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

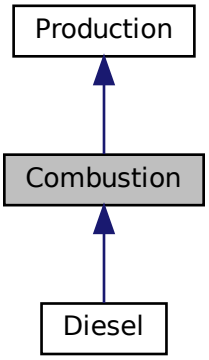
Class Documentation

4.1 Combustion Class Reference

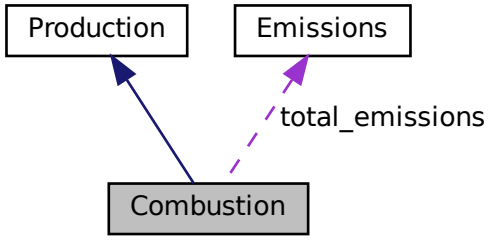
The root of the Combustion branch of the Production hierarchy. This branch contains derived classes which model the production of energy by way of combustibles.

`#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)

  Constructor (intended) for the Combustion class.
- 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.
- double fuel_cost_L

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

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

```
63 {
64     return;
65 }   /* Combustion() */
```

4.1.2.2 Combustion() [2/2]

```
Combustion::Combustion (
            int n_points,
            double n_years,
            CombustionInputs combustion_inputs )
```

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.

```
93   :
94 Production(
95     n_points,
96     n_years,
97     combustion_inputs.production_inputs
98 )
99 {
100     //  1. check inputs
101     this->__checkInputs(combustion_inputs);
102 
103     //  2. set attributes
104     this->fuel_cost_L = 0;
105 
106     this->linear_fuel_slope_LkWh = 0;
107     this->linear_fuel_intercept_LkWh = 0;
108 
109     this->CO2_emissions_intensity_kgL = 0;
110     this->CO_emissions_intensity_kgL = 0;
111     this->NOx_emissions_intensity_kgL = 0;
112     this->SOx_emissions_intensity_kgL = 0;
113     this->CH4_emissions_intensity_kgL = 0;
114     this->PM_emissions_intensity_kgL = 0;
115 
116     this->total_fuel_consumed_L = 0;
117 
118     this->fuel_consumption_vec_L.resize(this->n_points, 0);
119     this->fuel_cost_vec.resize(this->n_points, 0);
120 
121     this->CO2_emissions_vec_kg.resize(this->n_points, 0);
122     this->CO_emissions_vec_kg.resize(this->n_points, 0);
123     this->NOx_emissions_vec_kg.resize(this->n_points, 0);
124     this->SOx_emissions_vec_kg.resize(this->n_points, 0);
125     this->CH4_emissions_vec_kg.resize(this->n_points, 0);
126     this->PM_emissions_vec_kg.resize(this->n_points, 0);
127 
128     //  3. construction print
129     if (this->print_flag) {
130         std::cout « "Combustion object constructed at " « this « std::endl;
131     }
132 
133     return;
134 }   /* Combustion() */
```

4.1.2.3 ~Combustion()

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

Destructor for the Combustion class.

```
413 {
414     //  1. destruction print
415     if (this->print_flag) {
416         std::cout « "Combustion object at " « this « " destroyed" « std::endl;
417     }
418 
419     return;
420 }   /* ~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.

```
40 {
41     // ...
42 
43     return;
44 }   /* __checkInputs() */
```

4.1.3.2 __writeSummary()

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

Reimplemented in Diesel.

```
85 {return;}
```

4.1.3.3 __writeTimeSeries()

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

Reimplemented in Diesel.

```
90          {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.

```
236 {
237     //  1. invoke base class method
238     load_kW = Production :: commit(
239         timestep,
240         dt_hrs,
241         production_kW,
242         load_kW
243     );
244 
245 
246     if (this->is_running) {
247         //  2. compute and record fuel consumption
248         double fuel_consumed_L = this->getFuelConsumptionL(dt_hrs, production_kW);
249         this->fuel_consumption_vec_L[timestep] = fuel_consumed_L;
250 
251         //  3. compute and record emissions
252         Emissions emissions = this->getEmissionskg(fuel_consumed_L);
253         this->CO2_emissions_vec_kg[timestep] = emissions.CO2_kg;
254         this->CO_emissions_vec_kg[timestep] = emissions.CO_kg;
255         this->NOx_emissions_vec_kg[timestep] = emissions.NOx_kg;
256         this->SOx_emissions_vec_kg[timestep] = emissions.SOx_kg;
257         this->CH4_emissions_vec_kg[timestep] = emissions.CH4_kg;
258         this->PM_emissions_vec_kg[timestep] = emissions.PM_kg;
259 
260         //  4. incur fuel costs
```

```
261         this->fuel_cost_vec[timestep] = fuel_consumed_L * this->fuel_cost_L;
262     }
263
264     return load_kW;
265 }   /* 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.

Parameters

time_vec_hrs_ptr	A pointer to the time_vec_hrs attribute of the ElectricalLoad.

Reimplemented from Production.

```
180 {
181     //  1. account for fuel costs in net present cost
182     double t_hrs = 0;
183     double real_discount_scalar = 0;
184
185     for (int i = 0; i < this->n_points; i++) {
186         t_hrs = time_vec_hrs_ptr->at(i);
187
188         real_discount_scalar = 1.0 / pow(
189             1 + this->real_discount_annual,
190             t_hrs / 8760
191         );
192
193         this->net_present_cost += real_discount_scalar * this->fuel_cost_vec[i];
194     }
195
196     //  2. invoke base class method
197     Production :: computeEconomics(time_vec_hrs_ptr);
198
199     return;
200 }   /* computeEconomics() */
```

4.1.3.6 computeFuelAndEmissions()

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

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

```
150 {
151     for (int i = 0; i < n_points; i++) {
152         this->total_fuel_consumed_L += this->fuel_consumption_vec_L[i];
153
154         this->total_emissions.CO2_kg += this->CO2_emissions_vec_kg[i];
155         this->total_emissions.CO_kg += this->CO_emissions_vec_kg[i];
156         this->total_emissions.NOx_kg += this->NOx_emissions_vec_kg[i];
157         this->total_emissions.SOx_kg += this->SOx_emissions_vec_kg[i];
158         this->total_emissions.CH4_kg += this->CH4_emissions_vec_kg[i];
159         this->total_emissions.PM_kg += this->PM_emissions_vec_kg[i];
160     }
161
162     return;
163 }   /* 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.

```
313                                                         {
314     Emissions emissions;
315
316     emissions.CO2_kg = this->CO2_emissions_intensity_kgL * fuel_consumed_L;
317     emissions.CO_kg = this->CO_emissions_intensity_kgL * fuel_consumed_L;
318     emissions.NOx_kg = this->NOx_emissions_intensity_kgL * fuel_consumed_L;
319     emissions.SOx_kg = this->SOx_emissions_intensity_kgL * fuel_consumed_L;
320     emissions.CH4_kg = this->CH4_emissions_intensity_kgL * fuel_consumed_L;
321     emissions.PM_kg = this->PM_emissions_intensity_kgL * fuel_consumed_L;
322
323     return emissions;
324 }   /* 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].

```
287 {
288     double fuel_consumed_L = (
289         this->linear_fuel_slope_LkWh * production_kW +
290         this->linear_fuel_intercept_LkWh * this->capacity_kW
291     ) * dt_hrs;
292
293     return fuel_consumed_L;
294 } /* getFuelConsumptionL() */
```

4.1.3.9 requestProductionkW()

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

Reimplemented in Diesel.

```
130 {return 0;}
```

4.1.3.10 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.

```
360 {
361     //  1. handle sentinel
362     if (max_lines < 0) {
363         max_lines = this->n_points;
364     }
365 
366     //  2. create subdirectories
367     write_path += "Production/";
368     if (not std::filesystem::is_directory(write_path)) {
369         std::filesystem::create_directory(write_path);
370     }
371 
372     write_path += "Combustion/";
373     if (not std::filesystem::is_directory(write_path)) {
374         std::filesystem::create_directory(write_path);
375     }
376 
377     write_path += this->type_str;
378     write_path += "_";
379     write_path += std::to_string(int(ceil(this->capacity_kW)));
380     write_path += "kW_idx";
381     write_path += std::to_string(combustion_index);
382     write_path += "/";
383     std::filesystem::create_directory(write_path);
384 
385     //  3. write summary
386     this->__writeSummary(write_path);
387 
388     //  4. write time series
389     if (max_lines > this->n_points) {
390         max_lines = this->n_points;
391     }
392 
393     if (max_lines > 0) {
394         this->__writeTimeSeries(write_path, time_vec_hrs_ptr, max_lines);
395     }
```

```
396
397     return;
398 }   /* 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 fuel_consumption_vec_L

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

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

4.1.4.8 fuel_cost_L

```
double Combustion::fuel_cost_L
```

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

4.1.4.9 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 nominal costs).

4.1.4.10 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.

4.1.4.11 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.

4.1.4.12 NOx_emissions_intensity_kgL

```
double Combustion::NOx_emissions_intensity_kgL
```

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

4.1.4.13 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.

4.1.4.14 PM_emissions_intensity_kgL

```
double Combustion::PM_emissions_intensity_kgL
```

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

4.1.4.15 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.

4.1.4.16 SOx_emissions_intensity_kgL

```
double Combustion::SOx_emissions_intensity_kgL
```

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

4.1.4.17 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.

4.1.4.18 total_emissions

```
Emissions Combustion::total_emissions
```

An Emissions structure for holding total emissions [kg].

4.1.4.19 total_fuel_consumed_L

```
double Combustion::total_fuel_consumed_L
```

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

4.1.4.20 type

```
CombustionType Combustion::type
```

The type (CombustionType) of the asset.

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

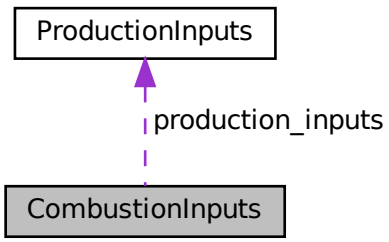
- header/Production/Combustion/Combustion.h
- source/Production/Combustion/Combustion.cpp

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.

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 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 *, std::vector< Combustion * > *, 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 *, std::vector< Combustion * > *, 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 *, std::vector< Combustion * > *, 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 *, std::vector< Combustion * > *, 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 *, std::vector< Combustion * > *, 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 * >)

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

  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)

  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.
- 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.

```
812 {
813     return;
814 }   /* Controller() */
```

4.3.2.2 ~Controller()

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

Destructor for the Controller class.

```
1041 {
1042     this->clear();
1043
1044     return;
1045 }   /* ~Controller() */
```

4.3.3 Member Function Documentation

4.3.3.1 __applyCycleChargingControl_CHARGING()

```
void Controller::__applyCycleChargingControl_CHARGING (
            int timestep,
            ElectricalLoad * electrical_load_ptr,
            std::vector< Combustion * > * combustion_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.
combustion_ptr_vec_ptr	A pointer to the Combustion 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.

```
384 {
385     //  1. default to load following
386     this->__applyLoadFollowingControl_CHARGING(
387         timestep,
388         electrical_load_ptr,
389         combustion_ptr_vec_ptr,
390         renewable_ptr_vec_ptr,
391         storage_ptr_vec_ptr
392     );
393 
394     return;
395 }   /* __applyCycleChargingControl_CHARGING() */
```

4.3.3.2 __applyCycleChargingControl_DISCHARGING()

```
void Controller::__applyCycleChargingControl_DISCHARGING (
              int timestep,
              ElectricalLoad * electrical_load_ptr,
              std::vector< Combustion * > * combustion_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.
combustion_ptr_vec_ptr	A pointer to the Combustion 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

```
434 {
435     //  1. get dt_hrs, net load
436     double dt_hrs = electrical_load_ptr->dt_vec_hrs[timestep];
437     double net_load_kW = this->net_load_vec_kW[timestep];
438 
439     //  2. partition Storage assets into depleted and non-depleted
440     std::list<Storage*> depleted_storage_ptr_list;
441     std::list<Storage*> nondepleted_storage_ptr_list;
442 
443     Storage* storage_ptr;
444     for (size_t i = 0; i < storage_ptr_vec_ptr->size(); i++) {
445         storage_ptr = storage_ptr_vec_ptr->at(i);
446 
447         //...
448     }
449 
450     //  3. discharge non-depleted storage assets
451     net_load_kW = this->__handleStorageDischarging(
452         timestep,
453         dt_hrs,
454         net_load_kW,
455         nondepleted_storage_ptr_list
456     );
457 
458     //  4. request optimal production from all Combustion assets
459     //     default to load following if no depleted storage
460     if (depleted_storage_ptr_list.empty()) {
461         net_load_kW = this->__handleCombustionDispatch(
462             timestep,
463             dt_hrs,
464             net_load_kW,
465             combustion_ptr_vec_ptr,
466             false   // is_cycle_charging
```

```
467         );
468     }
469 
470     else {
471         net_load_kW = this->__handleCombustionDispatch(
472             timestep,
473             dt_hrs,
474             net_load_kW,
475             combustion_ptr_vec_ptr,
476             true    // is_cycle_charging
477         );
478     }
479 
480     //  5. attempt to charge depleted Storage assets using any and all available
482     //     charge priority is Combustion, then Renewable
483     this->__handleStorageCharging(timestep, dt_hrs, depleted_storage_ptr_list);
484 
485     //  6. record any missed load
486     if (net_load_kW > 1e-6) {
487         this->missed_load_vec_kW[timestep] = net_load_kW;
488     }
489 
490     return;
491 }   /* __applyCycleChargingControl_DISCHARGING() */
```

4.3.3.3 __applyLoadFollowingControl_CHARGING()

```
void Controller::__applyLoadFollowingControl_CHARGING (
              int timestep,
              ElectricalLoad * electrical_load_ptr,
              std::vector< Combustion * > * combustion_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.
combustion_ptr_vec_ptr	A pointer to the Combustion 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.

```
245 {
246     //  1. get dt_hrs, set net load
247     double dt_hrs = electrical_load_ptr->dt_vec_hrs[timestep];
248     double net_load_kW = 0;
249 
250     //  2. request zero production from all Combustion assets
251     this->__handleCombustionDispatch(
252         timestep,
253         dt_hrs,
254         net_load_kW,
255         combustion_ptr_vec_ptr,
256         false   // is_cycle_charging
257     );
258 
259     //  3. attempt to charge all Storage assets using any and all available curtailment
260     //     charge priority is Combustion, then Renewable
261     this->__handleStorageCharging(timestep, dt_hrs, storage_ptr_vec_ptr);
262 
263     return;
264 }   /* __applyLoadFollowingControl_CHARGING() */
```

4.3.3.4 __applyLoadFollowingControl_DISCHARGING()

```
void Controller::__applyLoadFollowingControl_DISCHARGING (
            int timestep,
            ElectricalLoad * electrical_load_ptr,
            std::vector< Combustion * > * combustion_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.
combustion_ptr_vec_ptr	A pointer to the Combustion 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

```
302 {
303     //  1. get dt_hrs, net load
304     double dt_hrs = electrical_load_ptr->dt_vec_hrs[timestep];
305     double net_load_kW = this->net_load_vec_kW[timestep];
306 
307     //  2. partition Storage assets into depleted and non-depleted
308     std::list<Storage*> depleted_storage_ptr_list;
309     std::list<Storage*> nondepleted_storage_ptr_list;
310 
311     Storage* storage_ptr;
312     for (size_t i = 0; i < storage_ptr_vec_ptr->size(); i++) {
313         storage_ptr = storage_ptr_vec_ptr->at(i);
314 
315         //...
316     }
317 
318     //  3. discharge non-depleted storage assets
319     net_load_kW = this->__handleStorageDischarging(
320         timestep,
321         dt_hrs,
322         net_load_kW,
323         nondepleted_storage_ptr_list
324     );
325 
326     //  4. request optimal production from all Combustion assets
327     net_load_kW = this->__handleCombustionDispatch(
328         timestep,
329         dt_hrs,
330         net_load_kW,
331         combustion_ptr_vec_ptr,
332         false   // is_cycle_charging
333     );
334 
335     //  5. attempt to charge depleted Storage assets using any and all available
337     //     charge priority is Combustion, then Renewable
338     this->__handleStorageCharging(timestep, dt_hrs, depleted_storage_ptr_list);
339 
340     //  6. record any missed load
341     if (net_load_kW > 1e-6) {
342         this->missed_load_vec_kW[timestep] = net_load_kW;
343     }
344 
345     return;
346 }   /* __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.

```
57 {
58     //  1. init
59     this->net_load_vec_kW.resize(electrical_load_ptr->n_points, 0);
60     this->missed_load_vec_kW.resize(electrical_load_ptr->n_points, 0);
61 
62     //  2. populate net load vector
63     double dt_hrs = 0;
64     double load_kW = 0;
65     double net_load_kW = 0;
66     double production_kW = 0;
67 
68     Renewable* renewable_ptr;
69 
70     for (int i = 0; i < electrical_load_ptr->n_points; i++) {
71         dt_hrs = electrical_load_ptr->dt_vec_hrs[i];
72         load_kW = electrical_load_ptr->load_vec_kW[i];
73         net_load_kW = load_kW;
74 
75         for (size_t j = 0; j < renewable_ptr_vec_ptr->size(); j++) {
76             renewable_ptr = renewable_ptr_vec_ptr->at(j);
77 
78             production_kW = this->__getRenewableProduction(
79                 i,
80                 dt_hrs,
81                 renewable_ptr,
82                 resources_ptr
83             );
84 
85             load_kW = renewable_ptr->commit(
86                 i,
87                 dt_hrs,
88                 production_kW,
89                 load_kW
90             );
91 
92             net_load_kW -= production_kW;
93         }
94 
95         this->net_load_vec_kW[i] = net_load_kW;
96     }
97 
98     return;
99 }   /* __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.

```
121 {
122     //  1. get state table dimensions
123     int n_cols = combustion_ptr_vec_ptr->size();
124     int n_rows = pow(2, n_cols);
125 
126     //  2. init state table (all possible on/off combinations)
127     std::vector<std::vector<bool» state_table;
128     state_table.resize(n_rows, {});
129 
130     int x = 0;
131     for (int i = 0; i < n_rows; i++) {
132         state_table[i].resize(n_cols, false);
133 
134         x = i;
135         for (int j = 0; j < n_cols; j++) {
136             if (x % 2 == 0) {
137                 state_table[i][j] = true;
138             }
139             x /= 2;
140         }
141     }
142 
143     //  3. construct combustion map (handle duplicates by keeping rows with minimum
144     //     trues)
145     double total_capacity_kW = 0;
146     int truth_count = 0;
147     int current_truth_count = 0;
148 
149     for (int i = 0; i < n_rows; i++) {
150         total_capacity_kW = 0;
151         truth_count = 0;
152         current_truth_count = 0;
153 
154         for (int j = 0; j < n_cols; j++) {
155             if (state_table[i][j]) {
156                 total_capacity_kW += combustion_ptr_vec_ptr->at(j)->capacity_kW;
157                 truth_count++;
158             }
159         }
160 
161         if (this->combustion_map.count(total_capacity_kW) > 0) {
162             for (int j = 0; j < n_cols; j++) {
163                 if (this->combustion_map[total_capacity_kW][j]) {
164                     current_truth_count++;
165                 }
166             }
167 
168             if (truth_count < current_truth_count) {
169                 this->combustion_map.erase(total_capacity_kW);
170             }
171         }
172 
173         this->combustion_map.insert(
174             std::pair<double, std::vector<bool» (
175                 total_capacity_kW,
176                 state_table[i]
177             )
178         );
179     }
180 
181     //  4. test print
182     /*
183     std::cout « std::endl;
184 
185     std::cout « "\t\t";
186     for (size_t i = 0; i < combustion_ptr_vec_ptr->size(); i++) {
187         std::cout « combustion_ptr_vec_ptr->at(i)->capacity_kW « "\t";
188     }
189     std::cout « std::endl;
190 
191     std::map<double, std::vector<bool»::iterator iter;
192     for (
193         iter = this->combustion_map.begin();
194         iter != this->combustion_map.end();
195         iter++
196     ) {
197         std::cout « iter->first « ":\t{\t";
198 
199         for (size_t i = 0; i < iter->second.size(); i++) {
200             std::cout « iter->second[i] « "\t";
201         }
202         std::cout « "}" « std::endl;
```

```
203     }
204     */
205
206     return;
207 }   /* __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.

```
595 {
596     double production_kW = 0;
597
598     switch (renewable_ptr->type) {
599         case (RenewableType :: SOLAR): {
600             production_kW = renewable_ptr->computeProductionkW(
601                 timestep,
602                 dt_hrs,
603                 resources_ptr->resource_map_1D[renewable_ptr->resource_key][timestep]
604             );
605
606             break;
607         }
608
609         case (RenewableType :: TIDAL): {
610             production_kW = renewable_ptr->computeProductionkW(
611                 timestep,
612                 dt_hrs,
613                 resources_ptr->resource_map_1D[renewable_ptr->resource_key][timestep]
614             );
615
616             break;
617         }
618
619         case (RenewableType :: WAVE): {
620             production_kW = renewable_ptr->computeProductionkW(
621                 timestep,
622                 dt_hrs,
623                 resources_ptr->resource_map_2D[renewable_ptr->resource_key][timestep][0],
624                 resources_ptr->resource_map_2D[renewable_ptr->resource_key][timestep][1]
625             );
626
627             break;
628         }
629
630         case (RenewableType :: WIND): {
631             production_kW = renewable_ptr->computeProductionkW(
632                 timestep,
633                 dt_hrs,
634                 resources_ptr->resource_map_1D[renewable_ptr->resource_key][timestep]
635             );
```

```
636
637             break;
638         }
639
640         default: {
641             std::string error_str = "ERROR:  Controller::__getRenewableProduction():  ";
642             error_str += "renewable type ";
643             error_str += std::to_string(renewable_ptr->type);
644             error_str += " not recognized";
645
646             #ifdef _WIN32
647                 std::cout « error_str « std::endl;
648             #endif
649
650             throw std::runtime_error(error_str);
651
652             break;
653         }
654     }
655
656     return production_kW;
657 }   /* __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]
```

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.

bool is_cycle_charging)

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.

```
699 {
700     //  1. get minimal Combustion dispatch
701     double target_production_kW = 1.2 * net_load_kW;
702     double total_capacity_kW = 0;
703
704     std::map<double, std::vector<bool»::iterator iter = this->combustion_map.begin();
705     while (iter != std::prev(this->combustion_map.end(), 1)) {
706         if (target_production_kW <= total_capacity_kW) {
707             break;
708         }
709
710         iter++;
711         total_capacity_kW = iter->first;
712     }
```

```
713
714     //  2. share load proportionally (by rated capacity) over active diesels
715     Combustion* combustion_ptr;
716     double production_kW = 0;
717     double request_kW = 0;
718     double _net_load_kW = net_load_kW;
719
720     for (size_t i = 0; i < this->combustion_map[total_capacity_kW].size(); i++) {
721         combustion_ptr = combustion_ptr_vec_ptr->at(i);
722
723         if (total_capacity_kW > 0) {
724             request_kW =
725                 int(this->combustion_map[total_capacity_kW][i]) *
726                 net_load_kW *
727                 (combustion_ptr->capacity_kW / total_capacity_kW);
728         }
729
730         else {
731             request_kW = 0;
732         }
733
734         if (is_cycle_charging and request_kW > 0) {
735             if (request_kW < 0.85 * combustion_ptr->capacity_kW) {
736                 request_kW = 0.85 * combustion_ptr->capacity_kW;
737             }
738         }
739
740         production_kW = combustion_ptr->requestProductionkW(
741             timestep,
742             dt_hrs,
743             request_kW
744         );
745
746         _net_load_kW = combustion_ptr->commit(
747             timestep,
748             dt_hrs,
749             production_kW,
750             _net_load_kW
751         );
752     }
753
754     return _net_load_kW;
755 }   /* __handleCombustionDispatch() */
```

4.3.3.9 __handleStorageCharging() [1/2]

```
void Controller::__handleStorageCharging (
            int timestep,
            double dt_hrs,
            std::list< Storage * > storage_ptr_list )  [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.

```
521 {
522     //...
523
524     return;
525 }   /* __handleStorageCharging() */
```

4.3.3.10 __handleStorageCharging() [2/2]

```
void Controller::__handleStorageCharging (
            int timestep,
            double dt_hrs,
            std::vector< Storage * > * storage_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.

```
555 {
556     //...
557
558     return;
559 }   /* __handleStorageCharging() */
```

4.3.3.11 __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.

