test Resources object.
test_electrical_load_ptr	A pointer to the test ElectricalLoad object.
path_2_wind_resource_data	A path (either relative or absolute) to the wind resource data.
wind_resource_key	A key used to index into the Resources component of the test Resources object.

```
600 {
601     test_resources_ptr->addResource(
602         RenewableType::WIND,
603         path_2_wind_resource_data,
604         wind_resource_key,
605         test_electrical_load_ptr
606     );
607 
608     std::vector<double> expected_wind_resource_vec_ms = {
609         6.88566688469997,
610         5.02177105466549,
611         3.74211715899568,
612         5.67169579985362,
613         4.90670669971858,
614         4.29586955031368,
615         7.41155377205065,
616         10.2243290476943,
617         13.1258696725555,
618         13.7016198628274,
619         16.2481482330233,
620         16.5096744355418,
621         13.4354482206162,
622         14.0129230731609,
623         14.5554549260515,
624         13.4454539065912,
625         13.3447169512094,
626         11.7372615098554,
627         12.7200070078013,
628         10.6421127908149,
629         6.09869498990661,
630         5.66355596602321,
631         4.97316966910831,
632         3.48937138360567,
633         2.15917470979169,
634         1.29061103587027,
635         3.43475751425219,
636         4.11706326260927,
637         4.28905275747408,
638         5.75850263196241,
639         8.98293663055264,
640         11.7069822941315,
641         12.4031987075858,
642         15.4096570910089,
643         16.6210843829552,
644         13.3421219142573,
645         15.2112831900548,
646         18.350864533037,
647         15.8751799822971,
648         15.3921198799796,
649         15.9729192868434,
650         12.4728950178772,
651         10.177050481096,
652         10.7342247355551,
653         8.98846695631389,
654         4.14671169124739,
655         3.17256452697149,
656         3.40036336968628
657     };
658 
659     for (size_t i = 0; i < expected_wind_resource_vec_ms.size(); i++) {
```

```
660         testFloatEquals(
661             test_resources_ptr->resource_map_1D[wind_resource_key][i],
662             expected_wind_resource_vec_ms[i],
663             __FILE__,
664             __LINE__
665         );
666     }
667 
668     return;
669 }   /* testAddWindResource_Resources() */
```

5.72.2.7 testBadAdd_Resources()

```
void testBadAdd_Resources (
              Resources * test_resources_ptr,
              ElectricalLoad * test_electrical_load_ptr,
              std::string path_2_solar_resource_data,
              int solar_resource_key )
```

Function to test that trying to add bad resource data is being handled as expected.

Parameters

test_resources_ptr	A pointer to the test Resources object.
test_electrical_load_ptr	A pointer to the test ElectricalLoad object.
path_2_solar_resource_data	A path (either relative or absolute) to the given solar resource data.
solar_resource_key	A key for indexing into the test Resources object.

```
236 {
237     bool error_flag = true;
238 
239     try {
240         test_resources_ptr->addResource(
241             RenewableType::SOLAR,
242             path_2_solar_resource_data,
243             solar_resource_key,
244             test_electrical_load_ptr
245         );
246 
247         error_flag = false;
248     } catch (...) {
249         // Task failed successfully! =P
250     }
251     if (not error_flag) {
252         expectedErrorNotDetected(__FILE__, __LINE__);
253     }
254 
255 
256     try {
257         std::string path_2_solar_resource_data_BAD_TIMES =
258             "data/test/resources/solar_GHI_peak-1kWm2_1yr_dt-1hr_BAD_TIMES.csv";
259 
260         test_resources_ptr->addResource(
261             RenewableType::SOLAR,
262             path_2_solar_resource_data_BAD_TIMES,
263             -1,
264             test_electrical_load_ptr
265         );
266 
267         error_flag = false;
268     } catch (...) {
269         // Task failed successfully! =P
270     }
271     if (not error_flag) {
272         expectedErrorNotDetected(__FILE__, __LINE__);
273     }
274 
275 
276     try {
277         std::string path_2_solar_resource_data_BAD_LENGTH =
278             "data/test/resources/solar_GHI_peak-1kWm2_1yr_dt-1hr_BAD_LENGTH.csv";
```

```
279
280         test_resources_ptr->addResource(
281             RenewableType::SOLAR,
282             path_2_solar_resource_data_BAD_LENGTH,
283             -2,
284             test_electrical_load_ptr
285         );
286
287         error_flag = false;
288     } catch (...) {
289         // Task failed successfully! =P
290     }
291     if (not error_flag) {
292         expectedErrorNotDetected(__FILE__, __LINE__);
293     }
294
295     return;
296 }   /* testBadAdd_Resources() */
```

5.72.2.8 testConstruct_Resources()

```
Resources * testConstruct_Resources (
              void  )
```

A function to construct a Resources object and spot check some post-construction attributes.

Returns

A pointer to a test Resources object.

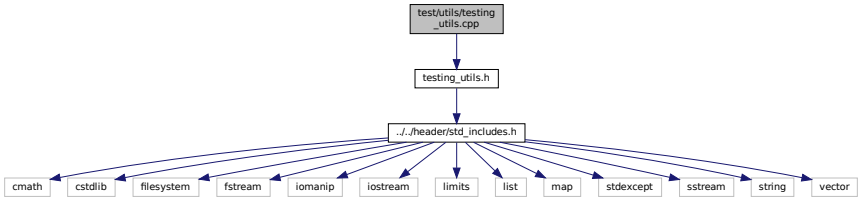
```
64 {
65     Resources* test_resources_ptr = new Resources();
66
67     testFloatEquals(
68         test_resources_ptr->resource_map_1D.size(),
69         0,
70         __FILE__,
71         __LINE__
72     );
73
74     testFloatEquals(
75         test_resources_ptr->path_map_1D.size(),
76         0,
77         __FILE__,
78         __LINE__
79     );
80
81     testFloatEquals(
82         test_resources_ptr->resource_map_2D.size(),
83         0,
84         __FILE__,
85         __LINE__
86     );
87
88     testFloatEquals(
89         test_resources_ptr->path_map_2D.size(),
90         0,
91         __FILE__,
92         __LINE__
93     );
94
95     return test_resources_ptr;
96 }   /* testConstruct_Resources() */
```

5.73 test/utils/testing_utils.cpp File Reference

Implementation file for various PGMcpp testing utilities.

```
#include "testing_utils.h"
```

Include dependency graph for testing_utils.cpp:



Functions

- void printGreen (std::string input_str)

  A function that sends green text to std::cout.
- void printGold (std::string input_str)

  A function that sends gold text to std::cout.
- void printRed (std::string input_str)

  A function that sends red text to std::cout.
- void testFloatEquals (double x, double y, std::string file, int line)

  Tests for the equality of two floating point numbers x and y (to within FLOAT_TOLERANCE).
- void testGreaterThan (double x, double y, std::string file, int line)

  Tests if x > y.
- void testGreaterThanOrEqualTo (double x, double y, std::string file, int line)

  Tests if x >= y.
- void testLessThan (double x, double y, std::string file, int line)

  Tests if x < y.
- void testLessThanOrEqualTo (double x, double y, std::string file, int line)

  Tests if x <= y.
- void testTruth (bool statement, std::string file, int line)

  Tests if the given statement is true.
- void expectedErrorNotDetected (std::string file, int line)

  A utility function to print out a meaningful error message whenever an expected error fails to be thrown/caught/detected.

5.73.1 Detailed Description

Implementation file for various PGMcpp testing utilities.

This is a library of utility functions used throughout the various test suites.

5.73.2 Function Documentation

5.73.2.1 expectedErrorNotDetected()

```
void expectedErrorNotDetected (
            std::string file,
            int line )
```

A utility function to print out a meaningful error message whenever an expected error fails to be thrown/caught/detected.

Parameters

file	The file in which the test is applied (you should be able to just pass in "__FILE__").
line	The line of the file in which the test is applied (you should be able to just pass in "__LINE__").

```
457 {
458     std::string error_str = "\n ERROR  failed to throw expected error prior to line ";
459     error_str += std::to_string(line);
460     error_str += " of ";
461     error_str += file;
462 
463     #ifdef _WIN32
464         std::cout « error_str « std::endl;
465     #endif
466 
467     throw std::runtime_error(error_str);
468     return;
469 }   /* expectedErrorNotDetected() */
```

5.73.2.2 printGold()

```
void printGold (
             std::string input_str )
```

A function that sends gold text to std::cout.