```
789 {
790     //...
791
792     return net_load_kW;
793 }   /* __handleStorageDischarging() */
```

4.3.3.12 applyDispatchControl()

```
void Controller::applyDispatchControl (
            ElectricalLoad * electrical_load_ptr,
```

```
            std::vector< Combustion * > * combustion_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.
combustion_ptr_vec_ptr	A pointer to the Combustion 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.

```
936 {
937     for (int i = 0; i < electrical_load_ptr->n_points; i++) {
938         switch (this->control_mode) {
939             case (ControlMode :: LOAD_FOLLOWING): {
940                 if (this->net_load_vec_kW[i] <= 0) {
941                     this->__applyLoadFollowingControl_CHARGING(
942                         i,
943                         electrical_load_ptr,
944                         combustion_ptr_vec_ptr,
945                         renewable_ptr_vec_ptr,
946                         storage_ptr_vec_ptr
947                     );
948                 }
949 
950                 else {
951                     this->__applyLoadFollowingControl_DISCHARGING(
952                         i,
953                         electrical_load_ptr,
954                         combustion_ptr_vec_ptr,
955                         renewable_ptr_vec_ptr,
956                         storage_ptr_vec_ptr
957                     );
958                 }
959 
960                 break;
961             }
962 
963             case (ControlMode :: CYCLE_CHARGING): {
964                 if (this->net_load_vec_kW[i] <= 0) {
965                     this->__applyCycleChargingControl_CHARGING(
966                         i,
967                         electrical_load_ptr,
968                         combustion_ptr_vec_ptr,
969                         renewable_ptr_vec_ptr,
970                         storage_ptr_vec_ptr
971                     );
972                 }
973 
974                 else {
975                     this->__applyCycleChargingControl_DISCHARGING(
976                         i,
977                         electrical_load_ptr,
978                         combustion_ptr_vec_ptr,
979                         renewable_ptr_vec_ptr,
980                         storage_ptr_vec_ptr
981                     );
982                 }
983 
984                 break;
985             }
986 
987             default: {
988                 std::string error_str = "ERROR:  Controller :: applyDispatchControl():  ";
989                 error_str += "control mode ";
990                 error_str += std::to_string(this->control_mode);
991                 error_str += " not recognized";
992 
993                 #ifdef _WIN32
994                     std::cout « error_str « std::endl;
995                 #endif
996 
997                 throw std::runtime_error(error_str);
998 
999                 break;
1000             }
1001         }
1002     }
```

```
1003
1004     return;
1005 }   /* applyDispatchControl() */
```

4.3.3.13 clear()

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

Method to clear all attributes of the Controller object.

```
1020 {
1021     this->net_load_vec_kW.clear();
1022     this->missed_load_vec_kW.clear();
1023     this->combustion_map.clear();
1024
1025     return;
1026 }   /* clear() */
```

4.3.3.14 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.

```
895 {
896     //  1. compute net load
897     this->__computeNetLoad(electrical_load_ptr, renewable_ptr_vec_ptr, resources_ptr);
898
899     //  2. construct Combustion table
900     this->__constructCombustionMap(combustion_ptr_vec_ptr);
901
902     return;
903 }   /* init() */
```

4.3.3.15 setControlMode()

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

Parameters

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

```
829 {
830     this->control_mode = control_mode;
831 
832     switch(control_mode) {
833         case (ControlMode :: LOAD_FOLLOWING): {
834             this->control_string = "LOAD_FOLLOWING";
835 
836             break;
837         }
838 
839         case (ControlMode :: CYCLE_CHARGING): {
840             this->control_string = "CYCLE_CHARGING";
841 
842             break;
843         }
844 
845         default: {
846             std::string error_str = "ERROR:  Controller :: setControlMode():  ";
847                 error_str += "control mode ";
848                 error_str += std::to_string(control_mode);
849                 error_str += " not recognized";
850 
851                 #ifdef _WIN32
852                     std::cout << error_str << std::endl;
853                 #endif
854 
855                 throw std::runtime_error(error_str);
856 
857             break;
858         }
859     }
860 
861     return;
862 }   /* 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:

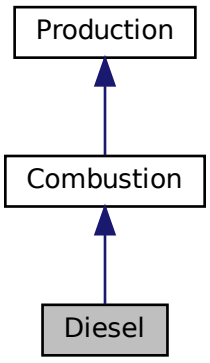
- header/Controller.h
- source/Controller.cpp

4.4 Diesel Class Reference

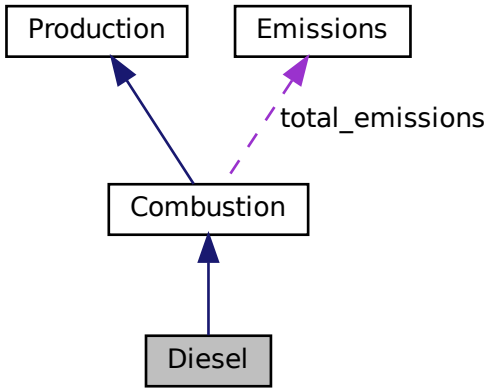
A derived class of the Combustion branch of Production which models production using a diesel generator.

```
#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)

  Constructor (intended) for the Diesel class.
- 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.

```
571 {
572     return;
573 }   /* Diesel() */
```

4.4.2.2 Diesel() [2/2]

```
Diesel::Diesel (
            int n_points,
            double n_years,
            DieselInputs diesel_inputs )
```

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.

```
601   :
602 Combustion(
603     n_points,
604     n_years,
605     diesel_inputs.combustion_inputs
606 )
607 {
608     //  1. check inputs
609     this->__checkInputs(diesel_inputs);
610 
611     //  2. set attributes
612     this->type = CombustionType :: DIESEL;
613     this->type_str = "DIESEL";
614 
615     this->replace_running_hrs = diesel_inputs.replace_running_hrs;
616 
617     this->fuel_cost_L = diesel_inputs.fuel_cost_L;
618 
619     this->minimum_load_ratio = diesel_inputs.minimum_load_ratio;
620     this->minimum_runtime_hrs = diesel_inputs.minimum_runtime_hrs;
621     this->time_since_last_start_hrs = 0;
622 
623     this->CO2_emissions_intensity_kgL = diesel_inputs.CO2_emissions_intensity_kgL;
624     this->CO_emissions_intensity_kgL = diesel_inputs.CO_emissions_intensity_kgL;
625     this->NOx_emissions_intensity_kgL = diesel_inputs.NOx_emissions_intensity_kgL;
626     this->SOx_emissions_intensity_kgL = diesel_inputs.SOx_emissions_intensity_kgL;
627     this->CH4_emissions_intensity_kgL = diesel_inputs.CH4_emissions_intensity_kgL;
628     this->PM_emissions_intensity_kgL = diesel_inputs.PM_emissions_intensity_kgL;
629 
630     if (diesel_inputs.linear_fuel_slope_LkWh < 0) {
631         this->linear_fuel_slope_LkWh = this->__getGenericFuelSlope();
632     }
633 
634     if (diesel_inputs.linear_fuel_intercept_LkWh < 0) {
635         this->linear_fuel_intercept_LkWh = this->__getGenericFuelIntercept();
636     }
637 
638     if (diesel_inputs.capital_cost < 0) {
639         this->capital_cost = this->__getGenericCapitalCost();
640     }
641 
642     if (diesel_inputs.operation_maintenance_cost_kWh < 0) {
643         this->operation_maintenance_cost_kWh = this->__getGenericOpMaintCost();
644     }
645 
646     if (not this->is_sunk) {
647         this->capital_cost_vec[0] = this->capital_cost;
648     }
649 
650     //  3. construction print
651     if (this->print_flag) {
652         std::cout « "Diesel object constructed at " « this « std::endl;
653     }
654 
655     return;
656 }   /* Diesel() */
```

4.4.2.3 ~Diesel()

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

Destructor for the Diesel class.

```
785 {
786     //  1. destruction print
787     if (this->print_flag) {
788         std::cout « "Diesel object at " « this « " destroyed" « std::endl;
789     }
790 
791     return;
792 }   /* ~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.

```
39 {
40     //  1. check fuel_cost_L
41     if (diesel_inputs.fuel_cost_L < 0) {
42         std::string error_str = "ERROR:  Diesel():  ";
43         error_str += "DieselInputs::fuel_cost_L must be >= 0";
44 
45         #ifdef _WIN32
46             std::cout << error_str << std::endl;
47         #endif
48 
49         throw std::invalid_argument(error_str);
50     }
51 
52     //  2. check CO2_emissions_intensity_kgL
53     if (diesel_inputs.CO2_emissions_intensity_kgL < 0) {
54         std::string error_str = "ERROR:  Diesel():  ";
55         error_str += "DieselInputs::CO2_emissions_intensity_kgL must be >= 0";
56 
57         #ifdef _WIN32
58             std::cout << error_str << std::endl;
59         #endif
60 
61         throw std::invalid_argument(error_str);
62     }
63 
64     //  3. check CO_emissions_intensity_kgL
65         if (diesel_inputs.CO_emissions_intensity_kgL < 0) {
66         std::string error_str = "ERROR:  Diesel():  ";
67         error_str += "DieselInputs::CO_emissions_intensity_kgL 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     //  4. check NOx_emissions_intensity_kgL
77     if (diesel_inputs.NOx_emissions_intensity_kgL < 0) {
78         std::string error_str = "ERROR:  Diesel():  ";
79         error_str += "DieselInputs::NOx_emissions_intensity_kgL must be >= 0";
80 
81         #ifdef _WIN32
82             std::cout << error_str << std::endl;
83         #endif
84 
85         throw std::invalid_argument(error_str);
86     }
87 
88     //  5. check SOx_emissions_intensity_kgL
89     if (diesel_inputs.SOx_emissions_intensity_kgL < 0) {
90         std::string error_str = "ERROR:  Diesel():  ";
91         error_str += "DieselInputs::SOx_emissions_intensity_kgL must be >= 0";
92 
93         #ifdef _WIN32
94             std::cout << error_str << std::endl;
95         #endif
96 
97         throw std::invalid_argument(error_str);
98     }
99 
```

```
100     //  6. check CH4_emissions_intensity_kgL
101     if (diesel_inputs.CH4_emissions_intensity_kgL < 0) {
102         std::string error_str = "ERROR:  Diesel():  ";
103         error_str += "DieselInputs::CH4_emissions_intensity_kgL must be >= 0";
104 
105         #ifdef _WIN32
106             std::cout << error_str << std::endl;
107         #endif
108 
109         throw std::invalid_argument(error_str);
110     }
111 
112     //  7. check PM_emissions_intensity_kgL
113     if (diesel_inputs.PM_emissions_intensity_kgL < 0) {
114         std::string error_str = "ERROR:  Diesel():  ";
115         error_str += "DieselInputs::PM_emissions_intensity_kgL must be >= 0";
116 
117         #ifdef _WIN32
118             std::cout << error_str << std::endl;
119         #endif
120 
121         throw std::invalid_argument(error_str);
122     }
123 
124     //  8. check minimum_load_ratio
125     if (diesel_inputs.minimum_load_ratio < 0) {
126         std::string error_str = "ERROR:  Diesel():  ";
127         error_str += "DieselInputs::minimum_load_ratio must be >= 0";
128 
129         #ifdef _WIN32
130             std::cout << error_str << std::endl;
131         #endif
132 
133         throw std::invalid_argument(error_str);
134     }
135 
136     //  9. check minimum_runtime_hrs
137     if (diesel_inputs.minimum_runtime_hrs < 0) {
138         std::string error_str = "ERROR:  Diesel():  ";
139         error_str += "DieselInputs::minimum_runtime_hrs must be >= 0";
140 
141         #ifdef _WIN32
142             std::cout << error_str << std::endl;
143         #endif
144 
145         throw std::invalid_argument(error_str);
146     }
147 
148     //  10. check replace_running_hrs
149     if (diesel_inputs.replace_running_hrs <= 0) {
150         std::string error_str = "ERROR:  Diesel():  ";
151         error_str += "DieselInputs::replace_running_hrs must be > 0";
152 
153         #ifdef _WIN32
154             std::cout << error_str << std::endl;
155         #endif
156 
157         throw std::invalid_argument(error_str);
158     }
159 
160     return;
161 }   /* __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].

```
238 {
239     double capital_cost_per_kW = 1000 * pow(this->capacity_kW, -0.425) + 800;
240 
241     return capital_cost_per_kW * this->capacity_kW;
242 }   /* __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].

```
213 {
214     double linear_fuel_intercept_LkWh = 0.0940 * pow(this->capacity_kW, -0.2735);
215 
216     return linear_fuel_intercept_LkWh;
217 }   /* __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].

```
185 {
186     double linear_fuel_slope_LkWh = 0.4234 * pow(this->capacity_kW, -0.1012);
187 
188     return linear_fuel_slope_LkWh;
189 }   /* __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].

```
266 {
267     double operation_maintenance_cost_kWh = 0.05 * pow(this->capacity_kW, -0.2) + 0.05;
268 
269     return operation_maintenance_cost_kWh;
270 }   /* __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.

```
300 {
301     /*
302      *  Helper method (private) to handle the starting/stopping of the diesel
303      *  generator. The minimum runtime constraint is enforced in this method.
304      */
305 
306     if (this->is_running) {
307         // handle stopping
308         if (
309             production_kW <= 0 and
310             this->time_since_last_start_hrs >= this->minimum_runtime_hrs
311         ) {
312             this->is_running = false;
313         }
314     }
315 
316     else {
317         // handle starting
318         if (production_kW > 0) {
319             this->is_running = true;
320             this->n_starts++;
321             this->time_since_last_start_hrs = 0;
322         }
323     }
324 
```

```
325     return;
326 }   /* __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.

```
345 {
346     //  1. create filestream
347     write_path += "summary_results.md";
348     std::ofstream ofs;
349     ofs.open(write_path, std::ofstream::out);
350 
351     //  2. write to summary results (markdown)
352     ofs « "# ";
353     ofs « std::to_string(int(ceil(this->capacity_kW)));
354     ofs « " kW DIESEL Summary Results\n";
355     ofs « "\n--------\n\n";
356 
357     //  2.1. Production attributes
358     ofs « "## Production Attributes\n";
359     ofs « "\n";
360 
361     ofs « "Capacity: " « this->capacity_kW « "kW  \n";
362     ofs « "\n";
363 
364     ofs « "Sunk Cost (N = 0 / Y = 1): " « this->is_sunk « "  \n";
365     ofs « "Capital Cost: " « this->capital_cost « "  \n";
366     ofs « "Operation and Maintenance Cost: " « this->operation_maintenance_cost_kWh
367         « " per kWh produced  \n";
368     ofs « "Nominal Inflation Rate (annual): " « this->nominal_inflation_annual
369         « "  \n";
370     ofs « "Nominal Discount Rate (annual): " « this->nominal_discount_annual
371         « "  \n";
372     ofs « "Real Discount Rate (annual): " « this->real_discount_annual « "  \n";
373     ofs « "\n";
374 
375     ofs « "Replacement Running Hours: " « this->replace_running_hrs « "  \n";
376     ofs « "\n--------\n\n";
377 
378     //  2.2. Combustion attributes
379     ofs « "## Combustion Attributes\n";
380     ofs « "\n";
381 
382     ofs « "Fuel Cost: " « this->fuel_cost_L « " per L  \n";
383     ofs « "\n";
384 
385     ofs « "Linear Fuel Slope: " « this->linear_fuel_slope_LkWh « " L/kWh  \n";
386     ofs « "Linear Fuel Intercept Coefficient: " « this->linear_fuel_intercept_LkWh
387         « " L/kWh  \n";
388     ofs « "\n";
389 
390     ofs « "Carbon Dioxide (CO2) Emissions Intensity: "
391         « this->CO2_emissions_intensity_kgL « " kg/L  \n";
392 
393     ofs « "Carbon Monoxide (CO) Emissions Intensity: "
394         « this->CO_emissions_intensity_kgL « " kg/L  \n";
395 
396     ofs « "Nitrogen Oxides (NOx) Emissions Intensity: "
397         « this->NOx_emissions_intensity_kgL « " kg/L  \n";
398 
399     ofs « "Sulfur Oxides (SOx) Emissions Intensity: "
400         « this->SOx_emissions_intensity_kgL « " kg/L  \n";
```

```
401
402     ofs « "Methane (CH4) Emissions Intensity: "
403         « this->CH4_emissions_intensity_kgL « " kg/L  \n";
404
405     ofs « "Particulate Matter (PM) Emissions Intensity: "
406         « this->PM_emissions_intensity_kgL « " kg/L  \n";
407
408     ofs « "\n--------\n\n";
409
410     //  2.3. Diesel attributes
411     ofs « "## Diesel Attributes\n";
412     ofs « "\n";
413
414     ofs « "Minimum Load Ratio: " « this->minimum_load_ratio « "  \n";
415     ofs « "Minimum Runtime: " « this->minimum_runtime_hrs « " hrs  \n";
416
417     ofs « "\n--------\n\n";
418
419     //  2.4. Diesel Results
420     ofs « "## Results\n";
421     ofs « "\n";
422
423     ofs « "Net Present Cost: " « this->net_present_cost « "  \n";
424     ofs « "\n";
425
426     ofs « "Total Dispatch: " « this->total_dispatch_kWh
427         « " kWh  \n";
428
429     ofs « "Levellized Cost of Energy: " « this->levellized_cost_of_energy_kWh
430         « " per kWh dispatched  \n";
431     ofs « "\n";
432
433     ofs « "Running Hours: " « this->running_hours « "  \n";
434     ofs « "Starts: " « this->n_starts « "  \n";
435     ofs « "Replacements: " « this->n_replacements « "  \n";
436
437     ofs « "Total Fuel Consumed: " « this->total_fuel_consumed_L « " L "
438         « "(Annual Average: " « this->total_fuel_consumed_L / this->n_years
439         « " L/yr)  \n";
440     ofs « "\n";
441
442     ofs « "Total Carbon Dioxide (CO2) Emissions: " «
443         this->total_emissions.CO2_kg « " kg "
444         « "(Annual Average: " «  this->total_emissions.CO2_kg / this->n_years
445         « " kg/yr)  \n";
446
447     ofs « "Total Carbon Monoxide (CO) Emissions: " «
448         this->total_emissions.CO_kg « " kg "
449         « "(Annual Average: " «  this->total_emissions.CO_kg / this->n_years
450         « " kg/yr)  \n";
451
452     ofs « "Total Nitrogen Oxides (NOx) Emissions: " «
453         this->total_emissions.NOx_kg « " kg "
454         « "(Annual Average: " «  this->total_emissions.NOx_kg / this->n_years
455         « " kg/yr)  \n";
456
457     ofs « "Total Sulfur Oxides (SOx) Emissions: " «
458         this->total_emissions.SOx_kg « " kg "
459         « "(Annual Average: " «  this->total_emissions.SOx_kg / this->n_years
460         « " kg/yr)  \n";
461
462     ofs « "Total Methane (CH4) Emissions: " « this->total_emissions.CH4_kg « " kg "
463         « "(Annual Average: " «  this->total_emissions.CH4_kg / this->n_years
464         « " kg/yr)  \n";
465
466     ofs « "Total Particulate Matter (PM) Emissions: " «
467         this->total_emissions.PM_kg « " kg "
468         « "(Annual Average: " «  this->total_emissions.PM_kg / this->n_years
469         « " kg/yr)  \n";
470
471     ofs « "\n--------\n\n";
472
473     ofs.close();
474     return;
475 }   /* __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.

```
505 {
506     //  1. create filestream
507     write_path += "time_series_results.csv";
508     std::ofstream ofs;
509     ofs.open(write_path, std::ofstream::out);
510 
511     //  2. write time series results (comma separated value)
512     ofs « "Time (since start of data) [hrs],";
513     ofs « "Production [kW],";
514     ofs « "Dispatch [kW],";
515     ofs « "Storage [kW],";
516     ofs « "Curtailment [kW],";
517     ofs « "Is Running (N = 0 / Y = 1),";
518     ofs « "Fuel Consumption [L],";
519     ofs « "Fuel Cost (actual),";
520     ofs « "Carbon Dioxide (CO2) Emissions [kg],";
521     ofs « "Carbon Monoxide (CO) Emissions [kg],";
522     ofs « "Nitrogen Oxides (NOx) Emissions [kg],";
523     ofs « "Sulfur Oxides (SOx) Emissions [kg],";
524     ofs « "Methane (CH4) Emissions [kg],";
525     ofs « "Particulate Matter (PM) Emissions [kg],";
526     ofs « "Capital Cost (actual),";
527     ofs « "Operation and Maintenance Cost (actual),";
528     ofs « "\n";
529 
530     for (int i = 0; i < max_lines; i++) {
531         ofs « time_vec_hrs_ptr->at(i) « ",";
532         ofs « this->production_vec_kW[i] « ",";
533         ofs « this->dispatch_vec_kW[i] « ",";
534         ofs « this->storage_vec_kW[i] « ",";
535         ofs « this->curtailment_vec_kW[i] « ",";
536         ofs « this->is_running_vec[i] « ",";
537         ofs « this->fuel_consumption_vec_L[i] « ",";
538         ofs « this->fuel_cost_vec[i] « ",";
539         ofs « this->CO2_emissions_vec_kg[i] « ",";
540         ofs « this->CO_emissions_vec_kg[i] « ",";
541         ofs « this->NOx_emissions_vec_kg[i] « ",";
542         ofs « this->SOx_emissions_vec_kg[i] « ",";
543         ofs « this->CH4_emissions_vec_kg[i] « ",";
544         ofs « this->PM_emissions_vec_kg[i] « ",";
545         ofs « this->capital_cost_vec[i] « ",";
546         ofs « this->operation_maintenance_cost_vec[i] « ",";
547         ofs « "\n";
548     }
549 
550     ofs.close();
551     return;
552 }   /* __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.

```
743 {
744     //  1. handle start/stop, enforce minimum runtime constraint
745     this->__handleStartStop(timestep, dt_hrs, production_kW);
746 
747     //  2. invoke base class method
748     load_kW = Combustion :: commit(
749         timestep,
750         dt_hrs,
751         production_kW,
752         load_kW
753     );
754 
755     if (this->is_running) {
756         //  3. log time since last start
757         this->time_since_last_start_hrs += dt_hrs;
758 
759         //  4. correct operation and maintenance costs (should be non-zero if idling)
760         if (production_kW <= 0) {
761             double produced_kWh = 0.01 * this->capacity_kW * dt_hrs;
762 
763             double operation_maintenance_cost =
764                 this->operation_maintenance_cost_kWh * produced_kWh;
765             this->operation_maintenance_cost_vec[timestep] = operation_maintenance_cost;
766         }
767     }
768 
769     return load_kW;
770 }   /* commit() */
```

4.4.3.10 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.

```
688 {
689     //  1. return on request of zero
690     if (request_kW <= 0) {
691         return 0;
692     }
693
694     double deliver_kW = request_kW;
695
696     //  2. enforce capacity constraint
697     if (deliver_kW > this->capacity_kW) {
698         deliver_kW = this->capacity_kW;
699     }
700
701     //  3. enforce minimum load ratio
702     if (deliver_kW < this->minimum_load_ratio * this->capacity_kW) {
703         deliver_kW = this->minimum_load_ratio * this->capacity_kW;
704     }
705
706     return deliver_kW;
707 }   /* 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:

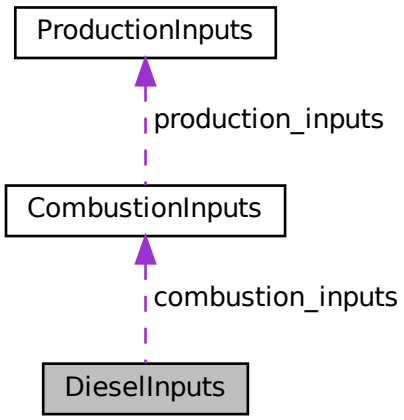
- header/Production/Combustion/Diesel.h
- source/Production/Combustion/Diesel.cpp

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.

```
37 {
38     return;
39 }   /* 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.

```
57 {
58     this->readLoadData(path_2_electrical_load_time_series);
59
60     return;
61 }   /* ElectricalLoad() */
```

4.6.2.3 ~ElectricalLoad()

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

Destructor for the ElectricalLoad class.

```
184 {
185     this->clear();
186     return;
187 }   /* ~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.

```
157 {
158     this->n_points = 0;
159     this->n_years = 0;
160     this->min_load_kW = 0;
161     this->mean_load_kW = 0;
162     this->max_load_kW = 0;
163 
164     this->path_2_electrical_load_time_series.clear();
165     this->time_vec_hrs.clear();
166     this->dt_vec_hrs.clear();
167     this->load_vec_kW.clear();
168 
169     return;
170 }   /* 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.

```
79 {
80     //  1. clear
81     this->clear();
82 
83     //  2. init CSV reader, record path
84     io::CSVReader<2> CSV(path_2_electrical_load_time_series);
85 
86     CSV.read_header(
87         io::ignore_extra_column,
88         "Time (since start of data) [hrs]",
89         "Electrical Load [kW]"
90     );
91 
92     this->path_2_electrical_load_time_series = path_2_electrical_load_time_series;
93 
94     //  3. read in time and load data, increment n_points, track min and max load
95     double time_hrs = 0;
96     double load_kW = 0;
97     double load_sum_kW = 0;
98 
99     this->n_points = 0;
100 
101     this->min_load_kW = std::numeric_limits<double>::infinity();
102     this->max_load_kW = -1 * std::numeric_limits<double>::infinity();
103 
104     while (CSV.read_row(time_hrs, load_kW)) {
105         this->time_vec_hrs.push_back(time_hrs);
106         this->load_vec_kW.push_back(load_kW);
107 
108         load_sum_kW += load_kW;
109 
110         this->n_points++;
111 
112         if (this->min_load_kW > load_kW) {
113             this->min_load_kW = load_kW;
114         }
115 
```

```
116         if (this->max_load_kW < load_kW) {
117             this->max_load_kW = load_kW;
118         }
119     }
120
121     //  4. compute mean load
122     this->mean_load_kW = load_sum_kW / this->n_points;
123
124     //  5. set number of years (assuming 8,760 hours per year)
125     this->n_years = this->time_vec_hrs[this->n_points - 1] / 8760;
126
127     //  6. populate dt_vec_hrs
128     this->dt_vec_hrs.resize(n_points, 0);
129
130     for (int i = 0; i < n_points; i++) {
131         if (i == n_points - 1) {
132             this->dt_vec_hrs[i] = this->dt_vec_hrs[i - 1];
133         }
134
135         else {
136             double dt_hrs = this->time_vec_hrs[i + 1] - this->time_vec_hrs[i];
137
138             this->dt_vec_hrs[i] = dt_hrs;
139         }
140     }
141
142     return;
143 }   /* 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:

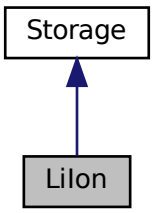
- header/Production/Combustion/Combustion.h

4.8 LiIon Class Reference

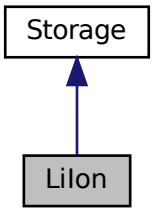
A derived class of Storage which models energy storage by way of lithium-ion batteries.

`#include <LiIon.h>`

Inheritance diagram for LiIon:



Collaboration diagram for LiIon:



Public Member Functions

- LiIon (void)

  Constructor for the LiIon class.
- ~LiIon (void)

  Destructor for the LiIon class.

4.8.1 Detailed Description

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

4.8.2 Constructor & Destructor Documentation

4.8.2.1 LiIon()

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

Constructor for the LiIon class.

```
35                  :
36 Storage()
37 {
38     //...
39
40     return;
41 }   /* LiIon() */
```

4.8.2.2 ~LiIon()

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

Destructor for the LiIon class.

```
64 {
65     //...
66
67     return;
68 }   /* ~LiIon() */
```

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

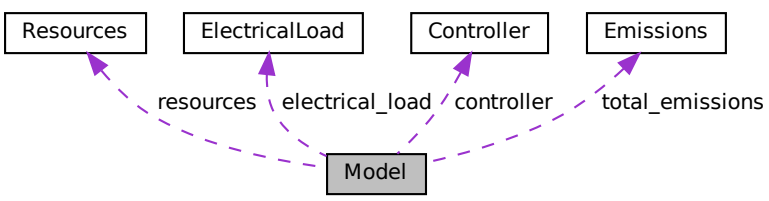
- header/Storage/LiIon.h
- source/Storage/LiIon.cpp

4.9 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 (RenewableType, std::string, int)

  A method to add a renewable resource time series 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 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_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< 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.
- 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.