Parameters

input_str	The text of the string to be sent to std::cout.

```
109 {
110     std::cout « "\x1B[33m" « input_str « "\033[0m";
111     return;
112 }   /* printGold() */
```

5.73.2.3 printGreen()

```
void printGreen (
             std::string input_str )
```

A function that sends green text to std::cout.

Parameters

input_str	The text of the string to be sent to std::cout.

```
89 {
90     std::cout « "\x1B[32m" « input_str « "\033[0m";
91     return;
92 }   /* printGreen() */
```

5.73.2.4 printRed()

```
void printRed (
```

```
            std::string input_str )
```

A function that sends red text to std::cout.

Parameters

input_str	The text of the string to be sent to std::cout.

```
129 {
130     std::cout « "\x1B[31m" « input_str « "\033[0m";
131     return;
132 }   /* printRed() */
```

5.73.2.5 testFloatEquals()

```
void testFloatEquals (
            double x,
            double y,
            std::string file,
            int line )
```

Tests for the equality of two floating point numbers *x* and *y* (to within FLOAT_TOLERANCE).

Parameters

x	The first of two numbers to test.
y	The second of two numbers to test.
file	The file in which the test is applied (you should be able to just pass in "__FILE__").
line	The line of the file in which the test is applied (you should be able to just pass in "__LINE__").

```
163 {
164     if (fabs(x - y) <= FLOAT_TOLERANCE) {
165         return;
166     }
167
168     std::string error_str = "ERROR: testFloatEquals():\t in ";
169     error_str += file;
170     error_str += "\tline ";
171     error_str += std::to_string(line);
172     error_str += ":\t\n";
173     error_str += std::to_string(x);
174     error_str += " and ";
175     error_str += std::to_string(y);
176     error_str += " are not equal to within +/- ";
177     error_str += std::to_string(FLOAT_TOLERANCE);
178     error_str += "\n";
179
180     #ifdef _WIN32
181         std::cout « error_str « std::endl;
182     #endif
183
184     throw std::runtime_error(error_str);
185     return;
186 }   /* testFloatEquals() */
```

5.73.2.6 testGreaterThan()

```
void testGreaterThan (
            double x,
```

```
            double y,
            std::string file,
            int line )
```

Tests if x $>$ y.

Parameters

x	The first of two numbers to test.
y	The second of two numbers to test.
file	The file in which the test is applied (you should be able to just pass in "__FILE__").
line	The line of the file in which the test is applied (you should be able to just pass in "__LINE__").

```
216 {
217     if (x > y) {
218         return;
219     }
220
221     std::string error_str = "ERROR: testGreaterThan():\t in ";
222     error_str += file;
223     error_str += "\tline ";
224     error_str += std::to_string(line);
225     error_str += ":\t\n";
226     error_str += std::to_string(x);
227     error_str += " is not greater than ";
228     error_str += std::to_string(y);
229     error_str += "\n";
230
231     #ifdef _WIN32
232         std::cout « error_str « std::endl;
233     #endif
234
235     throw std::runtime_error(error_str);
236     return;
237 }   /* testGreaterThan() */
```

5.73.2.7 testGreaterThanOrEqualTo()

```
void testGreaterThanOrEqualTo (
            double x,
            double y,
            std::string file,
            int line )
```

Tests if x $>=$ y.

Parameters

x	The first of two numbers to test.
y	The second of two numbers to test.
file	The file in which the test is applied (you should be able to just pass in "__FILE__").
line	The line of the file in which the test is applied (you should be able to just pass in "__LINE__").

```
267 {
268     if (x >= y) {
269         return;
270     }
271
272     std::string error_str = "ERROR: testGreaterThanOrEqualTo():\t in ";
273     error_str += file;
274     error_str += "\tline ";
275     error_str += std::to_string(line);
276     error_str += ":\t\n";
```

```
277     error_str += std::to_string(x);
278     error_str += " is not greater than or equal to ";
279     error_str += std::to_string(y);
280     error_str += "\n";
281 
282     #ifdef _WIN32
283         std::cout « error_str « std::endl;
284     #endif
285 
286     throw std::runtime_error(error_str);
287     return;
288 }   /* testGreaterThanOrEqualTo() */
```

5.73.2.8 testLessThan()

```
void testLessThan (
             double x,
             double y,
             std::string file,
             int line )
```

Tests if x < y.

Parameters

x	The first of two numbers to test.
y	The second of two numbers to test.
file	The file in which the test is applied (you should be able to just pass in "__FILE__").
line	The line of the file in which the test is applied (you should be able to just pass in "__LINE__").

```
318 {
319     if (x < y) {
320         return;
321     }
322 
323     std::string error_str = "ERROR: testLessThan():\t in ";
324     error_str += file;
325     error_str += "\tline ";
326     error_str += std::to_string(line);
327     error_str += ":\t\n";
328     error_str += std::to_string(x);
329     error_str += " is not less than ";
330     error_str += std::to_string(y);
331     error_str += "\n";
332 
333     #ifdef _WIN32
334         std::cout « error_str « std::endl;
335     #endif
336 
337     throw std::runtime_error(error_str);
338     return;
339 }   /* testLessThan() */
```

5.73.2.9 testLessThanOrEqualTo()

```
void testLessThanOrEqualTo (
             double x,
             double y,
             std::string file,
             int line )
```

Tests if x <= y.

Parameters

x	The first of two numbers to test.
y	The second of two numbers to test.
file	The file in which the test is applied (you should be able to just pass in "__FILE__").
line	The line of the file in which the test is applied (you should be able to just pass in "__LINE__").

```
369 {
370     if (x <= y) {
371         return;
372     }
373
374     std::string error_str = "ERROR: testLessThanOrEqualTo():\t in ";
375     error_str += file;
376     error_str += "\tline ";
377     error_str += std::to_string(line);
378     error_str += ":\t\n";
379     error_str += std::to_string(x);
380     error_str += " is not less than or equal to ";
381     error_str += std::to_string(y);
382     error_str += "\n";
383
384     #ifdef _WIN32
385         std::cout « error_str « std::endl;
386     #endif
387
388     throw std::runtime_error(error_str);
389     return;
390 }   /* testLessThanOrEqualTo() */
```

5.73.2.10 testTruth()

```
void testTruth (
              bool statement,
              std::string file,
              int line )
```

Tests if the given statement is true.

Parameters

statement	The statement whose truth is to be tested ("1 == 0", for example).
file	The file in which the test is applied (you should be able to just pass in "__FILE__").
line	The line of the file in which the test is applied (you should be able to just pass in "__LINE__").

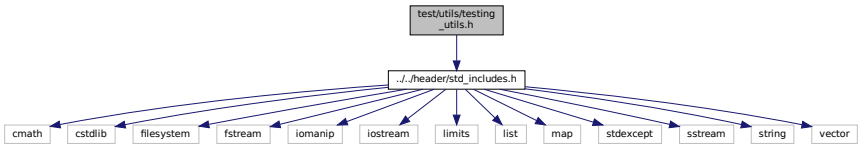
```
417 {
418     if (statement) {
419         return;
420     }
421
422     std::string error_str = "ERROR: testTruth():\t in ";
423     error_str += file;
424     error_str += "\tline ";
425     error_str += std::to_string(line);
426     error_str += ":\t\n";
427     error_str += "Given statement is not true";
428
429     #ifdef _WIN32
430         std::cout « error_str « std::endl;
431     #endif
432
433     throw std::runtime_error(error_str);
434     return;
435 }   /* testTruth() */
```

5.74 test/utils/testing_utils.h File Reference

Header file for various PGMcpp testing utilities.

```
#include "../../header/std_includes.h"
```

Include dependency graph for testing_utils.h:



This graph shows which files directly or indirectly include this file:

Macros

- #define FLOAT_TOLERANCE 1e-6

  A tolerance for application to floating point equality tests.

Functions

- void printGreen (std::string)

  A function that sends green text to std::cout.
- void printGold (std::string)

  A function that sends gold text to std::cout.
- void printRed (std::string)

  A function that sends red text to std::cout.
- void testFloatEquals (double, double, std::string, int)

  Tests for the equality of two floating point numbers x and y (to within FLOAT_TOLERANCE).
- void testGreaterThan (double, double, std::string, int)

  Tests if x > y.
- void testGreaterThanOrEqualTo (double, double, std::string, int)

  Tests if x >= y.
- void testLessThan (double, double, std::string, int)

  Tests if x < y.
- void testLessThanOrEqualTo (double, double, std::string, int)

  Tests if x <= y.
- void testTruth (bool, std::string, int)

  Tests if the given statement is true.
- void expectedErrorNotDetected (std::string, int)

  A utility function to print out a meaningful error message whenever an expected error fails to be thrown/caught/detected.