4.9.1 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.

4.9.2 Constructor & Destructor Documentation

4.9.2.1 Model() [1/2]

```
Model::Model (
            void  )
```

Constructor (dummy) for the Model class.

```
468 {
469     return;
470 }   /* Model() */
```

4.9.2.2 Model() [2/2]

```
Model::Model (
            ModelInputs model_inputs )
```

Constructor (intended) for the Model class.

Parameters

model_inputs	A structure of Model constructor inputs.

```
487 {
488     //  1. check inputs
489     this->__checkInputs(model_inputs);
490 
491     //  2. read in electrical load data
492     this->electrical_load.readLoadData(model_inputs.path_2_electrical_load_time_series);
493 
494     //  3. set control mode
495     this->controller.setControlMode(model_inputs.control_mode);
496 
497     //  4. set public attributes
498     this->total_fuel_consumed_L = 0;
499     this->net_present_cost = 0;
500     this->total_dispatch_discharge_kWh = 0;
501     this->levellized_cost_of_energy_kWh = 0;
502 
503     return;
504 }   /* Model() */
```

4.9.2.3 ~Model()

```
Model::~Model (
              void  )
```

Destructor for the Model class.

```
906 {
907     this->clear();
908     return;
909 }   /* ~Model() */
```

4.9.3 Member Function Documentation

4.9.3.1 __checkInputs()

```
void Model::__checkInputs (
              ModelInputs  )  [private]
```

Helper method (private) to check inputs to the Model constructor.

Parameters

model_inputs	A structure of Model constructor inputs.

```
40 {
41     //...
42 
43     return;
44 }   /* __checkInputs() */
```

4.9.3.2 __computeEconomics()

```
void Model::__computeEconomics (
              void  )  [private]
```

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

```
208 {
209     this->__computeNetPresentCost();
210     this->__computeLevellizedCostOfEnergy();
211 
212     return;
213 }   /* __computeEconomics() */
```

4.9.3.3 __computeFuelAndEmissions()

```
void Model::__computeFuelAndEmissions (
            void  )  [private]
```

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

```
60 {
61     for (size_t i = 0; i < this->combustion_ptr_vec.size(); i++) {
62         this->combustion_ptr_vec[i]->computeFuelAndEmissions();
63 
64         this->total_fuel_consumed_L +=
65             this->combustion_ptr_vec[i]->total_fuel_consumed_L;
66 
67         this->total_emissions.CO2_kg +=
68             this->combustion_ptr_vec[i]->total_emissions.CO2_kg;
69 
70         this->total_emissions.CO_kg +=
71             this->combustion_ptr_vec[i]->total_emissions.CO_kg;
72 
73         this->total_emissions.NOx_kg +=
74             this->combustion_ptr_vec[i]->total_emissions.NOx_kg;
75 
76         this->total_emissions.SOx_kg +=
77             this->combustion_ptr_vec[i]->total_emissions.SOx_kg;
78 
79         this->total_emissions.CH4_kg +=
80             this->combustion_ptr_vec[i]->total_emissions.CH4_kg;
81 
82         this->total_emissions.PM_kg +=
83             this->combustion_ptr_vec[i]->total_emissions.PM_kg;
84     }
85 
86     return;
87 }   /* __computeFuelAndEmissions() */
```

4.9.3.4 __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.

```
162 {
163     //  1. account for Combustion economics in levellized cost of energy
164     for (size_t i = 0; i < this->combustion_ptr_vec.size(); i++) {
165         this->levellized_cost_of_energy_kWh +=
166             (
167                 this->combustion_ptr_vec[i]->levellized_cost_of_energy_kWh *
168                 this->combustion_ptr_vec[i]->total_dispatch_kWh
169             ) / this->total_dispatch_discharge_kWh;
170     }
171 
172     //  2. account for Renewable economics in levellized cost of energy
173     for (size_t i = 0; i < this->renewable_ptr_vec.size(); i++) {
174         this->levellized_cost_of_energy_kWh +=
175             (
176                 this->renewable_ptr_vec[i]->levellized_cost_of_energy_kWh *
177                 this->renewable_ptr_vec[i]->total_dispatch_kWh
178             ) / this->total_dispatch_discharge_kWh;
179     }
180 
```

```
181     //  3. account for Storage economics in levellized cost of energy
182     for (size_t i = 0; i < this->storage_ptr_vec.size(); i++) {
183         /*
184         this->levellized_cost_of_energy_kWh +=
185             (
186                 this->storage_ptr_vec[i]->levellized_cost_of_energy_kWh *
187                 this->storage_ptr_vec[i]->total_discharge_kWh
188             ) / this->total_dispatch_discharge_kWh;
189         */
190     }
191
192     return;
193 }   /* __computeLevellizedCostOfEnergy() */
```

4.9.3.5 __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.

```
103 {
104     //  1. account for Combustion economics in net present cost
105     //     increment total dispatch
106     for (size_t i = 0; i < this->combustion_ptr_vec.size(); i++) {
107         this->combustion_ptr_vec[i]->computeEconomics(
108             &(this->electrical_load.time_vec_hrs)
109         );
110
111         this->net_present_cost += this->combustion_ptr_vec[i]->net_present_cost;
112
113         this->total_dispatch_discharge_kWh +=
114             this->combustion_ptr_vec[i]->total_dispatch_kWh;
115     }
116
117     //  2. account for Renewable economics in net present cost,
118     //     increment total dispatch
119     for (size_t i = 0; i < this->renewable_ptr_vec.size(); i++) {
120         this->renewable_ptr_vec[i]->computeEconomics(
121             &(this->electrical_load.time_vec_hrs)
122         );
123
124         this->net_present_cost += this->renewable_ptr_vec[i]->net_present_cost;
125
126         this->total_dispatch_discharge_kWh +=
127             this->renewable_ptr_vec[i]->total_dispatch_kWh;
128     }
129
130     //  3. account for Storage economics in net present cost
131     //     increment total dispatch
132     for (size_t i = 0; i < this->storage_ptr_vec.size(); i++) {
133         /*
134         this->storage_ptr_vec[i]->computeEconomics(
135             &(this->electrical_load.time_vec_hrs)
136         );
137
138         this->net_present_cost += this->storage_ptr_vec[i]->net_present_cost;
139
140         this->total_dispatch_discharge_kWh +=
141             this->storage_ptr_vec[i]->total_discharge_kWh;
142         */
143     }
144
145     return;
146 }   /* __computeNetPresentCost() */
```

4.9.3.6 __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.

```
231 {
232     //  1. create subdirectory
233     write_path += "Model/";
234     std::filesystem::create_directory(write_path);
235 
236     //  2. create filestream
237     write_path += "summary_results.md";
238     std::ofstream ofs;
239     ofs.open(write_path, std::ofstream::out);
240 
241     //  3. write summary results (markdown)
242     ofs « "# Model Summary Results\n";
243     ofs « "\n--------\n\n";
244 
245     //  3.1. ElectricalLoad
246     ofs « "## Electrical Load\n";
247     ofs « "\n";
248     ofs « "Path: " «
249         this->electrical_load.path_2_electrical_load_time_series « "  \n";
250     ofs « "Data Points: " « this->electrical_load.n_points « "  \n";
251     ofs « "Years: " « this->electrical_load.n_years « "  \n";
252     ofs « "Min: " « this->electrical_load.min_load_kW « " kW  \n";
253     ofs « "Mean: " « this->electrical_load.mean_load_kW « " kW  \n";
254     ofs « "Max: " « this->electrical_load.max_load_kW « " kW  \n";
255     ofs « "\n--------\n\n";
256 
257     //  3.2. Controller
258     ofs « "## Controller\n";
259     ofs « "\n";
260     ofs « "Control Mode: " « this->controller.control_string « "  \n";
261     ofs « "\n--------\n\n";
262 
263     //  3.3. Resources (1D)
264     ofs « "## 1D Renewable Resources\n";
265     ofs « "\n";
266 
267     std::map<int, std::string>::iterator string_map_1D_iter =
268         this->resources.string_map_1D.begin();
269     std::map<int, std::string>::iterator path_map_1D_iter =
270         this->resources.path_map_1D.begin();
271 
272     while (
273         string_map_1D_iter != this->resources.string_map_1D.end() and
274         path_map_1D_iter != this->resources.path_map_1D.end()
275     ) {
276         ofs « "Resource Key: " « string_map_1D_iter->first « "  \n";
277         ofs « "Type: " « string_map_1D_iter->second « "  \n";
278         ofs « "Path: " « path_map_1D_iter->second « "  \n";
279         ofs « "\n";
280 
281         string_map_1D_iter++;
282         path_map_1D_iter++;
283     }
284 
285     ofs « "\n--------\n\n";
286 
287     //  3.4. Resources (2D)
288     ofs « "## 2D Renewable Resources\n";
289     ofs « "\n";
290 
291     std::map<int, std::string>::iterator string_map_2D_iter =
292         this->resources.string_map_2D.begin();
293     std::map<int, std::string>::iterator path_map_2D_iter =
294         this->resources.path_map_2D.begin();
295 
296     while (
297         string_map_2D_iter != this->resources.string_map_2D.end() and
298         path_map_2D_iter != this->resources.path_map_2D.end()
299     ) {
300         ofs « "Resource Key: " « string_map_2D_iter->first « "  \n";
301         ofs « "Type: " « string_map_2D_iter->second « "  \n";
302         ofs « "Path: " « path_map_2D_iter->second « "  \n";
303         ofs « "\n";
304 
305         string_map_2D_iter++;
306         path_map_2D_iter++;
307     }
308 
309     ofs « "\n--------\n\n";
310 
```

```
311     //  3.5. Combustion
312     ofs « "## Combustion Assets\n";
313     ofs « "\n";
314
315     for (size_t i = 0; i < this->combustion_ptr_vec.size(); i++) {
316         ofs « "Asset Index: " « i « "  \n";
317         ofs « "Type: " « this->combustion_ptr_vec[i]->type_str « "  \n";
318         ofs « "Capacity: " « this->combustion_ptr_vec[i]->capacity_kW « " kW  \n";
319         ofs « "\n";
320     }
321
322     ofs « "\n--------\n\n";
323
324     //  3.6. Renewable
325     ofs « "## Renewable Assets\n";
326     ofs « "\n";
327
328     for (size_t i = 0; i < this->renewable_ptr_vec.size(); i++) {
329         ofs « "Asset Index: " « i « "  \n";
330         ofs « "Type: " « this->renewable_ptr_vec[i]->type_str « "  \n";
331         ofs « "Capacity: " « this->renewable_ptr_vec[i]->capacity_kW « " kW  \n";
332         ofs « "\n";
333     }
334
335     ofs « "\n--------\n\n";
336
337     //  3.7. Storage
338     ofs « "## Storage Assets\n";
339     ofs « "\n";
340
341     for (size_t i = 0; i < this->storage_ptr_vec.size(); i++) {
342         //...
343     }
344
345     ofs « "\n--------\n\n";
346
347     //  3.8. Model Results
348     ofs « "## Results\n";
349     ofs « "\n";
350
351     ofs « "Net Present Cost: " « this->net_present_cost « "  \n";
352     ofs « "\n";
353
354     ofs « "Total Dispatch + Discharge: " « this->total_dispatch_discharge_kWh
355         « " kWh  \n";
356
357     ofs « "Levellized Cost of Energy: " « this->levellized_cost_of_energy_kWh
358         « " per kWh dispatched/discharged  \n";
359     ofs « "\n";
360
361     ofs « "Total Fuel Consumed: " « this->total_fuel_consumed_L « " L "
362         « "(Annual Average: " «
363             this->total_fuel_consumed_L / this->electrical_load.n_years
364         « " L/yr)  \n";
365     ofs « "\n";
366
367     ofs « "Total Carbon Dioxide (CO2) Emissions: " «
368         this->total_emissions.CO2_kg « " kg "
369         « "(Annual Average: " «
370             this->total_emissions.CO2_kg / this->electrical_load.n_years
371         « " kg/yr)  \n";
372
373     ofs « "Total Carbon Monoxide (CO) Emissions: " «
374         this->total_emissions.CO_kg « " kg "
375         « "(Annual Average: " «
376             this->total_emissions.CO_kg / this->electrical_load.n_years
377         « " kg/yr)  \n";
378
379     ofs « "Total Nitrogen Oxides (NOx) Emissions: " «
380         this->total_emissions.NOx_kg « " kg "
381         « "(Annual Average: " «
382             this->total_emissions.NOx_kg / this->electrical_load.n_years
383         « " kg/yr)  \n";
384
385     ofs « "Total Sulfur Oxides (SOx) Emissions: " «
386         this->total_emissions.SOx_kg « " kg "
387         « "(Annual Average: " «
388             this->total_emissions.SOx_kg / this->electrical_load.n_years
389         « " kg/yr)  \n";
390
391     ofs « "Total Methane (CH4) Emissions: " « this->total_emissions.CH4_kg « " kg "
392         « "(Annual Average: " «
393             this->total_emissions.CH4_kg / this->electrical_load.n_years
394         « " kg/yr)  \n";
395
396     ofs « "Total Particulate Matter (PM) Emissions: " «
397         this->total_emissions.PM_kg « " kg "
```

```
398         << "(Annual Average: " <<
399             this->total_emissions.PM_kg / this->electrical_load.n_years
400         << " kg/yr)  \n";
401 
402     ofs << "\n--------\n\n";
403 
404     ofs.close();
405     return;
406 }   /* __writeSummary() */
```

4.9.3.7 __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.

```
426 {
427     //  1. create filestream
428     write_path += "Model/time_series_results.csv";
429     std::ofstream ofs;
430     ofs.open(write_path, std::ofstream::out);
431 
432     //  2. write time series results (comma separated value)
433     ofs << "Time (since start of data) [hrs],";
434     ofs << "Electrical Load [kW],";
435     ofs << "Net Load [kW],";
436     ofs << "Missed Load [kW],";
437     ofs << "\n";
438 
439     for (int i = 0; i < max_lines; i++) {
440         ofs << this->electrical_load.time_vec_hrs[i] << ",";
441         ofs << this->electrical_load.load_vec_kW[i] << ",";
442         ofs << this->controller.net_load_vec_kW[i] << ",";
443         ofs << this->controller.missed_load_vec_kW[i] << ",";
444         ofs << "\n";
445     }
446 
447     ofs.close();
448     return;
449 }   /* __writeTimeSeries() */
```

4.9.3.8 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.

```
521 {
522     Combustion* diesel_ptr = new Diesel(
523         this->electrical_load.n_points,
524         this->electrical_load.n_years,
525         diesel_inputs
526     );
527 
528     this->combustion_ptr_vec.push_back(diesel_ptr);
529 
530     return;
531 }   /* addDiesel() */
```

4.9.3.9 addResource()

```
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.

```
560 {
561     resources.addResource(
562         renewable_type,
563         path_2_resource_data,
564         resource_key,
565         &(this->electrical_load)
566     );
567 
568     return;
569 }   /* addResource() */
```

4.9.3.10 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.

```
586 {
587     Renewable* solar_ptr = new Solar(
588         this->electrical_load.n_points,
589         this->electrical_load.n_years,
590         solar_inputs
591     );
592 
593     this->renewable_ptr_vec.push_back(solar_ptr);
```

```
594
595     return;
596 }   /* addSolar() */
```

4.9.3.11 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.

```
613 {
614     Renewable* tidal_ptr = new Tidal(
615         this->electrical_load.n_points,
616         this->electrical_load.n_years,
617         tidal_inputs
618     );
619
620     this->renewable_ptr_vec.push_back(tidal_ptr);
621
622     return;
623 }   /* addTidal() */
```

4.9.3.12 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.

```
640 {
641     Renewable* wave_ptr = new Wave(
642         this->electrical_load.n_points,
643         this->electrical_load.n_years,
644         wave_inputs
645     );
646
647     this->renewable_ptr_vec.push_back(wave_ptr);
648
649     return;
650 }   /* addWave() */
```

4.9.3.13 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.

```
667 {
668     Renewable* wind_ptr = new Wind(
669         this->electrical_load.n_points,
670         this->electrical_load.n_years,
671         wind_inputs
672     );
673 
674     this->renewable_ptr_vec.push_back(wind_ptr);
675 
676     return;
677 }   /* addWind() */
```

4.9.3.14 clear()

```
void Model::clear (
             void  )
```

Method to clear all attributes of the Model object.

```
783 {
784     //  1. reset
785     this->reset();
786 
787     //  2. clear components
788     controller.clear();
789     electrical_load.clear();
790     resources.clear();
791 
792     return;
793 }   /* clear() */
```

4.9.3.15 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.

```
734 {
735     //  1. clear combustion_ptr_vec
736     for (size_t i = 0; i < this->combustion_ptr_vec.size(); i++) {
737         delete this->combustion_ptr_vec[i];
738     }
739     this->combustion_ptr_vec.clear();
740 
741     //  2. clear renewable_ptr_vec
742     for (size_t i = 0; i < this->renewable_ptr_vec.size(); i++) {
743         delete this->renewable_ptr_vec[i];
744     }
745     this->renewable_ptr_vec.clear();
746 
747     //  3. clear storage_ptr_vec
748     for (size_t i = 0; i < this->storage_ptr_vec.size(); i++) {
749         delete this->storage_ptr_vec[i];
750     }
751     this->storage_ptr_vec.clear();
752 
753     //  4. reset attributes
754     this->total_fuel_consumed_L = 0;
755 
756     this->total_emissions.CO2_kg = 0;
757     this->total_emissions.CO_kg = 0;
```

```
758     this->total_emissions.NOx_kg = 0;
759     this->total_emissions.SOx_kg = 0;
760     this->total_emissions.CH4_kg = 0;
761     this->total_emissions.PM_kg = 0;
762 
763     this->net_present_cost = 0;
764     this->total_dispatch_discharge_kWh = 0;
765     this->levellized_cost_of_energy_kWh = 0;
766 
767     return;
768 }   /* reset() */
```

4.9.3.16 run()

```
void Model::run (
            void  )
```

A method to run the Model.

```
692 {
693     // 1. init Controller
694     this->controller.init(
695         &(this->electrical_load),
696         &(this->renewable_ptr_vec),
697         &(this->resources),
698         &(this->combustion_ptr_vec)
699     );
700 
701     //  2. apply dispatch control
702     this->controller.applyDispatchControl(
703         &(this->electrical_load),
704         &(this->combustion_ptr_vec),
705         &(this->renewable_ptr_vec),
706         &(this->storage_ptr_vec)
707     );
708 
709     //  3. compute total fuel consumption and emissions
710     this->__computeFuelAndEmissions();
711 
712     //  4. compute key economic metrics
713     this->__computeEconomics();
714 
715     return;
716 }   /* run() */
```

4.9.3.17 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.

```
821 {
822     //  1. handle sentinel
823     if (max_lines < 0) {
824         max_lines = this->electrical_load.n_points;
```

```
825     }
826
827     //  2. check for pre-existing, warn (and remove), then create
828     if (write_path.back() != '/') {
829         write_path += '/';
830     }
831
832     if (std::filesystem::is_directory(write_path)) {
833         std::string warning_str = "WARNING:  Model::writeResults():  ";
834         warning_str += write_path;
835         warning_str += " already exists, contents will be overwritten!";
836
837         std::cout << warning_str << std::endl;
838
839         std::filesystem::remove_all(write_path);
840     }
841
842     std::filesystem::create_directory(write_path);
843
844     //  3. write summary
845     this->__writeSummary(write_path);
846
847     //  4. write time series
848     if (max_lines > this->electrical_load.n_points) {
849         max_lines = this->electrical_load.n_points;
850     }
851
852     if (max_lines > 0) {
853         this->__writeTimeSeries(write_path, max_lines);
854     }
855
856     //  5. call out to Combustion :: writeResults()
857     for (size_t i = 0; i < this->combustion_ptr_vec.size(); i++) {
858         this->combustion_ptr_vec[i]->writeResults(
859             write_path,
860             &(this->electrical_load.time_vec_hrs),
861             i,
862             max_lines
863         );
864     }
865
866     //  6. call out to Renewable :: writeResults()
867     for (size_t i = 0; i < this->renewable_ptr_vec.size(); i++) {
868         this->renewable_ptr_vec[i]->writeResults(
869             write_path,
870             &(this->electrical_load.time_vec_hrs),
871             &(this->resources.resource_map_1D),
872             &(this->resources.resource_map_2D),
873             i,
874             max_lines
875         );
876     }
877
878     //  7. call out to Storage :: writeResults()
879     for (size_t i = 0; i < this->storage_ptr_vec.size(); i++) {
880         /*
881         this->storage_ptr_vec[i]->writeResults(
882             write_path,
883             &(this->electrical_load.time_vec_hrs),
884             i,
885             max_lines
886         );
887         */
888     }
889
890     return;
891 }   /* writeResults() */
```

4.9.4 Member Data Documentation

4.9.4.1 combustion_ptr_vec

`std::vector<Combustion*> Model::combustion_ptr_vec`

A vector of pointers to the various Combustion assets in the Model.

4.9.4.2 controller

```
Controller Model::controller
```

Controller component of Model.

4.9.4.3 electrical_load

```
ElectricalLoad Model::electrical_load
```

ElectricalLoad component of Model.

4.9.4.4 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).

4.9.4.5 net_present_cost

```
double Model::net_present_cost
```

The net present cost of the Model (undefined currency).

4.9.4.6 renewable_ptr_vec

```
std::vector<Renewable*> Model::renewable_ptr_vec
```

A vector of pointers to the various Renewable assets in the Model.

4.9.4.7 resources

```
Resources Model::resources
```

Resources component of Model.

4.9.4.8 storage_ptr_vec

```
std::vector<Storage*> Model::storage_ptr_vec
```

A vector of pointers to the various Storage assets in the Model.

4.9.4.9 total_dispatch_discharge_kWh

```
double Model::total_dispatch_discharge_kWh
```

The total energy dispatched/discharged [kWh] over the Model run.

4.9.4.10 total_emissions

```
Emissions Model::total_emissions
```

An Emissions structure for holding total emissions [kg].

4.9.4.11 total_fuel_consumed_L

```
double Model::total_fuel_consumed_L
```

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

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

- header/Model.h
- source/Model.cpp

4.10 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.

4.10.1 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).

4.10.2 Member Data Documentation

4.10.2.1 control_mode

```
ControlMode ModelInputs::control_mode = ControlMode ::  LOAD_FOLLOWING
```

The control mode to be applied by the Controller object.

4.10.2.2 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:

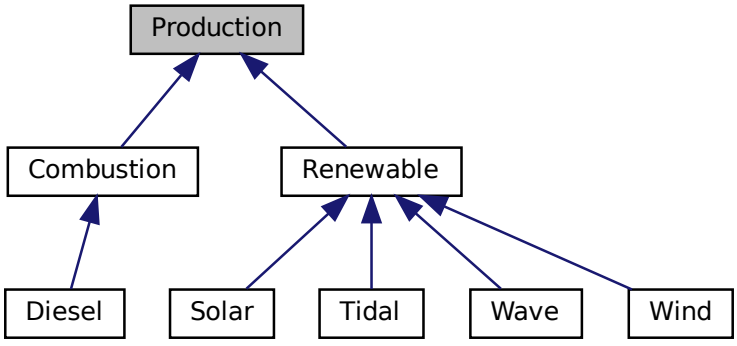
- header/Model.h

4.11 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:



Public Member Functions

- Production (void)

  Constructor (dummy) for the Production class.
- Production (int, double, ProductionInputs)

  Constructor (intended) for the Production class.
- virtual void computeEconomics (std::vector< double > *)

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

- 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).
- 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 dispatched and stored energy.
- std::string type_str

  A string describing the type of the asset.
- 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 > 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 nominal 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 nominal costs).

Private Member Functions

- void __checkInputs (int, ProductionInputs)

  Helper method to check inputs to the Production constructor.
- void __handleReplacement (int)

  Helper method to handle asset replacement and capital cost incursion, if applicable.
- 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.

4.11.1 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.

4.11.2 Constructor & Destructor Documentation

4.11.2.1 Production() [1/2]

```
Production::Production (
            void  )
```

Constructor (dummy) for the Production class.

```
165 {
166     return;
167 }   /* Production() */
```

4.11.2.2 Production() [2/2]

```
Production::Production (
            int n_points,
            double n_years,
            ProductionInputs production_inputs )
```

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.

```
196 {
197     //  1. check inputs
198     this->__checkInputs(n_points, production_inputs);
199 
200     //  2. set attributes
201     this->print_flag = production_inputs.print_flag;
202     this->is_running = false;
203     this->is_sunk = production_inputs.is_sunk;
204 
205     this->n_points = n_points;
206     this->n_starts = 0;
207     this->n_replacements = 0;
208 
209     this->n_years = n_years;
210 
211     this->running_hours = 0;
212     this->replace_running_hrs = production_inputs.replace_running_hrs;
213 
214     this->capacity_kW = production_inputs.capacity_kW;
215 
216     this->nominal_inflation_annual = production_inputs.nominal_inflation_annual;
217     this->nominal_discount_annual = production_inputs.nominal_discount_annual;
218     this->real_discount_annual = this->__computeRealDiscountAnnual(
219         production_inputs.nominal_inflation_annual,
220         production_inputs.nominal_discount_annual
221     );
222     this->capital_cost = 0;
223     this->operation_maintenance_cost_kWh = 0;
224     this->net_present_cost = 0;
225     this->total_dispatch_kWh = 0;
226     this->levellized_cost_of_energy_kWh = 0;
227 
228     this->is_running_vec.resize(this->n_points, 0);
229 
230     this->production_vec_kW.resize(this->n_points, 0);
231     this->dispatch_vec_kW.resize(this->n_points, 0);
232     this->storage_vec_kW.resize(this->n_points, 0);
233     this->curtailment_vec_kW.resize(this->n_points, 0);
234 
235     this->capital_cost_vec.resize(this->n_points, 0);
236     this->operation_maintenance_cost_vec.resize(this->n_points, 0);
237 
238     //  3. construction print
239     if (this->print_flag) {
```

```
240         std::cout « "Production object constructed at " « this « std::endl;
241     }
242
243     return;
244 }   /* Production() */
```

4.11.2.3 ~Production()

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

Destructor for the Production class.

```
394 {
395     //  1. destruction print
396     if (this->print_flag) {
397         std::cout « "Production object at " « this « " destroyed" « std::endl;
398     }
399
400     return;
401 }   /* ~Production() */
```

4.11.3 Member Function Documentation

4.11.3.1 __checkInputs()

```
void Production::__checkInputs (
            int n_points,
            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.

```
41 {
42     //  1. check n_points
43     if (n_points <= 0) {
44         std::string error_str = "ERROR:  Production():  n_points must be > 0";
45
46         #ifdef _WIN32
47             std::cout « error_str « std::endl;
48         #endif
49
50         throw std::invalid_argument(error_str);
51     }
52
53     //  2. check capacity_kW
54     if (production_inputs.capacity_kW <= 0) {
55         std::string error_str = "ERROR:  Production():  ";
56         error_str += "ProductionInputs::capacity_kW must be > 0";
57
58         #ifdef _WIN32
59             std::cout « error_str « std::endl;
60         #endif
61
62         throw std::invalid_argument(error_str);
63     }
64
```

```
65      //  3. check replace_running_hrs
66      if (production_inputs.replace_running_hrs <= 0) {
67          std::string error_str = "ERROR:  Production():  ";
68          error_str += "ProductionInputs::replace_running_hrs 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      return;
78  }   /* __checkInputs() */
```

4.11.3.2 __computeRealDiscountAnnual()

```
double Production::__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.

```
110 {
111     double real_discount_annual = nominal_discount_annual - nominal_inflation_annual;
112     real_discount_annual /= 1 + nominal_inflation_annual;
113
114     return real_discount_annual;
115 }   /* __computeRealDiscountAnnual() */
```

4.11.3.3 __handleReplacement()

```
void Production::__handleReplacement (
              int timestep )  [private]
```

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

Parameters

timestep	The current time step of the Model run.

```
133 {
134     if (
135         this->running_hours >= (this->n_replacements + 1) * this->replace_running_hrs
136     ) {
137         //  1. log replacement
138         this->n_replacements++;
139 
140         //  2. incur capital cost in timestep
141         this->capital_cost_vec[timestep] = this->capital_cost;
142     }
143 
144     return;
145 }   /* __handleReplacement() */
```

4.11.3.4 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, Diesel, and Combustion.

```
337 {
338     //  1. record production
339     this->production_vec_kW[timestep] = production_kW;
340 
341     //  2. compute and record dispatch and curtailment
342     double dispatch_kW = 0;
343     double curtailment_kW = 0;
344 
345     if (production_kW > load_kW) {
346         dispatch_kW = load_kW;
347         curtailment_kW = production_kW - dispatch_kW;
348     }
349 
350     else {
351         dispatch_kW = production_kW;
352     }
353 
354     this->dispatch_vec_kW[timestep] = dispatch_kW;
355     this->total_dispatch_kWh += dispatch_kW * dt_hrs;
356     this->curtailment_vec_kW[timestep] = curtailment_kW;
357 
358     //  3. update load
359     load_kW -= dispatch_kW;
360 
361     if (this->is_running) {
362         //  4. log running state, running hours
363         this->is_running_vec[timestep] = this->is_running;
364         this->running_hours += dt_hrs;
```

```
365
366         //  5. incur operation and maintenance costs
367         double produced_kWh = production_kW * dt_hrs;
368
369         double operation_maintenance_cost =
370             this->operation_maintenance_cost_kWh * produced_kWh;
371         this->operation_maintenance_cost_vec[timestep] = operation_maintenance_cost;
372
373         //  6. incur capital costs (i.e., handle replacement)
374         this->__handleReplacement(timestep);
375     }
376
377
378     return load_kW;
379 }   /* commit() */
```

4.11.3.5 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, and Combustion.

```
266 {
267     //  1. compute net present cost
268     double t_hrs = 0;
269     double real_discount_scalar = 0;
270
271     for (int i = 0; i < this->n_points; i++) {
272         t_hrs = time_vec_hrs_ptr->at(i);
273
274         real_discount_scalar = 1.0 / pow(
275             1 + this->real_discount_annual,
276             t_hrs / 8760
277         );
278
279         this->net_present_cost += real_discount_scalar * this->capital_cost_vec[i];
280
281         this->net_present_cost +=
282             real_discount_scalar * this->operation_maintenance_cost_vec[i];
283     }
284
286     //     assuming 8,760 hours per year
287     double n_years = time_vec_hrs_ptr->at(this->n_points - 1) / 8760;
288
289     double capital_recovery_factor =
290         (this->real_discount_annual * pow(1 + this->real_discount_annual, n_years)) /
291         (pow(1 + this->real_discount_annual, n_years) - 1);
292
293     double total_annualized_cost = capital_recovery_factor *
294         this->net_present_cost;
295
296     this->levellized_cost_of_energy_kWh =
```

```
297         (n_years * total_annualized_cost) /
298         total_dispatch_kWh;
299
300     return;
301 }   /* computeEconomics() */
```

4.11.4 Member Data Documentation

4.11.4.1 capacity_kW

```
double Production::capacity_kW
```

The rated production capacity [kW] of the asset.

4.11.4.2 capital_cost

```
double Production::capital_cost
```

The capital cost of the asset (undefined currency).

4.11.4.3 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 nominal costs).

4.11.4.4 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.

4.11.4.5 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.

4.11.4.6 is_running

```
bool Production::is_running
```

A boolean which indicates whether or not the asset is running.

4.11.4.7 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.

4.11.4.8 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).

4.11.4.9 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 dispatched and stored energy.

4.11.4.10 n_points

```
int Production::n_points
```

The number of points in the modelling time series.

4.11.4.11 n_replacements

```
int Production::n_replacements
```

The number of times the asset has been replaced.

4.11.4.12 n_starts

```
int Production::n_starts
```

The number of times the asset has been started.

4.11.4.13 n_years

```
double Production::n_years
```

The number of years being modelled.

4.11.4.14 net_present_cost

```
double Production::net_present_cost
```

The net present cost of this asset.

4.11.4.15 nominal_discount_annual

```
double Production::nominal_discount_annual
```

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

4.11.4.16 nominal_inflation_annual

```
double Production::nominal_inflation_annual
```

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

4.11.4.17 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.

4.11.4.18 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 nominal costs).

4.11.4.19 print_flag

```
bool Production::print_flag
```

A flag which indicates whether or not object construct/destruction should be verbose.

4.11.4.20 production_vec_kW

```
std::vector<double> Production::production_vec_kW
```

A vector of production [kW] at each point in the modelling time series.

4.11.4.21 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.

4.11.4.22 replace_running_hrs

```
double Production::replace_running_hrs
```

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

4.11.4.23 running_hours

```
double Production::running_hours
```

The number of hours for which the assset has been operating.

4.11.4.24 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.

4.11.4.25 total_dispatch_kWh

```
double Production::total_dispatch_kWh
```

The total energy dispatched [kWh] over the Model run.

4.11.4.26 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

4.12 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.

4.12.1 Detailed Description

A structure which bundles the necessary inputs for the Production constructor. Provides default values for every necessary input.

4.12.2 Member Data Documentation

4.12.2.1 capacity_kW

```
double ProductionInputs::capacity_kW = 100
```

The rated production capacity [kW] of the asset.

4.12.2.2 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).

4.12.2.3 nominal_discount_annual

```
double ProductionInputs::nominal_discount_annual = 0.04
```

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

4.12.2.4 nominal_inflation_annual

```
double ProductionInputs::nominal_inflation_annual = 0.02
```

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

4.12.2.5 print_flag

```
bool ProductionInputs::print_flag = false
```

A flag which indicates whether or not object construct/destruction should be verbose.

4.12.2.6 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:

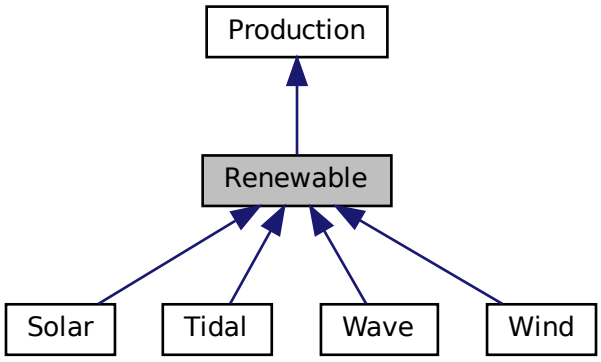
- header/Production/Production.h

4.13 Renewable Class Reference

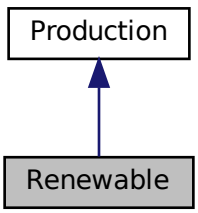
The root of the Renewable branch of the Production hierarchy. This branch contains derived classes which model the renewable production of energy.

```
#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)

  Constructor (intended) for the Renewable class.
- 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)

4.13.1 Detailed Description

The root of the Renewable branch of the Production hierarchy. This branch contains derived classes which model the renewable production of energy.

4.13.2 Constructor & Destructor Documentation

4.13.2.1 Renewable() [1/2]

```
Renewable::Renewable (
            void  )
```

Constructor (dummy) for the Renewable class.

```
92 {
93     //...
94
95     return;
96 }   /* Renewable() */
```

4.13.2.2 Renewable() [2/2]

```
Renewable::Renewable (
            int n_points,
            double n_years,
            RenewableInputs renewable_inputs )
```

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.

```
124   :
125 Production(
126     n_points,
127     n_years,
128     renewable_inputs.production_inputs
129 )
130 {
131     //  1. check inputs
132     this->__checkInputs(renewable_inputs);
133
134     //  2. set attributes
135     //...
136
137     //  3. construction print
138     if (this->print_flag) {
139         std::cout « "Renewable object constructed at " « this « std::endl;
140     }
141
142     return;
143 }   /* Renewable() */
```

4.13.2.3 ~Renewable()

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

Destructor for the Renewable class.

```
320 {
321     //  1. destruction print
322     if (this->print_flag) {
323         std::cout « "Renewable object at " « this « " destroyed" « std::endl;
324     }
325
326     return;
327 }   /* ~Renewable() */
```

4.13.3 Member Function Documentation

4.13.3.1 __checkInputs()

```
void Renewable::__checkInputs (
            RenewableInputs renewable_inputs )  [private]
```

Helper method to check inputs to the Renewable constructor.

```
37 {
38     //...
39 
40     return;
41 }   /* __checkInputs() */
```

4.13.3.2 __handleStartStop()

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

Helper method to handle the starting/stopping of the renewable asset.

```
56 {
57     if (this->is_running) {
58         // handle stopping
59         if (production_kW <= 0) {
60             this->is_running = false;
61         }
62     }
63 
64     else {
65         // handle starting
66         if (production_kW > 0) {
67             this->is_running = true;
68             this->n_starts++;
69         }
70     }
71 
72     return;
73 }   /* __handleStartStop() */
```

4.13.3.3 __writeSummary()

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

Reimplemented in Wind, Wave, Tidal, and Solar.

```
72 {return;}
```

4.13.3.4 __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.

```
79          {return;}
```

4.13.3.5 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.

```
201 {
202     //  1. handle start/stop
203     this->__handleStartStop(timestep, dt_hrs, production_kW);
204
205     //  2. invoke base class method
206     load_kW = Production :: commit(
207         timestep,
208         dt_hrs,
209         production_kW,
210         load_kW
211     );
212
213
214     //...
215
216     return load_kW;
217 }   /* commit() */
```

4.13.3.6 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.

```
160 {
161     //  1. invoke base class method
162     Production :: computeEconomics(time_vec_hrs_ptr);
163 
164     return;
165 }   /* computeEconomics() */
```

4.13.3.7 computeProductionkW() [1/2]

```
virtual double Renewable::computeProductionkW (
            int ,
            double ,
            double  )  [inline], [virtual]
```

Reimplemented in Wind, Tidal, and Solar.

```
95 {return 0;}
```

4.13.3.8 computeProductionkW() [2/2]

```
virtual double Renewable::computeProductionkW (
            int ,
            double ,
            double ,
            double  )  [inline], [virtual]
```

Reimplemented in Wave.

```
96 {return 0;}
```

4.13.3.9 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.

```
261 {
262     //  1. handle sentinel
263     if (max_lines < 0) {
264         max_lines = this->n_points;
265     }
266 
267     //  2. create subdirectories
268     write_path += "Production/";
269     if (not std::filesystem::is_directory(write_path)) {
270         std::filesystem::create_directory(write_path);
271     }
272 
273     write_path += "Renewable/";
274     if (not std::filesystem::is_directory(write_path)) {
275         std::filesystem::create_directory(write_path);
276     }
277 
278     write_path += this->type_str;
279     write_path += "_";
280     write_path += std::to_string(int(ceil(this->capacity_kW)));
281     write_path += "kW_idx";
282     write_path += std::to_string(renewable_index);
283     write_path += "/";
284     std::filesystem::create_directory(write_path);
285 
286     //  3. write summary
287     this->__writeSummary(write_path);
288 
289     //  4. write time series
290     if (max_lines > this->n_points) {
291         max_lines = this->n_points;
292     }
293 
294     if (max_lines > 0) {
295         this->__writeTimeSeries(
296             write_path,
297             time_vec_hrs_ptr,
298             resource_map_1D_ptr,
299             resource_map_2D_ptr,
300             max_lines
301         );
302     }
303 
304     return;
305 }   /* writeResults() */
```

4.13.4 Member Data Documentation

4.13.4.1 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.

4.13.4.2 type

```
RenewableType Renewable::type
```

The type (RenewableType) of the asset.

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

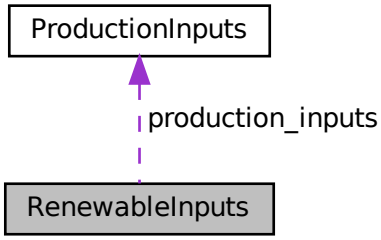
- header/Production/Renewable/Renewable.h
- source/Production/Renewable/Renewable.cpp

4.14 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.

4.14.1 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.

4.14.2 Member Data Documentation

4.14.2.1 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

4.15 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 (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> 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> 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 __checkTimePoint (double, double, std::string, ElectricalLoad ∗)

  Helper method to check received time point against expected time point.
- void __throwLengthError (std::string, ElectricalLoad ∗)

  Helper method to throw data length error.
- 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.

4.15.1 Detailed Description

A class which contains renewable resource data. Intended to serve as a component class of Model.

4.15.2 Constructor & Destructor Documentation

4.15.2.1 Resources()

```
Resources::Resources (
            void  )
```

Constructor for the Resources class.

```
577 {
578     return;
579 }   /* Resources() */
```

4.15.2.2 ∼Resources()

```
Resources::~Resources (
            void  )
```

Destructor for the Resources class.

```
721 {
722     this->clear();
723     return;
724 }   /* ~Resources() */
```

4.15.3 Member Function Documentation

4.15.3.1 __checkResourceKey1D()

```
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.

```
45 {
46     if (this->resource_map_1D.count(resource_key) > 0) {
47         std::string error_str = "ERROR:  Resources::addResource(";
48 
49         switch (renewable_type) {
50             case (RenewableType :: SOLAR): {
51                 error_str += "SOLAR):  ";
52 
53                 break;
54             }
55 
56             case (RenewableType :: TIDAL): {
57                 error_str += "TIDAL):  ";
58 
59                 break;
60             }
61 
62             case (RenewableType :: WIND): {
63                 error_str += "WIND):  ";
64 
65                 break;
66             }
67 
68             default: {
69                 error_str += "UNDEFINED_TYPE):  ";
70 
71                 break;
72             }
73         }
74 
75         error_str += "resource key (1D) ";
76         error_str += std::to_string(resource_key);
77         error_str += " is already in use";
78 
79         #ifdef _WIN32
80             std::cout « error_str « std::endl;
81         #endif
82 
83         throw std::invalid_argument(error_str);
84     }
85 
86     return;
87 }   /*  __checkResourceKey1D() */
```

4.15.3.2 __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.

```
109 {
110     if (this->resource_map_2D.count(resource_key) > 0) {
111         std::string error_str = "ERROR:  Resources::addResource(";
112 
113         switch (renewable_type) {
114             case (RenewableType :: WAVE): {
115                 error_str += "WAVE):  ";
116 
117                 break;
118             }
119 
120             default: {
121                 error_str += "UNDEFINED_TYPE):  ";
122 
123                 break;
124             }
125         }
126 
127         error_str += "resource key (2D) ";
128         error_str += std::to_string(resource_key);
129         error_str += " is already in use";
130 
131         #ifdef _WIN32
132             std::cout << error_str << std::endl;
133         #endif
134 
135         throw std::invalid_argument(error_str);
136     }
137 
138     return;
139 }   /*  __checkResourceKey2D() */
```

4.15.3.3 __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.

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.

```
173 {
174     if (time_received_hrs != time_expected_hrs) {
175         std::string error_str = "ERROR:  Resources::addResource():  ";
176         error_str += "the given resource time series at ";
177         error_str += path_2_resource_data;
178         error_str += " does not align with the ";
179         error_str += "previously given electrical load time series at ";
180         error_str += electrical_load_ptr->path_2_electrical_load_time_series;
181 
182         #ifdef _WIN32
183             std::cout << error_str << std::endl;
184         #endif
185 
186         throw std::runtime_error(error_str);
187     }
188 
```

```
189     return;
190 }   /* __checkTimePoint() */
```

4.15.3.4 __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.

```
257 {
258     //  1. init CSV reader, record path and type
259     io::CSVReader<2> CSV(path_2_resource_data);
260 
261     CSV.read_header(
262         io::ignore_extra_column,
263         "Time (since start of data) [hrs]",
264         "Solar GHI [kW/m2]"
265     );
266 
267     this->path_map_1D.insert(
268         std::pair<int, std::string>(resource_key, path_2_resource_data)
269     );
270 
271     this->string_map_1D.insert(std::pair<int, std::string>(resource_key, "SOLAR"));
272 
273     //  2. init map element
274     this->resource_map_1D.insert(
275         std::pair<int, std::vector<double»(resource_key, {})
276     );
277     this->resource_map_1D[resource_key].resize(electrical_load_ptr->n_points, 0);
278 
279 
280     //  3. read in resource data, check against time series (point-wise and length)
281     int n_points = 0;
282     double time_hrs = 0;
283     double time_expected_hrs = 0;
284     double solar_resource_kWm2 = 0;
285 
286     while (CSV.read_row(time_hrs, solar_resource_kWm2)) {
287         if (n_points > electrical_load_ptr->n_points) {
288             this->__throwLengthError(path_2_resource_data, electrical_load_ptr);
289         }
290 
291         time_expected_hrs = electrical_load_ptr->time_vec_hrs[n_points];
292         this->__checkTimePoint(
293             time_hrs,
294             time_expected_hrs,
295             path_2_resource_data,
296             electrical_load_ptr
297         );
298 
299         this->resource_map_1D[resource_key][n_points] = solar_resource_kWm2;
300 
301         n_points++;
302     }
303 
304     //  4. check data length
305     if (n_points != electrical_load_ptr->n_points) {
306         this->__throwLengthError(path_2_resource_data, electrical_load_ptr);
307     }
308 
309     return;
310 }   /* __readSolarResource() */
```

4.15.3.5 __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.

```
339 {
340     //  1. init CSV reader, record path and type
341     io::CSVReader<2> CSV(path_2_resource_data);
342 
343     CSV.read_header(
344         io::ignore_extra_column,
345         "Time (since start of data) [hrs]",
346         "Tidal Speed (hub depth) [m/s]"
347     );
348 
349     this->path_map_1D.insert(
350         std::pair<int, std::string>(resource_key, path_2_resource_data)
351     );
352 
353     this->string_map_1D.insert(std::pair<int, std::string>(resource_key, "TIDAL"));
354 
355     //  2. init map element
356     this->resource_map_1D.insert(
357         std::pair<int, std::vector<double»(resource_key, {})
358     );
359     this->resource_map_1D[resource_key].resize(electrical_load_ptr->n_points, 0);
360 
361 
362     //  3. read in resource data, check against time series (point-wise and length)
363     int n_points = 0;
364     double time_hrs = 0;
365     double time_expected_hrs = 0;
366     double tidal_resource_ms = 0;
367 
368     while (CSV.read_row(time_hrs, tidal_resource_ms)) {
369         if (n_points > electrical_load_ptr->n_points) {
370             this->__throwLengthError(path_2_resource_data, electrical_load_ptr);
371         }
372 
373         time_expected_hrs = electrical_load_ptr->time_vec_hrs[n_points];
374         this->__checkTimePoint(
375             time_hrs,
376             time_expected_hrs,
377             path_2_resource_data,
378             electrical_load_ptr
379         );
380 
381         this->resource_map_1D[resource_key][n_points] = tidal_resource_ms;
382 
383         n_points++;
384     }
385 
386     //  4. check data length
387     if (n_points != electrical_load_ptr->n_points) {
388         this->__throwLengthError(path_2_resource_data, electrical_load_ptr);
389     }
390 
391     return;
392 }   /* __readTidalResource() */
```

4.15.3.6 __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.

```
421 {
422     //  1. init CSV reader, record path and type
423     io::CSVReader<3> CSV(path_2_resource_data);
424 
425     CSV.read_header(
426         io::ignore_extra_column,
427         "Time (since start of data) [hrs]",
428         "Significant Wave Height [m]",
429         "Energy Period [s]"
430     );
431 
432     this->path_map_2D.insert(
433         std::pair<int, std::string>(resource_key, path_2_resource_data)
434     );
435 
436     this->string_map_2D.insert(std::pair<int, std::string>(resource_key, "WAVE"));
437 
438     //  2. init map element
439     this->resource_map_2D.insert(
440         std::pair<int, std::vector<std::vector<double»>(resource_key, {})
441     );
442     this->resource_map_2D[resource_key].resize(electrical_load_ptr->n_points, {0, 0});
443 
444 
445     //  3. read in resource data, check against time series (point-wise and length)
446     int n_points = 0;
447     double time_hrs = 0;
448     double time_expected_hrs = 0;
449     double significant_wave_height_m = 0;
450     double energy_period_s = 0;
451 
452     while (CSV.read_row(time_hrs, significant_wave_height_m, energy_period_s)) {
453         if (n_points > electrical_load_ptr->n_points) {
454             this->__throwLengthError(path_2_resource_data, electrical_load_ptr);
455         }
456 
457         time_expected_hrs = electrical_load_ptr->time_vec_hrs[n_points];
458         this->__checkTimePoint(
459             time_hrs,
460             time_expected_hrs,
461             path_2_resource_data,
462             electrical_load_ptr
463         );
464 
465         this->resource_map_2D[resource_key][n_points][0] = significant_wave_height_m;
466         this->resource_map_2D[resource_key][n_points][1] = energy_period_s;
467 
468         n_points++;
469     }
470 
471     //  4. check data length
472     if (n_points != electrical_load_ptr->n_points) {
473         this->__throwLengthError(path_2_resource_data, electrical_load_ptr);
474     }
475 
476     return;
477 }   /* __readWaveResource() */
```

4.15.3.7 __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.

```
506 {
507     //  1. init CSV reader, record path and type
508     io::CSVReader<2> CSV(path_2_resource_data);
509 
510     CSV.read_header(
511         io::ignore_extra_column,
512         "Time (since start of data) [hrs]",
513         "Wind Speed (hub height) [m/s]"
514     );
515 
516     this->path_map_1D.insert(
517         std::pair<int, std::string>(resource_key, path_2_resource_data)
518     );
519 
520     this->string_map_1D.insert(std::pair<int, std::string>(resource_key, "WIND"));
521 
522     //  2. init map element
523     this->resource_map_1D.insert(
524         std::pair<int, std::vector<double»(resource_key, {})
525     );
526     this->resource_map_1D[resource_key].resize(electrical_load_ptr->n_points, 0);
527 
528 
529     //  3. read in resource data, check against time series (point-wise and length)
530     int n_points = 0;
531     double time_hrs = 0;
532     double time_expected_hrs = 0;
533     double wind_resource_ms = 0;
534 
535     while (CSV.read_row(time_hrs, wind_resource_ms)) {
536         if (n_points > electrical_load_ptr->n_points) {
537             this->__throwLengthError(path_2_resource_data, electrical_load_ptr);
538         }
539 
540         time_expected_hrs = electrical_load_ptr->time_vec_hrs[n_points];
541         this->__checkTimePoint(
542             time_hrs,
543             time_expected_hrs,
544             path_2_resource_data,
545             electrical_load_ptr
546         );
547 
548         this->resource_map_1D[resource_key][n_points] = wind_resource_ms;
549 
550         n_points++;
551     }
552 
553     //  4. check data length
554     if (n_points != electrical_load_ptr->n_points) {
555         this->__throwLengthError(path_2_resource_data, electrical_load_ptr);
556     }
557 
558     return;
559 }   /* __readWindResource() */
```

4.15.3.8 __throwLengthError()

```
void Resources::__throwLengthError (
```

```
            std::string path_2_resource_data,
            ElectricalLoad * electrical_load_ptr )  [private]
```

Helper method to throw data length error.

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.

```
215 {
216     std::string error_str = "ERROR:  Resources::addResource():  ";
217     error_str += "the given resource time series at ";
218     error_str += path_2_resource_data;
219     error_str += " is not the same length as the previously given electrical";
220     error_str += " load time series at ";
221     error_str += electrical_load_ptr->path_2_electrical_load_time_series;
222 
223     #ifdef _WIN32
224         std::cout << error_str << std::endl;
225     #endif
226 
227     throw std::runtime_error(error_str);
228 
229     return;
230 }   /* __throwLengthError() */
```

4.15.3.9 addResource()

```
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.

```
616 {
617     switch (renewable_type) {
618         case (RenewableType :: SOLAR): {
619             this->__checkResourceKey1D(resource_key, renewable_type);
620 
621             this->__readSolarResource(
622                 path_2_resource_data,
623                 resource_key,
624                 electrical_load_ptr
625             );
626 
627             break;
628         }
629 
630         case (RenewableType :: TIDAL): {
631             this->__checkResourceKey1D(resource_key, renewable_type);
```

```
632
633             this->__readTidalResource(
634                 path_2_resource_data,
635                 resource_key,
636                 electrical_load_ptr
637             );
638
639             break;
640         }
641
642         case (RenewableType :: WAVE): {
643             this->__checkResourceKey2D(resource_key, renewable_type);
644
645             this->__readWaveResource(
646                 path_2_resource_data,
647                 resource_key,
648                 electrical_load_ptr
649             );
650
651             break;
652         }
653
654         case (RenewableType :: WIND): {
655             this->__checkResourceKey1D(resource_key, renewable_type);
656
657             this->__readWindResource(
658                 path_2_resource_data,
659                 resource_key,
660                 electrical_load_ptr
661             );
662
663             break;
664         }
665
666         default: {
667             std::string error_str = "ERROR:  Resources :: addResource(:  ";
668             error_str += "renewable type ";
669             error_str += std::to_string(renewable_type);
670             error_str += " not recognized";
671
672             #ifdef _WIN32
673                 std::cout « error_str « std::endl;
674             #endif
675
676             throw std::runtime_error(error_str);
677
678             break;
679         }
680     }
681
682     return;
683 }   /* addResource() */
```

4.15.3.10 clear()

```
void Resources::clear (
              void  )
```

Method to clear all attributes of the Resources object.

```
697 {
698     this->resource_map_1D.clear();
699     this->string_map_1D.clear();
700     this->path_map_1D.clear();
701
702     this->resource_map_2D.clear();
703     this->string_map_2D.clear();
704     this->path_map_2D.clear();
705
706     return;
707 }   /* clear() */
```

4.15.4 Member Data Documentation

4.15.4.1 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.