5.74.1 Detailed Description

Header file for various PGMcpp testing utilities.

This is a library of utility functions used throughout the various test suites.

5.74.2 Macro Definition Documentation

5.74.2.1 FLOAT_TOLERANCE

```
#define FLOAT_TOLERANCE 1e-6
```

A tolerance for application to floating point equality tests.

5.74.3 Function Documentation

5.74.3.1 expectedErrorNotDetected()

```
void expectedErrorNotDetected (
            std::string file,
            int line )
```

A utility function to print out a meaningful error message whenever an expected error fails to be thrown/caught/detected.

Parameters

file	The file in which the test is applied (you should be able to just pass in "__FILE__").
line	The line of the file in which the test is applied (you should be able to just pass in "__LINE__").

```
457 {
458     std::string error_str = "\n ERROR  failed to throw expected error prior to line ";
459     error_str += std::to_string(line);
460     error_str += " of ";
461     error_str += file;
462 
463     #ifdef _WIN32
464         std::cout « error_str « std::endl;
465     #endif
466 
467     throw std::runtime_error(error_str);
468     return;
469 }   /* expectedErrorNotDetected() */
```

5.74.3.2 printGold()

```
void printGold (
            std::string input_str )
```

A function that sends gold text to std::cout.

Parameters

input_str	The text of the string to be sent to std::cout.

```
109 {
110     std::cout « "\x1B[33m" « input_str « "\033[0m";
111     return;
112 }   /* printGold() */
```

5.74.3.3 printGreen()

```
void printGreen (
              std::string input_str )
```

A function that sends green text to std::cout.

Parameters

input_str	The text of the string to be sent to std::cout.

```
89 {
90     std::cout « "\x1B[32m" « input_str « "\033[0m";
91     return;
92 }   /* printGreen() */
```

5.74.3.4 printRed()

```
void printRed (
              std::string input_str )
```

A function that sends red text to std::cout.

Parameters

input_str	The text of the string to be sent to std::cout.

```
129 {
130     std::cout « "\x1B[31m" « input_str « "\033[0m";
131     return;
132 }   /* printRed() */
```

5.74.3.5 testFloatEquals()

```
void testFloatEquals (
              double x,
              double y,
              std::string file,
              int line )
```

Tests for the equality of two floating point numbers *x* and *y* (to within FLOAT_TOLERANCE).

Parameters

x	The first of two numbers to test.
y	The second of two numbers to test.
file	The file in which the test is applied (you should be able to just pass in "__FILE__").
line	The line of the file in which the test is applied (you should be able to just pass in "__LINE__").

```
163 {
164     if (fabs(x - y) <= FLOAT_TOLERANCE) {
165         return;
166     }
167 
168     std::string error_str = "ERROR: testFloatEquals():\t in ";
169     error_str += file;
170     error_str += "\tline ";
171     error_str += std::to_string(line);
172     error_str += ":\t\n";
173     error_str += std::to_string(x);
174     error_str += " and ";
175     error_str += std::to_string(y);
176     error_str += " are not equal to within +/- ";
177     error_str += std::to_string(FLOAT_TOLERANCE);
178     error_str += "\n";
179 
180     #ifdef _WIN32
181         std::cout « error_str « std::endl;
182     #endif
183 
184     throw std::runtime_error(error_str);
185     return;
186 }   /* testFloatEquals() */
```

5.74.3.6 testGreaterThan()

```
void testGreaterThan (
             double x,
             double y,
             std::string file,
             int line )
```

Tests if x > y.

Parameters

x	The first of two numbers to test.
y	The second of two numbers to test.
file	The file in which the test is applied (you should be able to just pass in "__FILE__").
line	The line of the file in which the test is applied (you should be able to just pass in "__LINE__").

```
216 {
217     if (x > y) {
218         return;
219     }
220 
221     std::string error_str = "ERROR: testGreaterThan():\t in ";
222     error_str += file;
223     error_str += "\tline ";
224     error_str += std::to_string(line);
225     error_str += ":\t\n";
226     error_str += std::to_string(x);
227     error_str += " is not greater than ";
228     error_str += std::to_string(y);
229     error_str += "\n";
230 
231     #ifdef _WIN32
232         std::cout « error_str « std::endl;
233     #endif
```

```
234
235     throw std::runtime_error(error_str);
236     return;
237 }   /* testGreaterThan() */
```

5.74.3.7 testGreaterThanOrEqualTo()

```
void testGreaterThanOrEqualTo (
             double x,
             double y,
             std::string file,
             int line )
```

Tests if x >= y.