4.15.4.2 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.

4.15.4.3 resource_map_1D

```
std::map<int, std::vector<double> > Resources::resource_map_1D
```

A map <int, vector> of given 1D renewable resource time series.

4.15.4.4 resource_map_2D

```
std::map<int, std::vector<std::vector<double> > > Resources::resource_map_2D
```

A map <int, vector> of given 2D renewable resource time series.

4.15.4.5 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.

4.15.4.6 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:

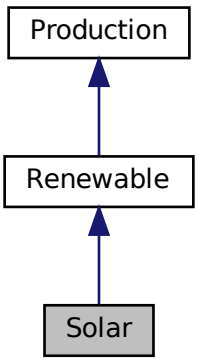
- header/Resources.h
- source/Resources.cpp

4.16 Solar Class Reference

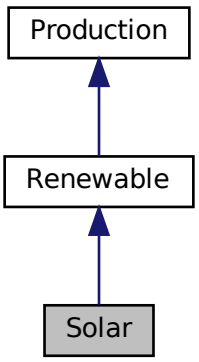
A derived class of the Renewable branch of Production which models solar production.

`#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)

Constructor (intended) for the Solar class.

- 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.).

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.
- 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.

4.16.1 Detailed Description

A derived class of the Renewable branch of Production which models solar production.

4.16.2 Constructor & Destructor Documentation

4.16.2.1 Solar() [1/2]

```
Solar::Solar (
            void  )
```

Constructor (dummy) for the Solar class.

```
281 {
282     //...
283
284     return;
285 }   /* Solar() */
```

4.16.2.2 Solar() [2/2]

```
Solar::Solar (
            int n_points,
            double n_years,
            SolarInputs solar_inputs )
```

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.

```
313   :
314 Renewable(
315     n_points,
316     n_years,
317     solar_inputs.renewable_inputs
318 )
319 {
320     //  1. check inputs
321     this->__checkInputs(solar_inputs);
322 
323     //  2. set attributes
324     this->type = RenewableType :: SOLAR;
325     this->type_str = "SOLAR";
326 
327     this->resource_key = solar_inputs.resource_key;
328 
329     this->derating = solar_inputs.derating;
330 
331     if (solar_inputs.capital_cost < 0) {
332         this->capital_cost = this->__getGenericCapitalCost();
333     }
334 
335     if (solar_inputs.operation_maintenance_cost_kWh < 0) {
336         this->operation_maintenance_cost_kWh = this->__getGenericOpMaintCost();
337     }
338 
339     if (not this->is_sunk) {
340         this->capital_cost_vec[0] = this->capital_cost;
341     }
342 
343     //  3. construction print
344     if (this->print_flag) {
345         std::cout « "Solar object constructed at " « this « std::endl;
346     }
347 
348     return;
349 }   /* Renewable() */
```

4.16.2.3 ~Solar()

```
Solar::~Solar (
            void  )
```

Destructor for the Solar class.

```
462 {
463     //  1. destruction print
464     if (this->print_flag) {
465         std::cout « "Solar object at " « this « " destroyed" « std::endl;
466     }
467 
468     return;
469 }   /* ~Solar() */
```

4.16.3 Member Function Documentation

4.16.3.1 __checkInputs()

```
void Solar::__checkInputs (
            SolarInputs solar_inputs )  [private]
```

Helper method to check inputs to the Solar constructor.

```
37 {
38     //  1. check derating
39     if (
40         solar_inputs.derating < 0 or
41         solar_inputs.derating > 1
42     ) {
43         std::string error_str = "ERROR:  Solar():  ";
44         error_str += "SolarInputs::derating must be in the closed interval [0, 1]";
45 
46         #ifdef _WIN32
47             std::cout << error_str << std::endl;
48         #endif
49 
50         throw std::invalid_argument(error_str);
51     }
52 
53     return;
54 }   /* __checkInputs() */
```

4.16.3.2 __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].

```
76 {
77     double capital_cost_per_kW = 1000 * pow(this->capacity_kW, -0.15) + 3000;
78 
79     return capital_cost_per_kW * this->capacity_kW;
80 }   /* __getGenericCapitalCost() */
```

4.16.3.3 __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].

```
103 {
104     return 0.01;
105 }   /* __getGenericOpMaintCost() */
```

4.16.3.4 __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.

```
123 {
124     //  1. create filestream
125     write_path += "summary_results.md";
126     std::ofstream ofs;
127     ofs.open(write_path, std::ofstream::out);
128 
129     //  2. write summary results (markdown)
130     ofs « "# ";
131     ofs « std::to_string(int(ceil(this->capacity_kW)));
132     ofs « " kW SOLAR Summary Results\n";
133     ofs « "\n--------\n\n";
134 
135     //  2.1. Production attributes
136     ofs « "## Production Attributes\n";
137     ofs « "\n";
138 
139     ofs « "Capacity: " « this->capacity_kW « "kW  \n";
140     ofs « "\n";
141 
142     ofs « "Sunk Cost (N = 0 / Y = 1): " « this->is_sunk « "  \n";
143     ofs « "Capital Cost: " « this->capital_cost « "  \n";
144     ofs « "Operation and Maintenance Cost: " « this->operation_maintenance_cost_kWh
145         « " per kWh produced  \n";
146     ofs « "Nominal Inflation Rate (annual): " « this->nominal_inflation_annual
147         « "  \n";
148     ofs « "Nominal Discount Rate (annual): " « this->nominal_discount_annual
149         « "  \n";
150     ofs « "Real Discount Rate (annual): " « this->real_discount_annual « "  \n";
151     ofs « "\n";
152 
153     ofs « "Replacement Running Hours: " « this->replace_running_hrs « "  \n";
154     ofs « "\n--------\n\n";
155 
156     //  2.2. Renewable attributes
157     ofs « "## Renewable Attributes\n";
158     ofs « "\n";
159 
160     ofs « "Resource Key (1D): " « this->resource_key « "  \n";
161 
162     ofs « "\n--------\n\n";
163 
164     //  2.3. Solar attributes
165     ofs « "## Solar Attributes\n";
166     ofs « "\n";
167 
168     ofs « "Derating Factor: " « this->derating « "  \n";
169 
170     ofs « "\n--------\n\n";
171 
172     //  2.4. Solar Results
173     ofs « "## Results\n";
174     ofs « "\n";
175 
176     ofs « "Net Present Cost: " « this->net_present_cost « "  \n";
177     ofs « "\n";
178 
179     ofs « "Total Dispatch: " « this->total_dispatch_kWh
180         « " kWh  \n";
181 
182     ofs « "Levellized Cost of Energy: " « this->levellized_cost_of_energy_kWh
183         « " per kWh dispatched  \n";
184     ofs « "\n";
185 
186     ofs « "Running Hours: " « this->running_hours « "  \n";
187     ofs « "Replacements: " « this->n_replacements « "  \n";
```

```
188
189     ofs « "\n--------\n\n";
190
191     ofs.close();
192     return;
193 }   /* __writeSummary() */
```

4.16.3.5 __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.

```
231 {
232     //  1. create filestream
233     write_path += "time_series_results.csv";
234     std::ofstream ofs;
235     ofs.open(write_path, std::ofstream::out);
236
237     //  2. write time series results (comma separated value)
238     ofs « "Time (since start of data) [hrs],";
239     ofs « "Solar Resource [kW/m2],";
240     ofs « "Production [kW],";
241     ofs « "Dispatch [kW],";
242     ofs « "Storage [kW],";
243     ofs « "Curtailment [kW],";
244     ofs « "Capital Cost (actual),";
245     ofs « "Operation and Maintenance Cost (actual),";
246     ofs « "\n";
247
248     for (int i = 0; i < max_lines; i++) {
249         ofs « time_vec_hrs_ptr->at(i) « ",";
250         ofs « resource_map_1D_ptr->at(this->resource_key)[i] « ",";
251         ofs « this->production_vec_kW[i] « ",";
252         ofs « this->dispatch_vec_kW[i] « ",";
253         ofs « this->storage_vec_kW[i] « ",";
254         ofs « this->curtailment_vec_kW[i] « ",";
255         ofs « this->capital_cost_vec[i] « ",";
256         ofs « this->operation_maintenance_cost_vec[i] « ",";
257         ofs « "\n";
258     }
259
260     ofs.close();
261     return;
262 }   /* __writeTimeSeries() */
```

4.16.3.6 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.

```
434 {
435     //  1. invoke base class method
436     load_kW = Renewable :: commit(
437         timestep,
438         dt_hrs,
439         production_kW,
440         load_kW
441     );
442 
443 
444     //...
445 
446     return load_kW;
447 }   /* commit() */
```

4.16.3.7 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.

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. irradiance) [kW/m2].

Returns

The production [kW] of the solar PV array.

Reimplemented from Renewable.

```
383 {
384     // check if no resource
385     if (solar_resource_kWm2 <= 0) {
386         return 0;
387     }
388 
389     // compute production
390     double production_kW = this->derating * solar_resource_kWm2 * this->capacity_kW;
391 
392     // cap production at capacity
393     if (production_kW > this->capacity_kW) {
394         production_kW = this->capacity_kW;
395     }
396 
397     return production_kW;
398 }   /* computeProductionkW() */
```

4.16.4 Member Data Documentation

4.16.4.1 derating

```
double Solar::derating
```

The derating of the solar PV array (i.e., shadowing, soiling, etc.).

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

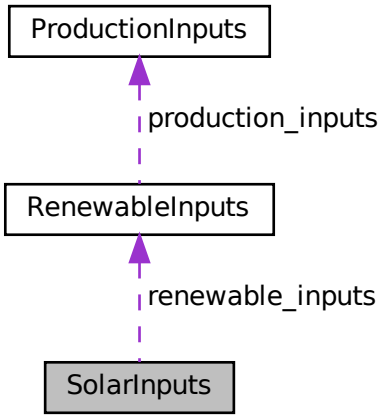
- header/Production/Renewable/Solar.h
- source/Production/Renewable/Solar.cpp

4.17 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.).

4.17.1 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.

4.17.2 Member Data Documentation

4.17.2.1 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].

4.17.2.2 derating

```
double SolarInputs::derating = 0.8
```

The derating of the solar PV array (i.e., shadowing, soiling, etc.).

4.17.2.3 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].

4.17.2.4 renewable_inputs

```
RenewableInputs SolarInputs::renewable_inputs
```

An encapsulated RenewableInputs instance.

4.17.2.5 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:

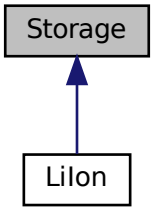
- header/Production/Renewable/Solar.h

4.18 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:



Public Member Functions

- Storage (void)

  Constructor for the Storage class.
- virtual ~Storage (void)

  Destructor for the Storage class.

4.18.1 Detailed Description

The base class of the Storage hierarchy. This hierarchy contains derived classes which model the storage of energy.

4.18.2 Constructor & Destructor Documentation

4.18.2.1 Storage()

```
Storage::Storage (
            void  )
```

Constructor for the Storage class.

```
36 {
37     //...
38
39     return;
40 }   /* Storage() */
```

4.18.2.2 ~Storage()

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

Destructor for the Storage class.

```
63 {
64     //...
65
66     return;
67 }   /* ~Storage() */
```

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

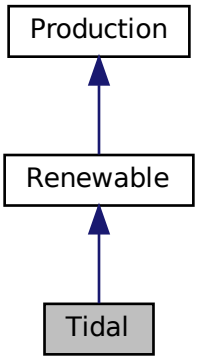
- header/Storage/Storage.h
- source/Storage/Storage.cpp

4.19 Tidal Class Reference

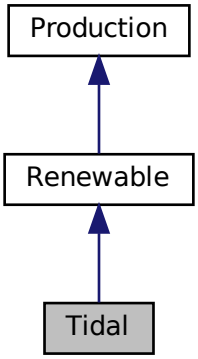
A derived class of the Renewable branch of Production which models tidal production.

```
#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)

  Constructor (intended) for the Tidal class.
- 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.

4.19.1 Detailed Description

A derived class of the Renewable branch of Production which models tidal production.

4.19.2 Constructor & Destructor Documentation

4.19.2.1 Tidal() [1/2]

```
Tidal::Tidal (
            void  )
```

Constructor (dummy) for the Tidal class.

```
427 {
428     return;
429 }   /* Tidal() */
```

4.19.2.2 Tidal() [2/2]

```
Tidal::Tidal (
            int n_points,
            double n_years,
            TidalInputs tidal_inputs )
```

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.

```
457   :
458 Renewable(
459     n_points,
460     n_years,
461     tidal_inputs.renewable_inputs
462 )
463 {
464     //  1. check inputs
465     this->__checkInputs(tidal_inputs);
466 
467     //  2. set attributes
468     this->type = RenewableType :: TIDAL;
469     this->type_str = "TIDAL";
470 
471     this->resource_key = tidal_inputs.resource_key;
472 
473     this->design_speed_ms = tidal_inputs.design_speed_ms;
474 
475     this->power_model = tidal_inputs.power_model;
476 
477     switch (this->power_model) {
478         case (TidalPowerProductionModel :: TIDAL_POWER_CUBIC): {
479             this->power_model_string = "CUBIC";
480 
481             break;
482         }
483 
484         case (TidalPowerProductionModel :: TIDAL_POWER_EXPONENTIAL): {
485             this->power_model_string = "EXPONENTIAL";
486 
487             break;
488         }
489 
490         case (TidalPowerProductionModel :: TIDAL_POWER_LOOKUP): {
491             this->power_model_string = "LOOKUP";
492 
493             break;
494         }
495 
496         default: {
497             std::string error_str = "ERROR:  Tidal():  ";
498             error_str += "power production model ";
499             error_str += std::to_string(this->power_model);
500             error_str += " not recognized";
501 
502             #ifdef _WIN32
503                 std::cout « error_str « std::endl;
504             #endif
505 
506             throw std::runtime_error(error_str);
507 
508             break;
509         }
510     }
511 
512     if (tidal_inputs.capital_cost < 0) {
513         this->capital_cost = this->__getGenericCapitalCost();
514     }
515 
516     if (tidal_inputs.operation_maintenance_cost_kWh < 0) {
517         this->operation_maintenance_cost_kWh = this->__getGenericOpMaintCost();
518     }
519 
520     if (not this->is_sunk) {
521         this->capital_cost_vec[0] = this->capital_cost;
522     }
523 
524     //  3. construction print
525     if (this->print_flag) {
526         std::cout « "Tidal object constructed at " « this « std::endl;
527     }
528 
529     return;
530 }   /* Renewable() */
```

4.19.2.3 ~Tidal()

```
Tidal::~Tidal (
            void  )
```

Destructor for the Tidal class.

```
684 {
685     //  1. destruction print
686     if (this->print_flag) {
687         std::cout « "Tidal object at " « this « " destroyed" « std::endl;
688     }
689 
690     return;
691 }   /* ~Tidal() */
```

4.19.3 Member Function Documentation

4.19.3.1 __checkInputs()

```
void Tidal::__checkInputs (
            TidalInputs tidal_inputs )  [private]
```

Helper method to check inputs to the Tidal constructor.

```
37 {
38     //  1. check design_speed_ms
39     if (tidal_inputs.design_speed_ms <= 0) {
40         std::string error_str = "ERROR:  Tidal():  ";
41         error_str += "TidalInputs::design_speed_ms must be > 0";
42 
43         #ifdef _WIN32
44             std::cout « error_str « std::endl;
45         #endif
46 
47         throw std::invalid_argument(error_str);
48     }
49 
50     return;
51 }   /* __checkInputs() */
```

4.19.3.2 __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]

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.

```
138 {
139     double production = 0;
140 
141     if (
142         tidal_resource_ms < 0.15 * this->design_speed_ms or
143         tidal_resource_ms > 1.25 * this->design_speed_ms
144     ){
145         production = 0;
146     }
147 
148     else if (
149         0.15 * this->design_speed_ms <= tidal_resource_ms and
150         tidal_resource_ms <= this->design_speed_ms
151     ) {
152         production =
153             (1 / pow(this->design_speed_ms, 3)) * pow(tidal_resource_ms, 3);
154     }
155 
156     else {
157         production = 1;
158     }
159 
160     return production * this->capacity_kW;
161 }   /* __computeCubicProductionkW() */
```

4.19.3.3 __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.

```
195 {
196     double production = 0;
197 
198     double turbine_speed =
199         (tidal_resource_ms - this->design_speed_ms) / this->design_speed_ms;
200 
201     if (turbine_speed < -0.71 or turbine_speed > 0.65) {
202         production = 0;
203     }
204 
205     else if (turbine_speed >= -0.71 and turbine_speed <= 0) {
206         production = 1.69215 * exp(1.25909 * turbine_speed) - 0.69215;
207     }
208 
209     else {
210         production = 1;
211     }
```

```
212
213     return production * this->capacity_kW;
214 }   /* __computeExponentialProductionkW() */
```

4.19.3.4 __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.

```
246 {
247     // *** WORK IN PROGRESS *** //
248
249     return 0;
250 }   /* __computeLookupProductionkW() */
```

4.19.3.5 __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].

```
73 {
74     double capital_cost_per_kW = 2000 * pow(this->capacity_kW, -0.15) + 4000;
75
76     return capital_cost_per_kW * this->capacity_kW;
77 }   /* __getGenericCapitalCost() */
```

4.19.3.6 __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].

```
100 {
101     double operation_maintenance_cost_kWh = 0.05 * pow(this->capacity_kW, -0.2) + 0.05;
102 
103     return operation_maintenance_cost_kWh;
104 }   /* __getGenericOpMaintCost() */
```

4.19.3.7 __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.

```
268 {
269     //  1. create filestream
270     write_path += "summary_results.md";
271     std::ofstream ofs;
272     ofs.open(write_path, std::ofstream::out);
273 
274     //  2. write summary results (markdown)
275     ofs « "# ";
276     ofs « std::to_string(int(ceil(this->capacity_kW)));
277     ofs « " kW TIDAL Summary Results\n";
278     ofs « "\n--------\n\n";
279 
280     //  2.1. Production attributes
281     ofs « "## Production Attributes\n";
282     ofs « "\n";
283 
284     ofs « "Capacity: " « this->capacity_kW « "kW  \n";
285     ofs « "\n";
286 
287     ofs « "Sunk Cost (N = 0 / Y = 1): " « this->is_sunk « "  \n";
288     ofs « "Capital Cost: " « this->capital_cost « "  \n";
289     ofs « "Operation and Maintenance Cost: " « this->operation_maintenance_cost_kWh
290         « " per kWh produced  \n";
291     ofs « "Nominal Inflation Rate (annual): " « this->nominal_inflation_annual
292         « "  \n";
293     ofs « "Nominal Discount Rate (annual): " « this->nominal_discount_annual
294         « "  \n";
```

```
295     ofs « "Real Discount Rate (annual): " « this->real_discount_annual « "  \n";
296     ofs « "\n";
297
298     ofs « "Replacement Running Hours: " « this->replace_running_hrs « "  \n";
299     ofs « "\n--------\n\n";
300
301     //  2.2. Renewable attributes
302     ofs « "## Renewable Attributes\n";
303     ofs « "\n";
304
305     ofs « "Resource Key (1D): " « this->resource_key « "  \n";
306
307     ofs « "\n--------\n\n";
308
309     //  2.3. Tidal attributes
310     ofs « "## Tidal Attributes\n";
311     ofs « "\n";
312
313     ofs « "Power Production Model: " « this->power_model_string « "  \n";
314     ofs « "Design Speed: " « this->design_speed_ms « " m/s  \n";
315
316     ofs « "\n--------\n\n";
317
318     //  2.4. Tidal Results
319     ofs « "## Results\n";
320     ofs « "\n";
321
322     ofs « "Net Present Cost: " « this->net_present_cost « "  \n";
323     ofs « "\n";
324
325     ofs « "Total Dispatch: " « this->total_dispatch_kWh
326         « " kWh  \n";
327
328     ofs « "Levellized Cost of Energy: " « this->levellized_cost_of_energy_kWh
329         « " per kWh dispatched  \n";
330     ofs « "\n";
331
332     ofs « "Running Hours: " « this->running_hours « "  \n";
333     ofs « "Replacements: " « this->n_replacements « "  \n";
334
335     ofs « "\n--------\n\n";
336
337     ofs.close();
338
339     return;
340 }   /* __writeSummary() */
```

4.19.3.8 __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.

```
378 {
379     //  1. create filestream
380     write_path += "time_series_results.csv";
381     std::ofstream ofs;
382     ofs.open(write_path, std::ofstream::out);
383 
384     //  2. write time series results (comma separated value)
385     ofs « "Time (since start of data) [hrs],";
386     ofs « "Tidal Resource [m/s],";
387     ofs « "Production [kW],";
388     ofs « "Dispatch [kW],";
389     ofs « "Storage [kW],";
390     ofs « "Curtailment [kW],";
391     ofs « "Capital Cost (actual),";
392     ofs « "Operation and Maintenance Cost (actual),";
393     ofs « "\n";
394 
395     for (int i = 0; i < max_lines; i++) {
396         ofs « time_vec_hrs_ptr->at(i) « ",";
397         ofs « resource_map_1D_ptr->at(this->resource_key)[i] « ",";
398         ofs « this->production_vec_kW[i] « ",";
399         ofs « this->dispatch_vec_kW[i] « ",";
400         ofs « this->storage_vec_kW[i] « ",";
401         ofs « this->curtailment_vec_kW[i] « ",";
402         ofs « this->capital_cost_vec[i] « ",";
403         ofs « this->operation_maintenance_cost_vec[i] « ",";
404         ofs « "\n";
405     }
406 
407     return;
408 }   /* __writeTimeSeries() */
```

4.19.3.9 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.

```
656 {
657     //  1. invoke base class method
658     load_kW = Renewable :: commit(
659         timestep,
660         dt_hrs,
661         production_kW,
662         load_kW
663     );
664 
665 
```

```
666     //...
667
668     return load_kW;
669 }   /* commit() */
```

4.19.3.10 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.

```
562 {
563     // check if no resource
564     if (tidal_resource_ms <= 0) {
565         return 0;
566     }
567
568     // compute production
569     double production_kW = 0;
570
571     switch (this->power_model) {
572         case (TidalPowerProductionModel :: TIDAL_POWER_CUBIC): {
573             production_kW = this->__computeCubicProductionkW(
574                 timestep,
575                 dt_hrs,
576                 tidal_resource_ms
577             );
578
579             break;
580         }
581
582
583         case (TidalPowerProductionModel :: TIDAL_POWER_EXPONENTIAL): {
584             production_kW = this->__computeExponentialProductionkW(
585                 timestep,
586                 dt_hrs,
587                 tidal_resource_ms
588             );
589
590             break;
591         }
592
593         case (TidalPowerProductionModel :: TIDAL_POWER_LOOKUP): {
594             production_kW = this->__computeLookupProductionkW(
595                 timestep,
596                 dt_hrs,
597                 tidal_resource_ms
598             );
599
600             break;
601         }
```

```
602
603         default: {
604             std::string error_str = "ERROR:  Tidal::computeProductionkW():  ";
605             error_str += "power model ";
606             error_str += std::to_string(this->power_model);
607             error_str += " not recognized";
608
609             #ifdef _WIN32
610                 std::cout << error_str << std::endl;
611             #endif
612
613             throw std::runtime_error(error_str);
614
615             break;
616         }
617     }
618
619     return production_kW;
620 }   /* computeProductionkW() */
```

4.19.4 Member Data Documentation

4.19.4.1 design_speed_ms

```
double Tidal::design_speed_ms
```

The tidal stream speed [m/s] at which the tidal turbine achieves its rated capacity.

4.19.4.2 power_model

```
TidalPowerProductionModel Tidal::power_model
```

The tidal power production model to be applied.

4.19.4.3 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:

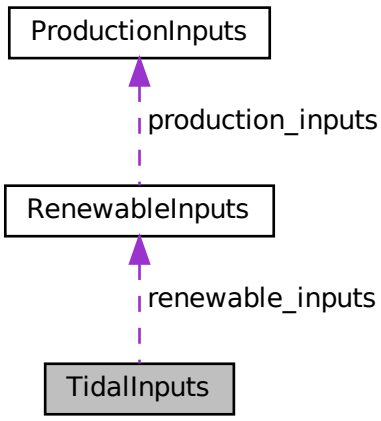
- header/Production/Renewable/Tidal.h
- source/Production/Renewable/Tidal.cpp

4.20 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.

4.20.1 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.

4.20.2 Member Data Documentation

4.20.2.1 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].

4.20.2.2 design_speed_ms

```
double TidalInputs::design_speed_ms = 3
```

The tidal stream speed [m/s] at which the tidal turbine achieves its rated capacity.

4.20.2.3 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].

4.20.2.4 power_model

```
TidalPowerProductionModel TidalInputs::power_model = TidalPowerProductionModel ::  TIDAL_POWER_CUBIC
```

The tidal power production model to be applied.

4.20.2.5 renewable_inputs

```
RenewableInputs TidalInputs::renewable_inputs
```

An encapsulated RenewableInputs instance.

4.20.2.6 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:

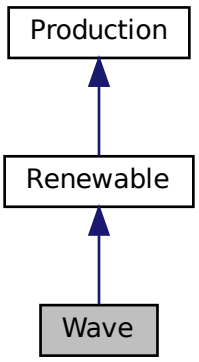
- header/Production/Renewable/Tidal.h

4.21 Wave Class Reference

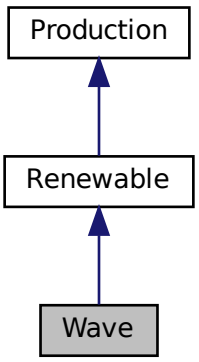
A derived class of the Renewable branch of Production which models wave production.

`#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)

  Constructor (intended) for the Wave class.
- 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.

4.21.1 Detailed Description

A derived class of the Renewable branch of Production which models wave production.

4.21.2 Constructor & Destructor Documentation

4.21.2.1 Wave() [1/2]

```
Wave::Wave (
            void  )
```

Constructor (dummy) for the Wave class.

```
480 {
481     return;
482 }   /* Wave() */
```

4.21.2.2 Wave() [2/2]

```
Wave::Wave (
            int n_points,
            double n_years,
            WaveInputs wave_inputs )
```

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.

```
510   :
511 Renewable(
512     n_points,
513     n_years,
514     wave_inputs.renewable_inputs
515 )
516 {
517     //  1. check inputs
518     this->__checkInputs(wave_inputs);
519 
520     //  2. set attributes
521     this->type = RenewableType :: WAVE;
522     this->type_str = "WAVE";
523 
524     this->resource_key = wave_inputs.resource_key;
525 
526     this->design_significant_wave_height_m =
527         wave_inputs.design_significant_wave_height_m;
528     this->design_energy_period_s = wave_inputs.design_energy_period_s;
529 
530     this->power_model = wave_inputs.power_model;
531 
532     switch (this->power_model) {
533         case (WavePowerProductionModel :: WAVE_POWER_GAUSSIAN): {
534             this->power_model_string = "GAUSSIAN";
535 
536             break;
537         }
538 
539         case (WavePowerProductionModel :: WAVE_POWER_PARABOLOID): {
540             this->power_model_string = "PARABOLOID";
541 
542             break;
543         }
```

```
544
545         case (WavePowerProductionModel :: WAVE_POWER_LOOKUP): {
546             this->power_model_string = "LOOKUP";
547
548             break;
549         }
550
551         default: {
552             std::string error_str = "ERROR:  Wave():  ";
553             error_str += "power production model ";
554             error_str += std::to_string(this->power_model);
555             error_str += " not recognized";
556
557             #ifdef _WIN32
558                 std::cout << error_str << std::endl;
559             #endif
560
561             throw std::runtime_error(error_str);
562
563             break;
564         }
565     }
566
567     if (wave_inputs.capital_cost < 0) {
568         this->capital_cost = this->__getGenericCapitalCost();
569     }
570
571     if (wave_inputs.operation_maintenance_cost_kWh < 0) {
572         this->operation_maintenance_cost_kWh = this->__getGenericOpMaintCost();
573     }
574
575     if (not this->is_sunk) {
576         this->capital_cost_vec[0] = this->capital_cost;
577     }
578
579     //  3. construction print
580     if (this->print_flag) {
581         std::cout << "Wave object constructed at " << this << std::endl;
582     }
583
584     return;
585 }   /* Renewable() */
```

4.21.2.3 ~Wave()

```
Wave::~Wave (
            void  )
```

Destructor for the Wave class.

```
745 {
746     //  1. destruction print
747     if (this->print_flag) {
748         std::cout << "Wave object at " << this << " destroyed" << std::endl;
749     }
750
751     return;
752 }   /* ~Wave() */
```

4.21.3 Member Function Documentation

4.21.3.1 __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.

```
39 {
40     //  1. check design_significant_wave_height_m
41     if (wave_inputs.design_significant_wave_height_m <= 0) {
42         std::string error_str = "ERROR:  Wave():  ";
43         error_str += "WaveInputs::design_significant_wave_height_m must be > 0";
44 
45         #ifdef _WIN32
46             std::cout « error_str « std::endl;
47         #endif
48 
49         throw std::invalid_argument(error_str);
50     }
51 
52     //  2. check design_energy_period_s
53     if (wave_inputs.design_energy_period_s <= 0) {
54         std::string error_str = "ERROR:  Wave():  ";
55         error_str += "WaveInputs::design_energy_period_s must be > 0";
56 
57         #ifdef _WIN32
58             std::cout « error_str « std::endl;
59         #endif
60 
61         throw std::invalid_argument(error_str);
62     }
63 
64     return;
65 }   /* __checkInputs() */
```

4.21.3.2 __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.

```
160 {
161     double H_s_nondim =
162         (significant_wave_height_m - this->design_significant_wave_height_m) /
163         this->design_significant_wave_height_m;
164 
165     double T_e_nondim =
166         (energy_period_s - this->design_energy_period_s) /
```

```
167         this->design_energy_period_s;
168
169     double production = exp(
170         -2.25119 * pow(T_e_nondim, 2) +
171         3.44570 * T_e_nondim * H_s_nondim -
172         4.01508 * pow(H_s_nondim, 2)
173     );
174
175     return production * this->capacity_kW;
176 }   /* __computeGaussianProductionkW() */
```

4.21.3.3 __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.

```
277 {
278     // *** WORK IN PROGRESS *** //
279
280     return 0;
281 }   /* __computeLookupProductionkW() */
```

4.21.3.4 __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.

```
217 {
218     // first, check for idealized wave breaking (deep water)
219     if (significant_wave_height_m >= 0.2184 * pow(energy_period_s, 2)) {
220         return 0;
221     }
222 
223     // otherwise, apply generic quadratic performance model
224     // (with outputs bounded to [0, 1])
225     double production =
226         0.289 * significant_wave_height_m -
227         0.00111 * pow(significant_wave_height_m, 2) * energy_period_s -
228         0.0169 * energy_period_s;
229 
230     if (production < 0) {
231         production = 0;
232     }
233 
234     else if (production > 1) {
235         production = 1;
236     }
237 
238     return production * this->capacity_kW;
239 }   /* __computeParaboloidProductionkW() */
```

4.21.3.5 __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].

```
87 {
88     double capital_cost_per_kW = 7000 * pow(this->capacity_kW, -0.15) + 5000;
89 
90     return capital_cost_per_kW * this->capacity_kW;
91 }   /* __getGenericCapitalCost() */
```

4.21.3.6 __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].

```
115 {
116     double operation_maintenance_cost_kWh = 0.05 * pow(this->capacity_kW, -0.2) + 0.05;
117 
118     return operation_maintenance_cost_kWh;
119 }   /* __getGenericOpMaintCost() */
```

4.21.3.7 __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.

```
299 {
300     //  1. create filestream
301     write_path += "summary_results.md";
302     std::ofstream ofs;
303     ofs.open(write_path, std::ofstream::out);
304 
305     //  2. write summary results (markdown)
306     ofs « "# ";
307     ofs « std::to_string(int(ceil(this->capacity_kW)));
308     ofs « " kW WAVE Summary Results\n";
309     ofs « "\n--------\n\n";
310 
311     //  2.1. Production attributes
312     ofs « "## Production Attributes\n";
313     ofs « "\n";
314 
315     ofs « "Capacity: " « this->capacity_kW « "kW  \n";
316     ofs « "\n";
317 
318     ofs « "Sunk Cost (N = 0 / Y = 1): " « this->is_sunk « "  \n";
319     ofs « "Capital Cost: " « this->capital_cost « "  \n";
320     ofs « "Operation and Maintenance Cost: " « this->operation_maintenance_cost_kWh
321         « " per kWh produced  \n";
322     ofs « "Nominal Inflation Rate (annual): " « this->nominal_inflation_annual
323         « "  \n";
324     ofs « "Nominal Discount Rate (annual): " « this->nominal_discount_annual
```

```
325         « "  \n";
326     ofs « "Real Discount Rate (annual): " « this->real_discount_annual « "  \n";
327     ofs « "\n";
328 
329     ofs « "Replacement Running Hours: " « this->replace_running_hrs « "  \n";
330     ofs « "\n--------\n\n";
331 
332     //  2.2. Renewable attributes
333     ofs « "## Renewable Attributes\n";
334     ofs « "\n";
335 
336     ofs « "Resource Key (2D): " « this->resource_key « "  \n";
337 
338     ofs « "\n--------\n\n";
339 
340     //  2.3. Wave attributes
341     ofs « "## Wave Attributes\n";
342     ofs « "\n";
343 
344     ofs « "Power Production Model: " « this->power_model_string « "  \n";
345     switch (this->power_model) {
346         case (WavePowerProductionModel :: WAVE_POWER_GAUSSIAN): {
347             ofs « "Design Significant Wave Height: "
348                 « this->design_significant_wave_height_m « " m  \n";
349 
350             ofs « "Design Energy Period: " « this->design_energy_period_s « " s  \n";
351 
352             break;
353         }
354 
355         case (WavePowerProductionModel :: WAVE_POWER_LOOKUP): {
356             //...
357 
358             break;
359         }
360 
361         default: {
362             // write nothing!
363 
364             break;
365         }
366     }
367 
368     ofs « "\n--------\n\n";
369 
370     //  2.4. Wave Results
371     ofs « "## Results\n";
372     ofs « "\n";
373 
374     ofs « "Net Present Cost: " « this->net_present_cost « "  \n";
375     ofs « "\n";
376 
377     ofs « "Total Dispatch: " « this->total_dispatch_kWh
378         « " kWh  \n";
379 
380     ofs « "Levellized Cost of Energy: " « this->levellized_cost_of_energy_kWh
381         « " per kWh dispatched  \n";
382     ofs « "\n";
383 
384     ofs « "Running Hours: " « this->running_hours « "  \n";
385     ofs « "Replacements: " « this->n_replacements « "  \n";
386 
387     ofs « "\n--------\n\n";
388 
389     ofs.close();
390 
391     return;
392 }   /* __writeSummary() */
```

4.21.3.8 __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.

```
430 {
431     //  1. create filestream
432     write_path += "time_series_results.csv";
433     std::ofstream ofs;
434     ofs.open(write_path, std::ofstream::out);
435 
436     //  2. write time series results (comma separated value)
437     ofs « "Time (since start of data) [hrs],";
438     ofs « "Significant Wave Height [m],";
439     ofs « "Energy Period [s],";
440     ofs « "Production [kW],";
441     ofs « "Dispatch [kW],";
442     ofs « "Storage [kW],";
443     ofs « "Curtailment [kW],";
444     ofs « "Capital Cost (actual),";
445     ofs « "Operation and Maintenance Cost (actual),";
446     ofs « "\n";
447 
448     for (int i = 0; i < max_lines; i++) {
449         ofs « time_vec_hrs_ptr->at(i) « ",";
450         ofs « resource_map_2D_ptr->at(this->resource_key)[i][0] « ",";
451         ofs « resource_map_2D_ptr->at(this->resource_key)[i][1] « ",";
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() */
```

4.21.3.9 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.

```
717 {
718     //  1. invoke base class method
719     load_kW = Renewable :: commit(
720         timestep,
721         dt_hrs,
722         production_kW,
723         load_kW
724     );
725 
726 
727     //...
728 
729     return load_kW;
730 }   /* commit() */
```

4.21.3.10 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.

```
621 {
622     // check if no resource
623     if (significant_wave_height_m <= 0 or energy_period_s <= 0) {
624         return 0;
625     }
626 
627     // compute production
628     double production_kW = 0;
629 
630     switch (this->power_model) {
631         case (WavePowerProductionModel :: WAVE_POWER_PARABOLOID): {
632             production_kW = this->__computeParaboloidProductionkW(
633                 timestep,
634                 dt_hrs,
635                 significant_wave_height_m,
636                 energy_period_s
637             );
638 
```

```
639             break;
640         }
641 
642         case (WavePowerProductionModel :: WAVE_POWER_GAUSSIAN): {
643             production_kW = this->__computeGaussianProductionkW(
644                 timestep,
645                 dt_hrs,
646                 significant_wave_height_m,
647                 energy_period_s
648             );
649 
650             break;
651         }
652 
653         case (WavePowerProductionModel :: WAVE_POWER_LOOKUP): {
654             production_kW = this->__computeLookupProductionkW(
655                 timestep,
656                 dt_hrs,
657                 significant_wave_height_m,
658                 energy_period_s
659             );
660 
661             break;
662         }
663 
664         default: {
665             std::string error_str = "ERROR:  Wave::computeProductionkW():  ";
666             error_str += "power model ";
667             error_str += std::to_string(this->power_model);
668             error_str += " not recognized";
669 
670             #ifdef _WIN32
671                 std::cout « error_str « std::endl;
672             #endif
673 
674             throw std::runtime_error(error_str);
675 
676             break;
677         }
678     }
679 
680     return production_kW;
681 }   /* computeProductionkW() */
```

4.21.4 Member Data Documentation

4.21.4.1 design_energy_period_s

```
double Wave::design_energy_period_s
```

The energy period [s] at which the wave energy converter achieves its rated capacity.

4.21.4.2 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.

4.21.4.3 power_model

```
WavePowerProductionModel Wave::power_model
```

The wave power production model to be applied.

4.21.4.4 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:

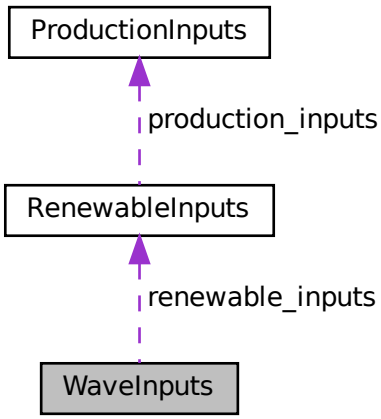
- header/Production/Renewable/Wave.h
- source/Production/Renewable/Wave.cpp

4.22 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.

4.22.1 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.

4.22.2 Member Data Documentation

4.22.2.1 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].

4.22.2.2 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.

4.22.2.3 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.

4.22.2.4 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].

4.22.2.5 power_model

```
WavePowerProductionModel WaveInputs::power_model = WavePowerProductionModel ::  WAVE_POWER_PARABOLOID
```

The wave power production model to be applied.

4.22.2.6 renewable_inputs

```
RenewableInputs WaveInputs::renewable_inputs
```

An encapsulated RenewableInputs instance.

4.22.2.7 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:

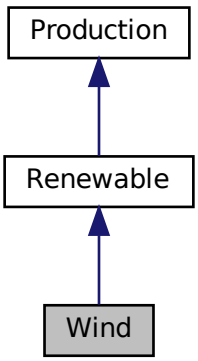
- header/Production/Renewable/Wave.h

4.23 Wind Class Reference

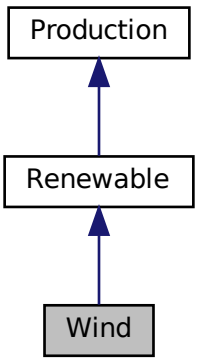
A derived class of the Renewable branch of Production which models wind production.

`#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)

Constructor (intended) for the Wind class.

- 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 __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.

4.23.1 Detailed Description

A derived class of the Renewable branch of Production which models wind production.

4.23.2 Constructor & Destructor Documentation

4.23.2.1 Wind() [1/2]

```
Wind::Wind (
            void  )
```

Constructor (dummy) for the Wind class.

```
390 {
391     return;
392 }   /* Wind() */
```

4.23.2.2 Wind() [2/2]

```
Wind::Wind (
            int n_points,
            double n_years,
            WindInputs wind_inputs )
```

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.

```
420   :
421 Renewable(
422     n_points,
423     n_years,
424     wind_inputs.renewable_inputs
425 )
426 {
427     //  1. check inputs
428     this->__checkInputs(wind_inputs);
429
430     //  2. set attributes
431     this->type = RenewableType :: WIND;
432     this->type_str = "WIND";
433
434     this->resource_key = wind_inputs.resource_key;
435
436     this->design_speed_ms = wind_inputs.design_speed_ms;
437
438     this->power_model = wind_inputs.power_model;
439
440     switch (this->power_model) {
441         case (WindPowerProductionModel :: WIND_POWER_EXPONENTIAL): {
442             this->power_model_string = "EXPONENTIAL";
443
444             break;
445         }
446
447         case (WindPowerProductionModel :: WIND_POWER_LOOKUP): {
448             this->power_model_string = "LOOKUP";
449
450             break;
451         }
452
453         default: {
454             std::string error_str = "ERROR:  Wind():  ";
455             error_str += "power production model ";
456             error_str += std::to_string(this->power_model);
457             error_str += " not recognized";
458
459             #ifdef _WIN32
460                 std::cout « error_str « std::endl;
461             #endif
462
463             throw std::runtime_error(error_str);
```

```
464
465             break;
466         }
467     }
468
469     if (wind_inputs.capital_cost < 0) {
470         this->capital_cost = this->__getGenericCapitalCost();
471     }
472
473     if (wind_inputs.operation_maintenance_cost_kWh < 0) {
474         this->operation_maintenance_cost_kWh = this->__getGenericOpMaintCost();
475     }
476
477     if (not this->is_sunk) {
478         this->capital_cost_vec[0] = this->capital_cost;
479     }
480
481     //  3. construction print
482     if (this->print_flag) {
483         std::cout << "Wind object constructed at " << this << std::endl;
484     }
485
486     return;
487 }   /* Renewable() */
```

4.23.2.3 ~Wind()

```
Wind::~Wind (
              void  )
```

Destructor for the Wind class.

```
630 {
631     //  1. destruction print
632     if (this->print_flag) {
633         std::cout << "Wind object at " << this << " destroyed" << std::endl;
634     }
635
636     return;
637 }   /* ~Wind() */
```

4.23.3 Member Function Documentation

4.23.3.1 __checkInputs()

```
void Wind::__checkInputs (
              WindInputs wind_inputs )  [private]
```

Helper method to check inputs to the Wind constructor.

Parameters

wind_inputs	A structure of Wind constructor inputs.

```
39 {
40     //  1. check design_speed_ms
41     if (wind_inputs.design_speed_ms <= 0) {
42         std::string error_str = "ERROR:  Wind():  ";
43         error_str += "WindInputs::design_speed_ms must be > 0";
44
45         #ifdef _WIN32
46             std::cout << error_str << std::endl;
```

```
47          #endif
48
49          throw std::invalid_argument(error_str);
50      }
51
52      return;
53  }   /* __checkInputs() */
```

4.23.3.2 __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.

```
140 {
141     double production = 0;
142
143     double turbine_speed = (wind_resource_ms - this->design_speed_ms) /
144         this->design_speed_ms;
145
146     if (turbine_speed < -0.76 or turbine_speed > 0.68) {
147         production = 0;
148     }
149
150     else if (turbine_speed >= -0.76 and turbine_speed <= 0) {
151         production = 1.03273 * exp(-5.97588 * pow(turbine_speed, 2)) - 0.03273;
152     }
153
154     else {
155         production = 0.16154 * exp(-9.30254 * pow(turbine_speed, 2)) + 0.83846;
156     }
157
158     return production * this->capacity_kW;
159 }   /* __computeExponentialProductionkW() */
```

4.23.3.3 __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.

```
191 {
192     // *** WORK IN PROGRESS *** //
193
194     return 0;
195 }   /* __computeLookupProductionkW() */
```

4.23.3.4 __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].

```
75 {
76     double capital_cost_per_kW = 3000 * pow(this->capacity_kW, -0.15) + 3000;
77
78     return capital_cost_per_kW * this->capacity_kW;
79 }   /* __getGenericCapitalCost() */
```

4.23.3.5 __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].

```
102 {
103     double operation_maintenance_cost_kWh = 0.025 * pow(this->capacity_kW, -0.2) + 0.025;
104
105     return operation_maintenance_cost_kWh;
106 }   /* __getGenericOpMaintCost() */
```

4.23.3.6 __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.

```
213 {
214     //  1. create filestream
215     write_path += "summary_results.md";
216     std::ofstream ofs;
217     ofs.open(write_path, std::ofstream::out);
218 
219     //  2. write summary results (markdown)
220     ofs « "# ";
221     ofs « std::to_string(int(ceil(this->capacity_kW)));
222     ofs « " kW WIND Summary Results\n";
223     ofs « "\n--------\n\n";
224 
225 
226     //  2.1. Production attributes
227     ofs « "## Production Attributes\n";
228     ofs « "\n";
229 
230     ofs « "Capacity: " « this->capacity_kW « "kW  \n";
231     ofs « "\n";
232 
233     ofs « "Sunk Cost (N = 0 / Y = 1): " « this->is_sunk « "  \n";
234     ofs « "Capital Cost: " « this->capital_cost « "  \n";
235     ofs « "Operation and Maintenance Cost: " « this->operation_maintenance_cost_kWh
236         « " per kWh produced  \n";
237     ofs « "Nominal Inflation Rate (annual): " « this->nominal_inflation_annual
238         « "  \n";
239     ofs « "Nominal Discount Rate (annual): " « this->nominal_discount_annual
240         « "  \n";
241     ofs « "Real Discount Rate (annual): " « this->real_discount_annual « "  \n";
242     ofs « "\n";
243 
244     ofs « "Replacement Running Hours: " « this->replace_running_hrs « "  \n";
245     ofs « "\n--------\n\n";
246 
247     //  2.2. Renewable attributes
248     ofs « "## Renewable Attributes\n";
249     ofs « "\n";
250 
251     ofs « "Resource Key (1D): " « this->resource_key « "  \n";
252 
253     ofs « "\n--------\n\n";
254 
255     //  2.3. Wind attributes
256     ofs « "## Wind Attributes\n";
257     ofs « "\n";
258 
259     ofs « "Power Production Model: " « this->power_model_string « "  \n";
260     switch (this->power_model) {
261         case (WindPowerProductionModel :: WIND_POWER_EXPONENTIAL): {
262             ofs « "Design Speed: " « this->design_speed_ms « " m/s  \n";
263 
264             break;
265         }
266 
267         case (WindPowerProductionModel :: WIND_POWER_LOOKUP): {
268             //...
269 
270             break;
271         }
272 
273         default: {
274             // write nothing!
275 
276             break;
277         }
278     }
279 
280     ofs « "\n--------\n\n";
281 
282     //  2.4. Wind Results
283     ofs « "## Results\n";
284     ofs « "\n";
285 
286     ofs « "Net Present Cost: " « this->net_present_cost « "  \n";
287     ofs « "\n";
288 
289     ofs « "Total Dispatch: " « this->total_dispatch_kWh
```

```
290         « " kWh  \n";
291
292     ofs « "Levellized Cost of Energy: " « this->levellized_cost_of_energy_kWh
293         « " per kWh dispatched  \n";
294     ofs « "\n";
295
296     ofs « "Running Hours: " « this->running_hours « "  \n";
297     ofs « "Replacements: " « this->n_replacements « "  \n";
298
299     ofs « "\n--------\n\n";
300
301     ofs.close();
302
303     return;
304 }   /* __writeSummary() */
```

4.23.3.7 __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.

```
342 {
343     //  1. create filestream
344     write_path += "time_series_results.csv";
345     std::ofstream ofs;
346     ofs.open(write_path, std::ofstream::out);
347
348     //  2. write time series results (comma separated value)
349     ofs « "Time (since start of data) [hrs],";
350     ofs « "Wind Resource [m/s],";
351     ofs « "Production [kW],";
352     ofs « "Dispatch [kW],";
353     ofs « "Storage [kW],";
354     ofs « "Curtailment [kW],";
355     ofs « "Capital Cost (actual),";
356     ofs « "Operation and Maintenance Cost (actual),";
357     ofs « "\n";
358
359     for (int i = 0; i < max_lines; i++) {
360         ofs « time_vec_hrs_ptr->at(i) « ",";
361         ofs « resource_map_1D_ptr->at(this->resource_key)[i] « ",";
362         ofs « this->production_vec_kW[i] « ",";
363         ofs « this->dispatch_vec_kW[i] « ",";
364         ofs « this->storage_vec_kW[i] « ",";
365         ofs « this->curtailment_vec_kW[i] « ",";
366         ofs « this->capital_cost_vec[i] « ",";
367         ofs « this->operation_maintenance_cost_vec[i] « ",";
368         ofs « "\n";
369     }
370
371     return;
```

```
372 }   /* __writeTimeSeries() */
```

4.23.3.8 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.

```
602 {
603     //  1. invoke base class method
604     load_kW = Renewable :: commit(
605         timestep,
606         dt_hrs,
607         production_kW,
608         load_kW
609     );
610 
611 
612     //...
613 
614     return load_kW;
615 }   /* commit() */
```

4.23.3.9 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.