Parameters

x	The first of two numbers to test.
y	The second of two numbers to test.
file	The file in which the test is applied (you should be able to just pass in "__FILE__").
line	The line of the file in which the test is applied (you should be able to just pass in "__LINE__").

```
267 {
268     if (x >= y) {
269         return;
270     }
271
272     std::string error_str = "ERROR: testGreaterThanOrEqualTo():\t in ";
273     error_str += file;
274     error_str += "\tline ";
275     error_str += std::to_string(line);
276     error_str += ":\t\n";
277     error_str += std::to_string(x);
278     error_str += " is not greater than or equal to ";
279     error_str += std::to_string(y);
280     error_str += "\n";
281
282     #ifdef _WIN32
283         std::cout « error_str « std::endl;
284     #endif
285
286     throw std::runtime_error(error_str);
287     return;
288 }   /* testGreaterThanOrEqualTo() */
```

5.74.3.8 testLessThan()

```
void testLessThan (
             double x,
             double y,
             std::string file,
             int line )
```

Tests if x < y.

Parameters

x	The first of two numbers to test.

Parameters

y	The second of two numbers to test.
file	The file in which the test is applied (you should be able to just pass in "__FILE__").
line	The line of the file in which the test is applied (you should be able to just pass in "__LINE__").

```
318 {
319     if (x < y) {
320         return;
321     }
322
323     std::string error_str = "ERROR: testLessThan():\t in ";
324     error_str += file;
325     error_str += "\tline ";
326     error_str += std::to_string(line);
327     error_str += ":\t\n";
328     error_str += std::to_string(x);
329     error_str += " is not less than ";
330     error_str += std::to_string(y);
331     error_str += "\n";
332
333     #ifdef _WIN32
334         std::cout « error_str « std::endl;
335     #endif
336
337     throw std::runtime_error(error_str);
338     return;
339 }   /* testLessThan() */
```

5.74.3.9 testLessThanOrEqualTo()

```
void testLessThanOrEqualTo (
            double x,
            double y,
            std::string file,
            int line )
```

Tests if x <= y.

Parameters

x	The first of two numbers to test.
y	The second of two numbers to test.
file	The file in which the test is applied (you should be able to just pass in "__FILE__").
line	The line of the file in which the test is applied (you should be able to just pass in "__LINE__").

```
369 {
370     if (x <= y) {
371         return;
372     }
373
374     std::string error_str = "ERROR: testLessThanOrEqualTo():\t in ";
375     error_str += file;
376     error_str += "\tline ";
377     error_str += std::to_string(line);
378     error_str += ":\t\n";
379     error_str += std::to_string(x);
380     error_str += " is not less than or equal to ";
381     error_str += std::to_string(y);
382     error_str += "\n";
383
384     #ifdef _WIN32
385         std::cout « error_str « std::endl;
386     #endif
387
388     throw std::runtime_error(error_str);
389     return;
```

```
390 }   /* testLessThanOrEqualTo() */
```

5.74.3.10 testTruth()

```
void testTruth (
            bool statement,
            std::string file,
            int line )
```

Tests if the given statement is true.

Parameters

statement	The statement whose truth is to be tested ("1 == 0", for example).
file	The file in which the test is applied (you should be able to just pass in "__FILE__").
line	The line of the file in which the test is applied (you should be able to just pass in "__LINE__").

```
417 {
418     if (statement) {
419         return;
420     }
421
422     std::string error_str = "ERROR: testTruth():\t in ";
423     error_str += file;
424     error_str += "\tline ";
425     error_str += std::to_string(line);
426     error_str += ":\t\n";
427     error_str += "Given statement is not true";
428
429     #ifdef _WIN32
430         std::cout « error_str « std::endl;
431     #endif
432
433     throw std::runtime_error(error_str);
434     return;
435 }   /* testTruth() */
```

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