```
519 {
520     // check if no resource
521     if (wind_resource_ms <= 0) {
522         return 0;
523     }
524 
525     // compute production
526     double production_kW = 0;
527 
528     switch (this->power_model) {
529         case (WindPowerProductionModel :: WIND_POWER_EXPONENTIAL): {
530             production_kW = this->__computeExponentialProductionkW(
531                 timestep,
532                 dt_hrs,
533                 wind_resource_ms
534             );
535 
536             break;
537         }
538 
539         case (WindPowerProductionModel :: WIND_POWER_LOOKUP): {
540             production_kW = this->__computeLookupProductionkW(
541                 timestep,
542                 dt_hrs,
543                 wind_resource_ms
544             );
545 
546             break;
547         }
548 
549         default: {
550             std::string error_str = "ERROR:  Wind::computeProductionkW():  ";
551             error_str += "power model ";
552             error_str += std::to_string(this->power_model);
553             error_str += " not recognized";
554 
555             #ifdef _WIN32
556                 std::cout « error_str « std::endl;
557             #endif
558 
559             throw std::runtime_error(error_str);
560 
561             break;
562         }
563     }
564 
565     return production_kW;
566 }   /* computeProductionkW() */
```

4.23.4 Member Data Documentation

4.23.4.1 design_speed_ms

```
double Wind::design_speed_ms
```

The wind speed [m/s] at which the wind turbine achieves its rated capacity.

4.23.4.2 power_model

```
WindPowerProductionModel Wind::power_model
```

The wind power production model to be applied.

4.23.4.3 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:

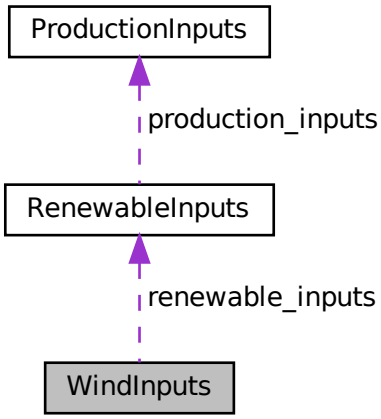
- header/Production/Renewable/Wind.h
- source/Production/Renewable/Wind.cpp

4.24 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 = 8

  The wind speed [m/s] at which the wind turbine achieves its rated capacity.

- WindPowerProductionModel power_model = WindPowerProductionModel :: WIND_POWER_EXPONENTIAL

  The wind power production model to be applied.

4.24.1 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.

4.24.2 Member Data Documentation

4.24.2.1 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].

4.24.2.2 design_speed_ms

```
double WindInputs::design_speed_ms = 8
```

The wind speed [m/s] at which the wind turbine achieves its rated capacity.

4.24.2.3 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].

4.24.2.4 power_model

```
WindPowerProductionModel WindInputs::power_model = WindPowerProductionModel ::  WIND_POWER_EXPONENTIAL
```

The wind power production model to be applied.

4.24.2.5 renewable_inputs

```
RenewableInputs WindInputs::renewable_inputs
```

An encapsulated RenewableInputs instance.

4.24.2.6 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

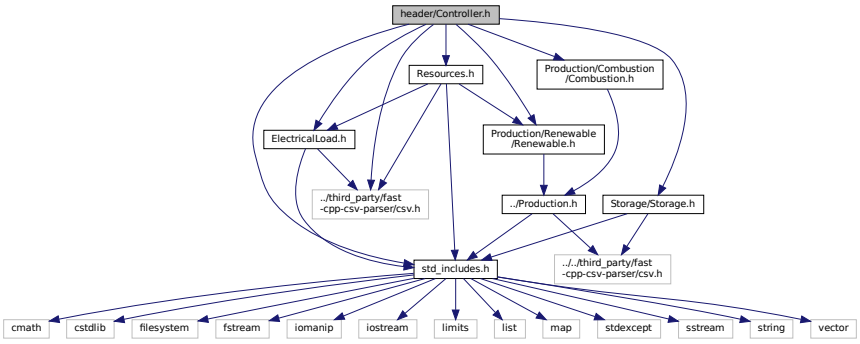
File Documentation

5.1 header/Controller.h File Reference

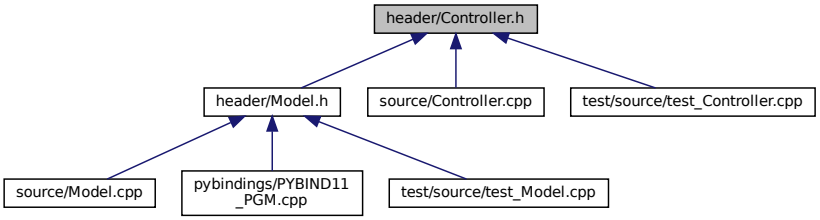
Header file the Controller class.

```
#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/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 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.

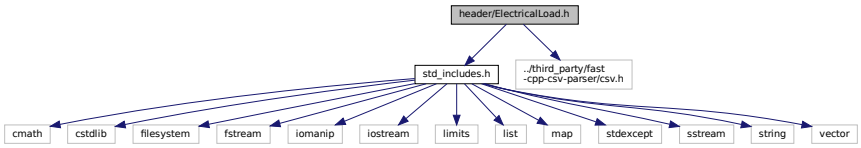
```
43                  {
44     LOAD_FOLLOWING,
45     CYCLE_CHARGING,
46     N_CONTROL_MODES
47 };
```

5.2 header/ElectricalLoad.h File Reference

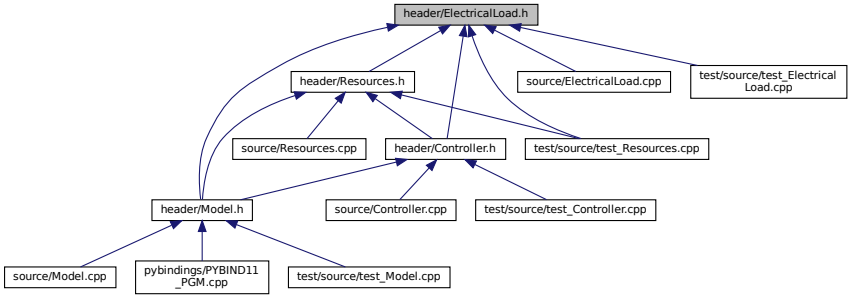
Header file the ElectricalLoad class.

```
#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.

5.2.1 Detailed Description

Header file the ElectricalLoad class.

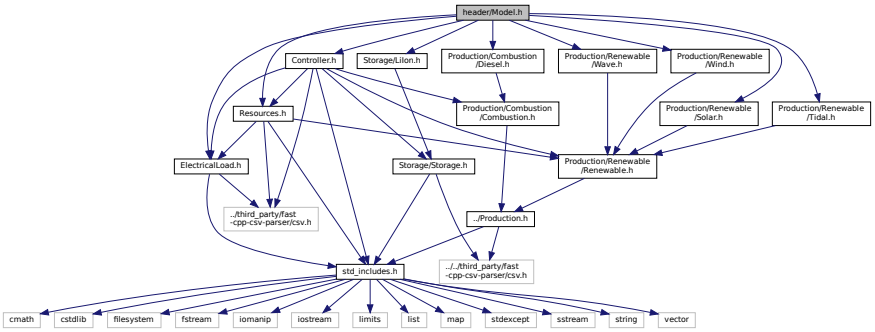
5.3 header/Model.h File Reference

Header file the Model class.

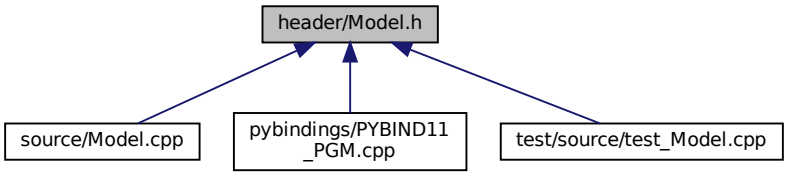
```
#include "Controller.h"
#include "ElectricalLoad.h"
#include "Resources.h"
#include "Production/Combustion/Diesel.h"
#include "Production/Renewable/Solar.h"
#include "Production/Renewable/Tidal.h"
#include "Production/Renewable/Wave.h"
#include "Production/Renewable/Wind.h"
```

```
#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.

5.3.1 Detailed Description

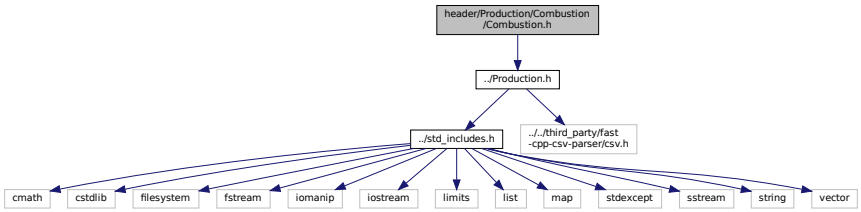
Header file the Model class.

5.4 header/Production/Combustion/Combustion.h File Reference

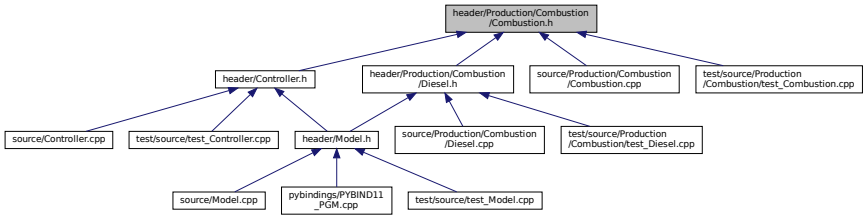
Header file the Combustion class.

```
#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.

5.4.1 Detailed Description

Header file the Combustion class.

5.4.2 Enumeration Type Documentation

5.4.2.1 CombustionType

```
enum CombustionType
```

An enumeration of the types of Combustion asset supported by PGMcpp.

Enumerator

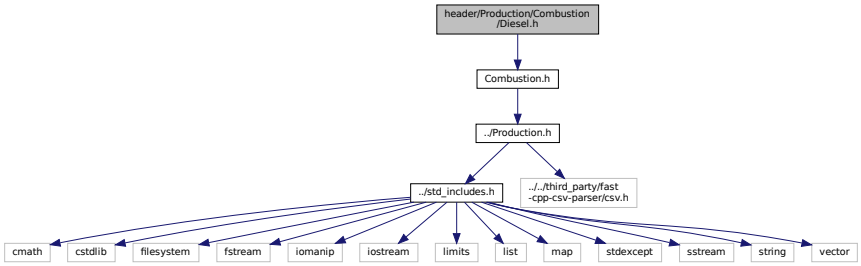
DIESEL	A diesel generator.
N_COMBUSTION_TYPES	A simple hack to get the number of elements in CombustionType.

```
33                  {
34     DIESEL,
35     N_COMBUSTION_TYPES
36 };
```

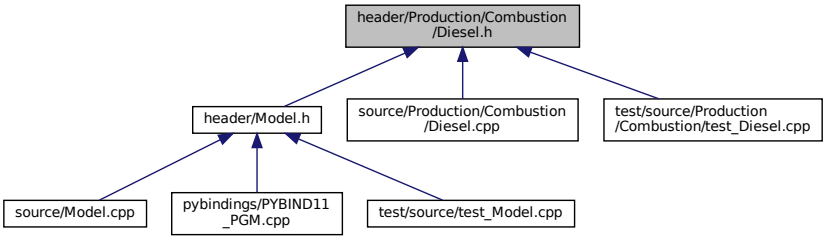
5.5 header/Production/Combustion/Diesel.h File Reference

Header file 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.

5.5.1 Detailed Description

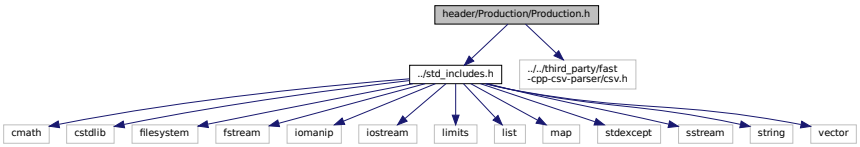
Header file the Diesel class.

5.6 header/Production/Production.h File Reference

Header file the Production class.

```
#include "../std_includes.h"
#include "../../third_party/fast-cpp-csv-parser/csv.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.

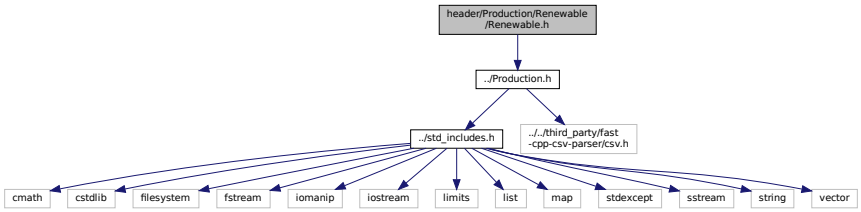
5.6.1 Detailed Description

Header file the Production class.

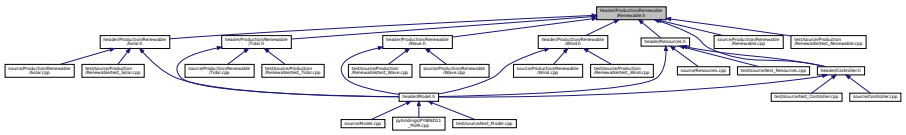
5.7 header/Production/Renewable/Renewable.h File Reference

Header file 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.

5.7.1 Detailed Description

Header file the Renewable class.

5.7.2 Enumeration Type Documentation

5.7.2.1 RenewableType

`enum RenewableType`

An enumeration of the types of Renewable asset supported by PGMcpp.

Enumerator

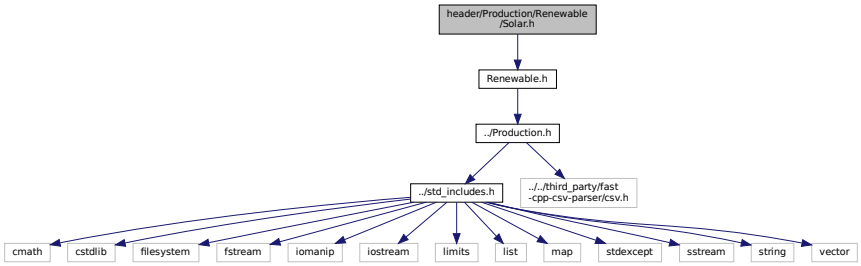
SOLAR	A solar photovoltaic (PV) array.
TIDAL	A tidal stream turbine (or tidal energy converter, TEC)
WAVE	A wave energy converter (WEC)
WIND	A wind turbine.
N_RENEWABLE_TYPES	A simple hack to get the number of elements in RenewableType.

```
33                      {
34     SOLAR,
35     TIDAL,
36     WAVE,
37     WIND,
38     N_RENEWABLE_TYPES
39 };
```

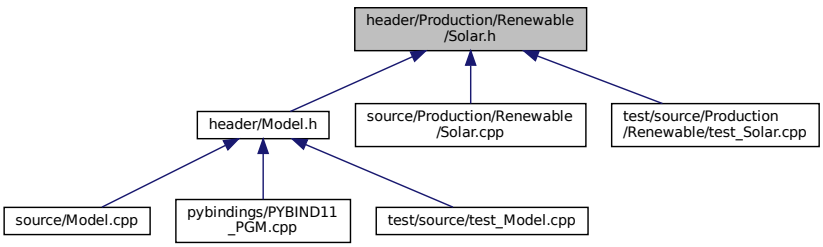
5.8 header/Production/Renewable/Solar.h File Reference

Header file 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.

5.8.1 Detailed Description

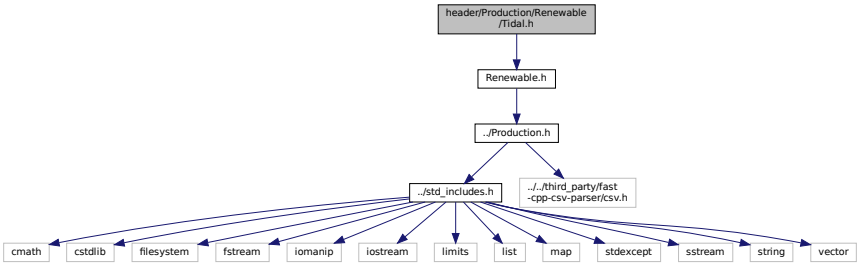
Header file the Solar class.

5.9 header/Production/Renewable/Tidal.h File Reference

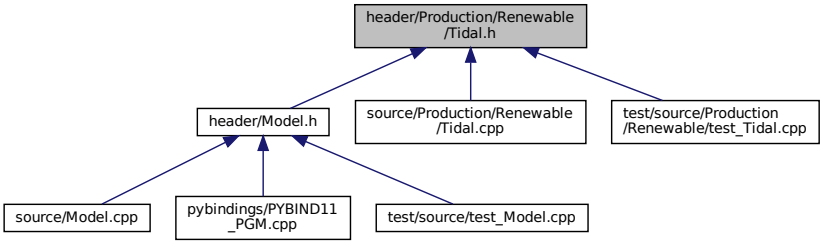
Header file the Tidal class.

```
#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 }

5.9.1 Detailed Description

Header file the Tidal class.

5.9.2 Enumeration Type Documentation

5.9.2.1 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.

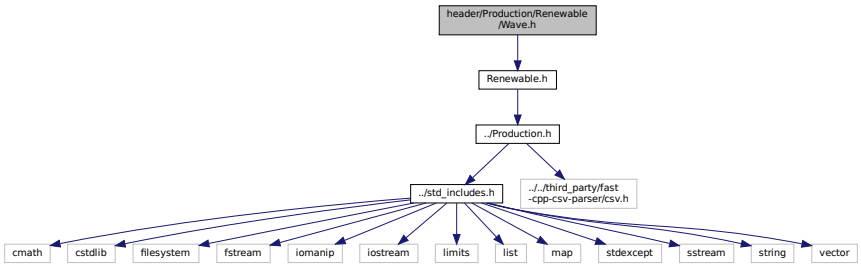
```
34                                {
35     TIDAL_POWER_CUBIC,
36     TIDAL_POWER_EXPONENTIAL,
37     TIDAL_POWER_LOOKUP,
38     N_TIDAL_POWER_PRODUCTION_MODELS
39 };
```

5.10 header/Production/Renewable/Wave.h File Reference

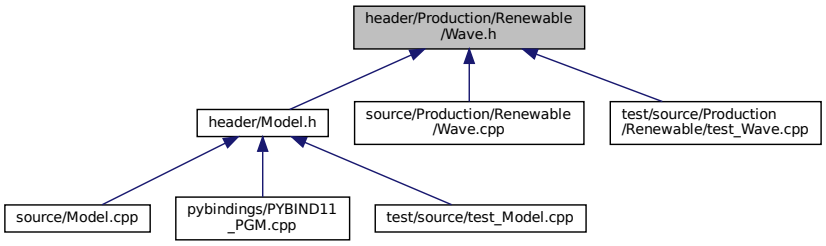
Header file the Wave class.

```
#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 }

5.10.1 Detailed Description

Header file the Wave class.

5.10.2 Enumeration Type Documentation

5.10.2.1 WavePowerProductionModel

`enum WavePowerProductionModel`

Enumerator

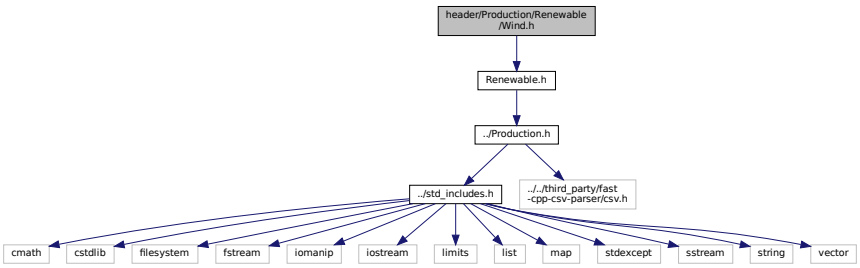
WAVE_POWER_GAUSSIAN	A Gaussian power production model.
WAVE_POWER_PARABOLOID	A paraboloid power production model.
WAVE_POWER_LOOKUP	Lookup from a given performance matrix.
N_WAVE_POWER_PRODUCTION_MODELS	A simple hack to get the number of elements in WavePowerProductionModel.

```
34                              {
35     WAVE_POWER_GAUSSIAN,
36     WAVE_POWER_PARABOLOID,
37     WAVE_POWER_LOOKUP,
38     N_WAVE_POWER_PRODUCTION_MODELS
39 };
```

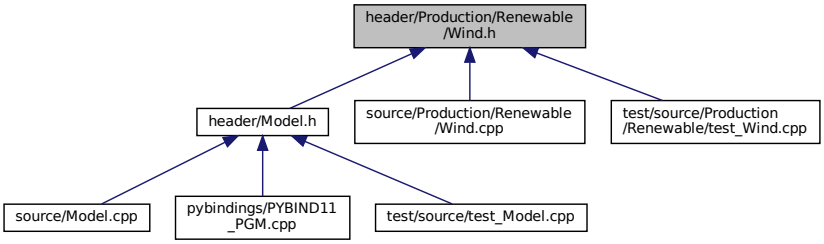
5.11 header/Production/Renewable/Wind.h File Reference

Header file 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_EXPONENTIAL , WIND_POWER_LOOKUP , N_WIND_POWER_PRODUCTION_MODELS }

5.11.1 Detailed Description

Header file the Wind class.

5.11.2 Enumeration Type Documentation

5.11.2.1 WindPowerProductionModel

```
enum WindPowerProductionModel
```

Enumerator

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.

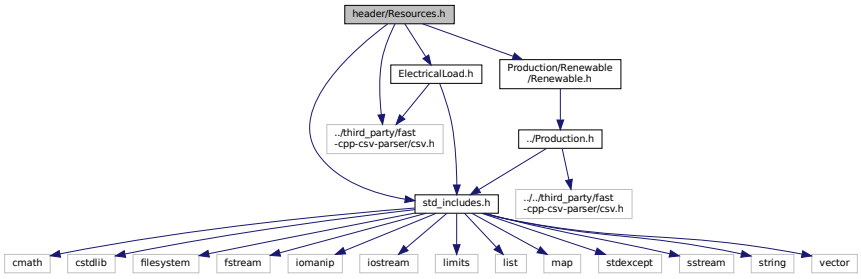
```
34                              {
35     WIND_POWER_EXPONENTIAL,
36     WIND_POWER_LOOKUP,
37     N_WIND_POWER_PRODUCTION_MODELS
38 };
```

5.12 header/Resources.h File Reference

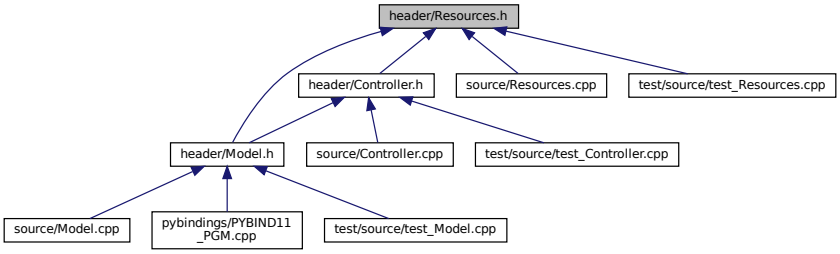
Header file the Resources class.

```
#include "std_includes.h"
#include "../third_party/fast-cpp-csv-parser/csv.h"
#include "ElectricalLoad.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.

5.12.1 Detailed Description

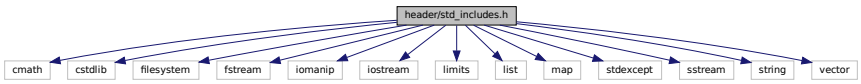
Header file the Resources class.

5.13 header/std_includes.h File Reference

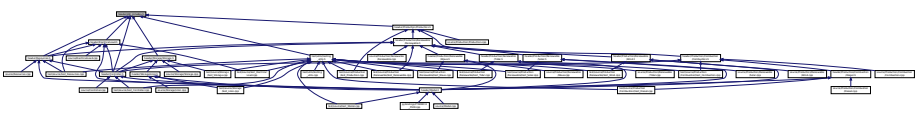
Header file which simply batches together the usual, standard includes.

```
#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:



5.13.1 Detailed Description

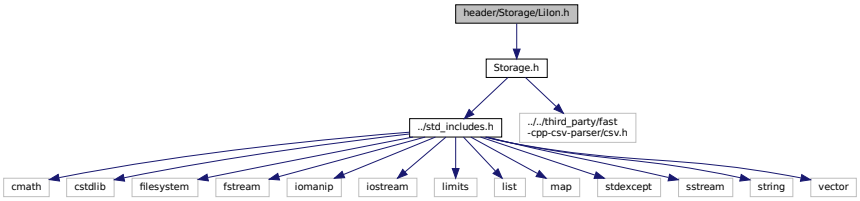
Header file which simply batches together the usual, standard includes.

5.14 header/Storage/LiIon.h File Reference

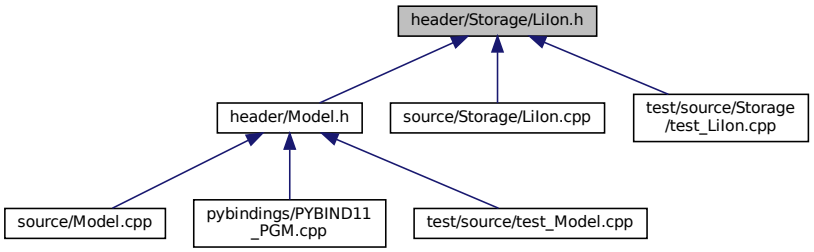
Header file the LiIon class.

```
#include "Storage.h"
```

Include dependency graph for LiIon.h:



This graph shows which files directly or indirectly include this file:



Classes

- class LiIon

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

5.14.1 Detailed Description

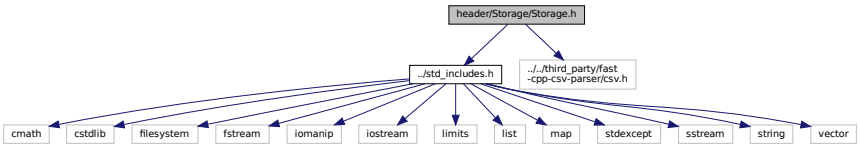
Header file the LiIon class.

5.15 header/Storage/Storage.h File Reference

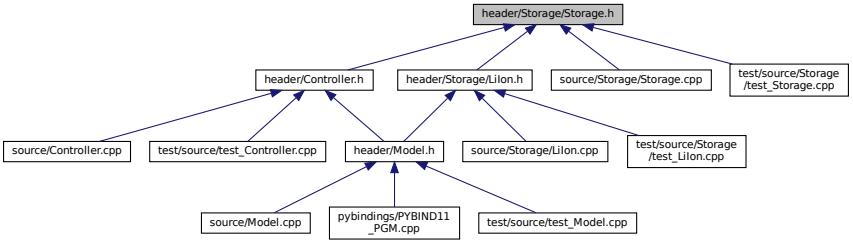
Header file the Storage class.

```
#include "../std_includes.h"
#include "../../third_party/fast-cpp-csv-parser/csv.h"
```

Include dependency graph for Storage.h:



This graph shows which files directly or indirectly include this file:



Classes

- class Storage

  The base class of the Storage hierarchy. This hierarchy contains derived classes which model the storage of energy.

5.15.1 Detailed Description

Header file the Storage class.

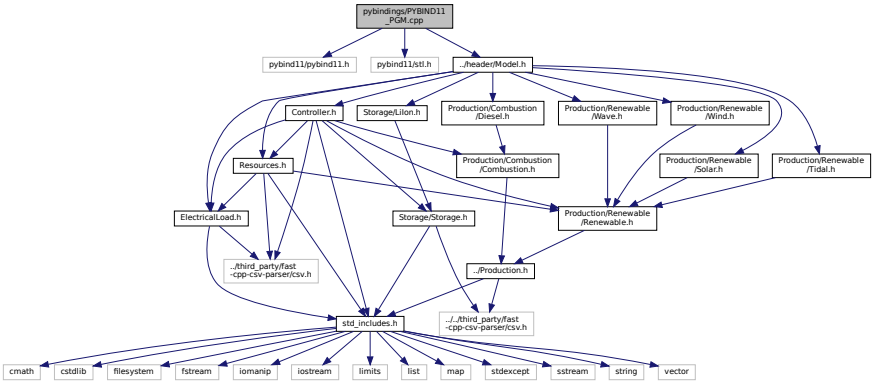
5.16 pybindings/PYBIND11_PGM.cpp File Reference

Python 3 bindings file for PGMcpp.

```
#include <pybind11/pybind11.h>
#include <pybind11/stl.h>
```

```
#include "../header/Model.h"
```

Include dependency graph for PYBIND11_PGM.cpp:



Functions

- PYBIND11_MODULE (PGMcpp, m)

5.16.1 Detailed Description

Python 3 bindings file for PGMcpp.

This is a file which defines the Python 3 bindings to be generated for PGMcpp. To generate bindings, use the provided setup.py.

ref: https://pybind11.readthedocs.io/en/stable/

5.16.2 Function Documentation

5.16.2.1 PYBIND11_MODULE()

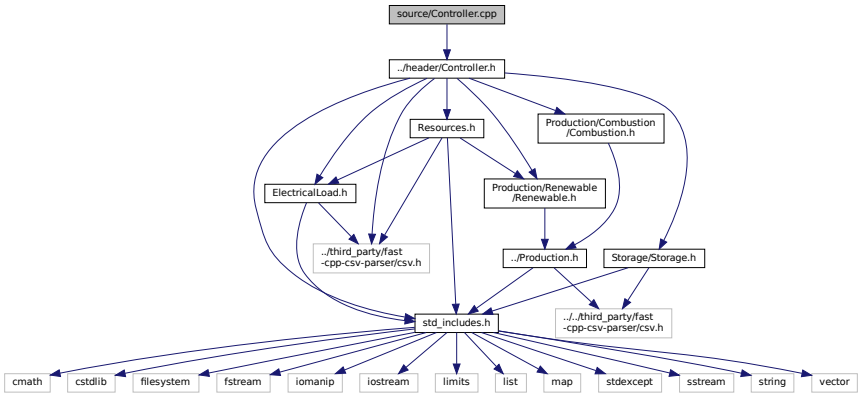
```
PYBIND11_MODULE (
            PGMcpp ,
            m   )
30                          {
31
32 // ================ Controller ================ //
33 /*
34 pybind11::class_<Controller>(m, "Controller")
35     .def(pybind11::init());
36 */
37 // ================ END Controller ================ //
38
39
40
41 // ================ ElectricalLoad ================ //
42 /*
43 pybind11::class_<ElectricalLoad>(m, "ElectricalLoad")
44     .def_readwrite("n_points", &ElectricalLoad::n_points)
45     .def_readwrite("max_load_kW", &ElectricalLoad::max_load_kW)
```

```
46     .def_readwrite("mean_load_kW", &ElectricalLoad::mean_load_kW)
47     .def_readwrite("min_load_kW", &ElectricalLoad::min_load_kW)
48     .def_readwrite("dt_vec_hrs", &ElectricalLoad::dt_vec_hrs)
49     .def_readwrite("load_vec_kW", &ElectricalLoad::load_vec_kW)
50     .def_readwrite("time_vec_hrs", &ElectricalLoad::time_vec_hrs)
51
52     .def(pybind11::init<std::string>());
53 */
54 // ================ END ElectricalLoad ================ //
55
56
57
58 // ================ Model ================ //
59 /*
60 pybind11::class_<Model>(m, "Model")
61     .def(
62         pybind11::init<
63             ElectricalLoad*,
64             RenewableResources*
65         >()
66     );
67 */
68 // ================ END Model ================ //
69
70
71
72 // ================ RenewableResources ================ //
73 /*
74 pybind11::class_<RenewableResources>(m, "RenewableResources")
75     .def(pybind11::init());
76     /*
77     .def(pybind11::init<>());
78     */
79 */
80 // ================ END RenewableResources ================ //
81
82 }   /* PYBIND11_MODULE() */
```

5.17 source/Controller.cpp File Reference

Implementation file for the Controller class.

`#include "../header/Controller.h"`
Include dependency graph for Controller.cpp:



5.17.1 Detailed Description

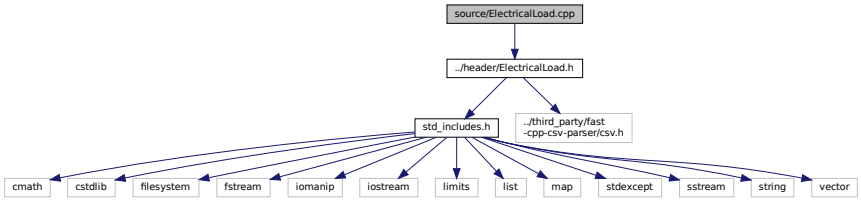
Implementation file for the Controller class.

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

5.18 source/ElectricalLoad.cpp File Reference

Implementation file for the ElectricalLoad class.

`#include "../header/ElectricalLoad.h"`
Include dependency graph for ElectricalLoad.cpp:



5.18.1 Detailed Description

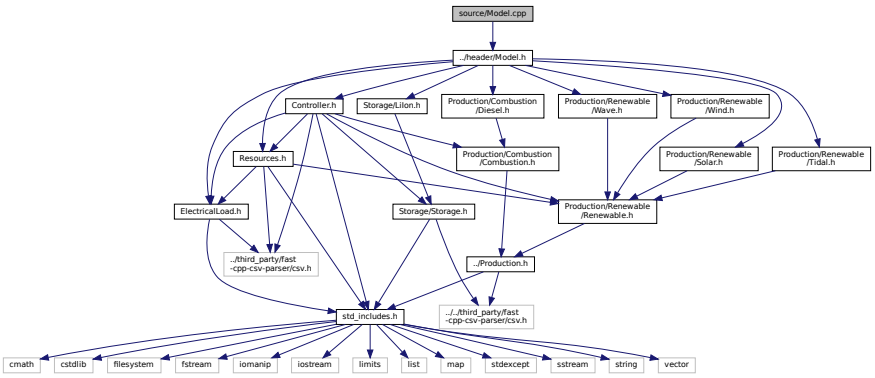
Implementation file for the ElectricalLoad class.

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

5.19 source/Model.cpp File Reference

Implementation file for the Model class.

`#include "../header/Model.h"`
Include dependency graph for Model.cpp:



5.19.1 Detailed Description

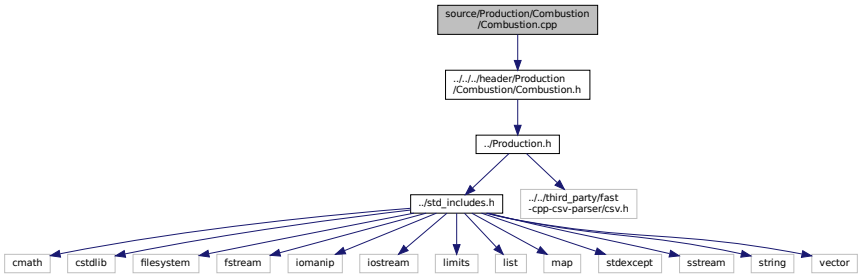
Implementation file for the Model class.

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.

5.20 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:



5.20.1 Detailed Description

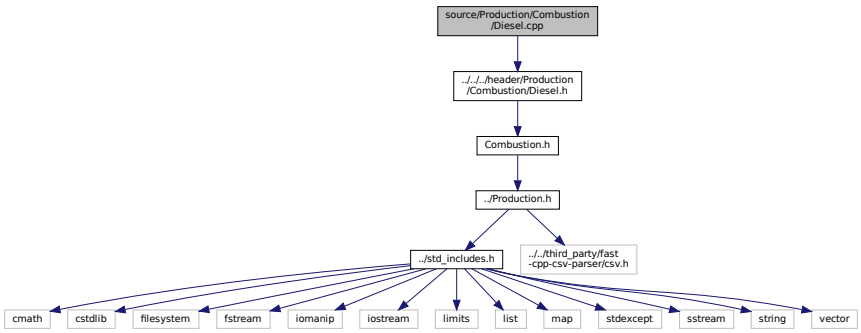
Implementation file for the Combustion class.

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.

5.21 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:



5.21.1 Detailed Description

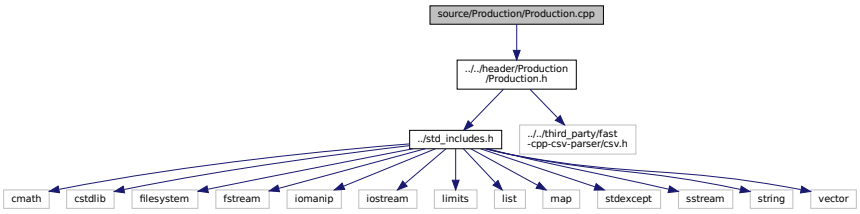
Implementation file for the Diesel class.

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

5.22 source/Production/Production.cpp File Reference

Implementation file for the Production class.

```
#include "../../header/Production/Production.h"
```
Include dependency graph for Production.cpp:



5.22.1 Detailed Description

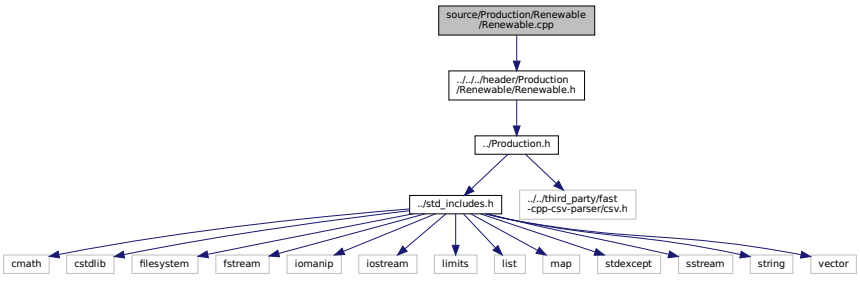
Implementation file for the Production class.

The base class of the Production hierarchy. This hierarchy contains derived classes which model the production of energy, be it renewable or otherwise.

5.23 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:



5.23.1 Detailed Description

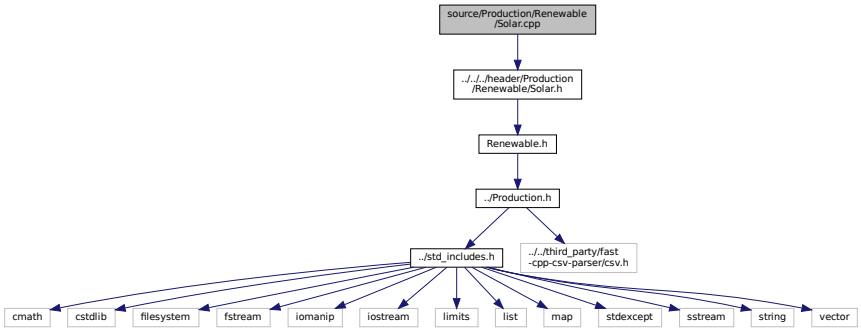
Implementation file for the Renewable class.

The root of the Renewable branch of the Production hierarchy. This branch contains derived classes which model the renewable production of energy.

5.24 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:



5.24.1 Detailed Description

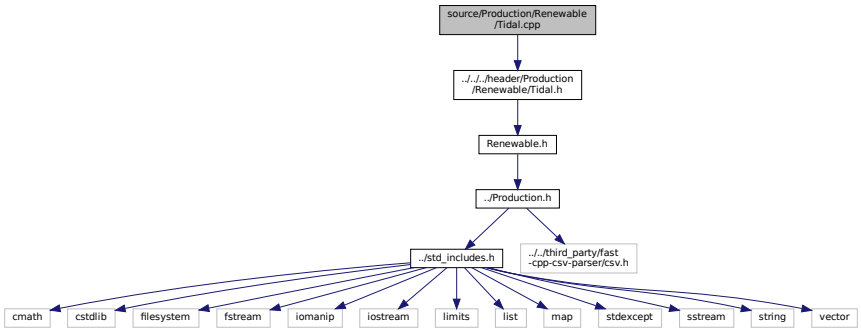
Implementation file for the Solar class.

A derived class of the Renewable branch of Production which models solar production.

5.25 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:



5.25.1 Detailed Description

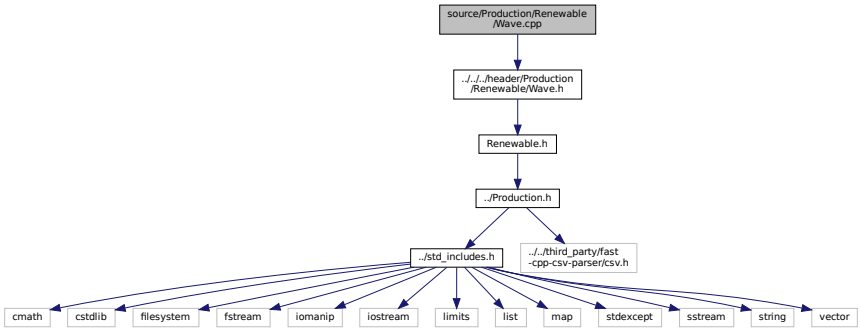
Implementation file for the Tidal class.

A derived class of the Renewable branch of Production which models tidal production.

5.26 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:



5.26.1 Detailed Description

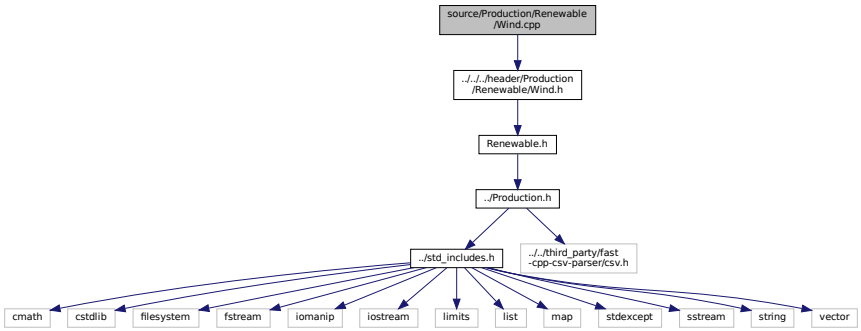
Implementation file for the Wave class.

A derived class of the Renewable branch of Production which models wave production.

5.27 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:



5.27.1 Detailed Description

Implementation file for the Wind class.

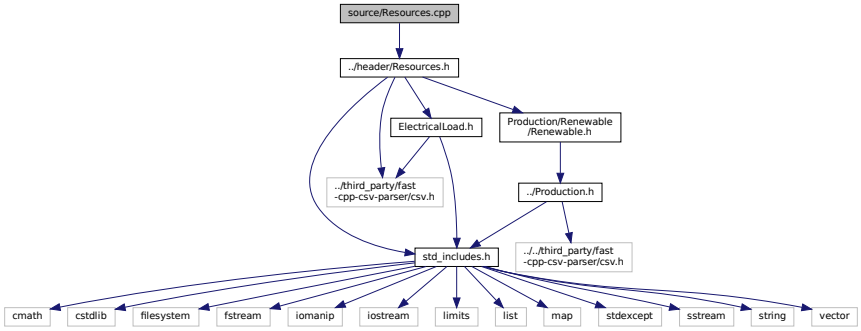
A derived class of the Renewable branch of Production which models wind production.

5.28 source/Resources.cpp File Reference

Implementation file for the Resources class.

```
#include "../header/Resources.h"
```

Include dependency graph for Resources.cpp:



5.28.1 Detailed Description

Implementation file for the Resources class.

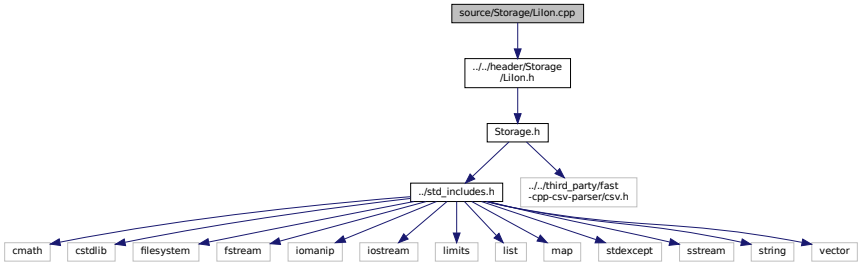
A class which contains renewable resource data. Intended to serve as a component class of Model.

5.29 source/Storage/LiIon.cpp File Reference

Implementation file for the LiIon class.

```
#include "../../header/Storage/LiIon.h"
```

Include dependency graph for LiIon.cpp:



5.29.1 Detailed Description

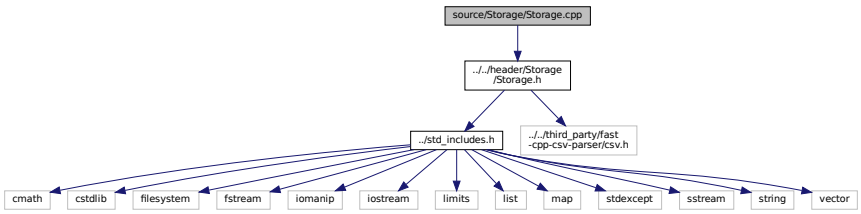
Implementation file for the LiIon class.

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

5.30 source/Storage/Storage.cpp File Reference

Implementation file for the Storage class.

```
#include "../../header/Storage/Storage.h"
```
Include dependency graph for Storage.cpp:



5.30.1 Detailed Description

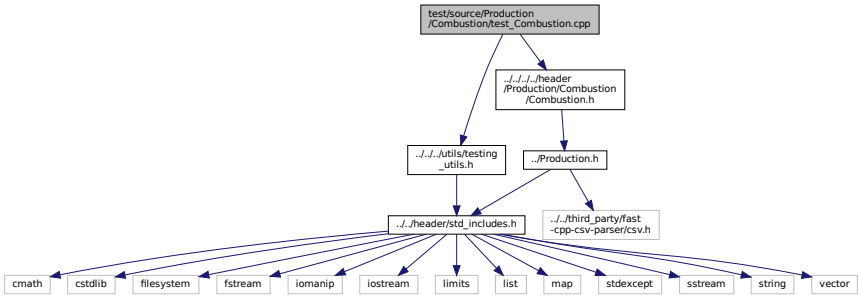
Implementation file for the Storage class.

The base class of the Storage hierarchy. This hierarchy contains derived classes which model the storage of energy.

5.31 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

- int main (int argc, char **argv)

5.31.1 Detailed Description

Testing suite for Combustion class.

A suite of tests for the Combustion class.

5.31.2 Function Documentation

5.31.2.1 main()

```
int main (
              int argc,
              char ** argv )
27 {
28     #ifdef _WIN32
29         activateVirtualTerminal();
30     #endif  /* _WIN32 */
31
32     printGold("\tTesting Production <-- Combustion");
33
34     srand(time(NULL));
35
36
37 try {
38
39 // ======== CONSTRUCTION ========================================================== //
40
41 CombustionInputs combustion_inputs;
42
43 Combustion test_combustion(8760, 1, combustion_inputs);
44
45 // ======== END CONSTRUCTION ====================================================== //
46
47
48
49 // ======== ATTRIBUTES ============================================================ //
50
51 testTruth(
52     not combustion_inputs.production_inputs.print_flag,
53     __FILE__,
54     __LINE__
55 );
56
57 testFloatEquals(
58     test_combustion.fuel_consumption_vec_L.size(),
59     8760,
60     __FILE__,
61     __LINE__
62 );
63
64 testFloatEquals(
65     test_combustion.fuel_cost_vec.size(),
66     8760,
67     __FILE__,
68     __LINE__
69 );
70
71 testFloatEquals(
72     test_combustion.CO2_emissions_vec_kg.size(),
73     8760,
74     __FILE__,
75     __LINE__
76 );
77
78 testFloatEquals(
79     test_combustion.CO_emissions_vec_kg.size(),
80     8760,
81     __FILE__,
82     __LINE__
83 );
84
85 testFloatEquals(
```

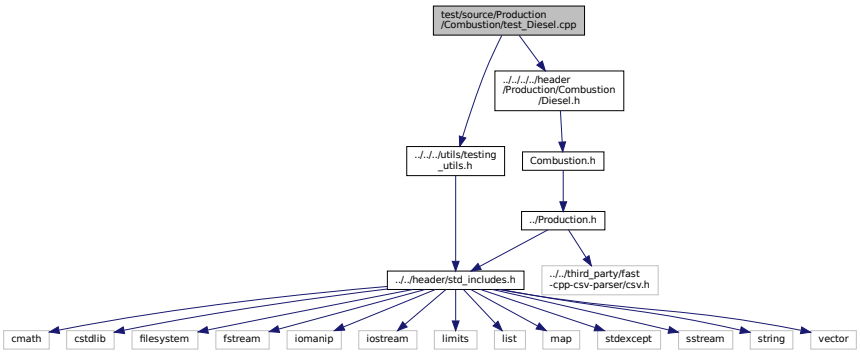
```
86      test_combustion.NOx_emissions_vec_kg.size(),
87      8760,
88      __FILE__,
89      __LINE__
90  );
91
92  testFloatEquals(
93      test_combustion.SOx_emissions_vec_kg.size(),
94      8760,
95      __FILE__,
96      __LINE__
97  );
98
99  testFloatEquals(
100     test_combustion.CH4_emissions_vec_kg.size(),
101     8760,
102     __FILE__,
103     __LINE__
104 );
105
106 testFloatEquals(
107     test_combustion.PM_emissions_vec_kg.size(),
108     8760,
109     __FILE__,
110     __LINE__
111 );
112
113 // ======== END ATTRIBUTES ============================================================ //
114
115 }   /* try */
116
117
118 catch (...) {
119     //...
120
121     printGold(" .............. ");
122     printRed("FAIL");
123     std::cout « std::endl;
124     throw;
125 }
126
127
128 printGold(" .............. ");
129 printGreen("PASS");
130 std::cout « std::endl;
131 return 0;
132
133 }   /* main() */
```

5.32 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

- int main (int argc, char **argv)

5.32.1 Detailed Description

Testing suite for Diesel class.

A suite of tests for the Diesel class.

5.32.2 Function Documentation

5.32.2.1 main()

```
int main (
              int argc,
              char ** argv )
```

```
27 {
28     #ifdef _WIN32
29         activateVirtualTerminal();
30     #endif  /* _WIN32 */
31
32     printGold("\tTesting Production <-- Combustion <-- Diesel");
33
34     srand(time(NULL));
35
36
37     Combustion* test_diesel_ptr;
38
39 try {
40
41 // ======== CONSTRUCTION ============================================================ //
42
43 bool error_flag = true;
44
45 try {
46     DieselInputs bad_diesel_inputs;
47     bad_diesel_inputs.fuel_cost_L = -1;
48
49     Diesel bad_diesel(8760, 1, bad_diesel_inputs);
50
51     error_flag = false;
52 } catch (...) {
53     // Task failed successfully! =P
54 }
55 if (not error_flag) {
56     expectedErrorNotDetected(__FILE__, __LINE__);
57 }
58
59 DieselInputs diesel_inputs;
60
61 test_diesel_ptr =  new Diesel(8760, 1, diesel_inputs);
62
63
64 // ======== END CONSTRUCTION ======================================================== //
65
66
67
68 // ======== ATTRIBUTES ============================================================== //
69
70 testTruth(
71     not diesel_inputs.combustion_inputs.production_inputs.print_flag,
72     __FILE__,
73     __LINE__
74 );
75
76 testFloatEquals(
77     test_diesel_ptr->type,
```

```
78      CombustionType :: DIESEL,
79      __FILE__,
80      __LINE__
81  );
82
83  testTruth(
84      test_diesel_ptr->type_str == "DIESEL",
85      __FILE__,
86      __LINE__
87  );
88
89  testFloatEquals(
90      test_diesel_ptr->linear_fuel_slope_LkWh,
91      0.265675,
92      __FILE__,
93      __LINE__
94  );
95
96  testFloatEquals(
97      test_diesel_ptr->linear_fuel_intercept_LkWh,
98      0.026676,
99      __FILE__,
100      __LINE__
101 );
102
103 testFloatEquals(
104     test_diesel_ptr->capital_cost,
105     94125.375446,
106     __FILE__,
107     __LINE__
108 );
109
110 testFloatEquals(
111     test_diesel_ptr->operation_maintenance_cost_kWh,
112     0.069905,
113     __FILE__,
114     __LINE__
115 );
116
117 testFloatEquals(
118     ((Diesel*)test_diesel_ptr)->minimum_load_ratio,
119     0.2,
120     __FILE__,
121     __LINE__
122 );
123
124 testFloatEquals(
125     ((Diesel*)test_diesel_ptr)->minimum_runtime_hrs,
126     4,
127     __FILE__,
128     __LINE__
129 );
130
131 testFloatEquals(
132     test_diesel_ptr->replace_running_hrs,
133     30000,
134     __FILE__,
135     __LINE__
136 );
137
138 // ======== END ATTRIBUTES ============================================================ //
139
140
141
142 // ======== METHODS ================================================================== //
143
144 //  test capacity constraint
145 testFloatEquals(
146     test_diesel_ptr->requestProductionkW(0, 1, 2 * test_diesel_ptr->capacity_kW),
147     test_diesel_ptr->capacity_kW,
148     __FILE__,
149     __LINE__
150 );
151
152 //  test minimum load ratio constraint
153 testFloatEquals(
154     test_diesel_ptr->requestProductionkW(
155         0,
156         1,
157         0.5 * ((Diesel*)test_diesel_ptr)->minimum_load_ratio *
158             test_diesel_ptr->capacity_kW
159     ),
160     ((Diesel*)test_diesel_ptr)->minimum_load_ratio * test_diesel_ptr->capacity_kW,
161     __FILE__,
162     __LINE__
163 );
164
```

```
165 //  test commit()
166 std::vector<double> dt_vec_hrs (48, 1);
167
168 std::vector<double> load_vec_kW = {
169     1, 1, 0, 1, 0, 0, 1, 1, 1, 0, 1, 1,
170     1, 1, 1, 0, 0, 0, 0, 0, 0, 1, 1, 0,
171     1, 1, 1, 1, 1, 0, 1, 1, 1, 1, 0, 1,
172     1, 0, 0, 0, 1, 1, 1, 0, 1, 1, 0, 0
173 };
174
175 std::vector<bool> expected_is_running_vec = {
176     1, 1, 1, 1, 0, 0, 1, 1, 1, 1, 1, 1,
177     1, 1, 1, 0, 0, 0, 0, 0, 0, 1, 1, 1,
178     1, 1, 1, 1, 1, 0, 1, 1, 1, 1, 0, 1,
179     1, 1, 1, 0, 1, 1, 1, 1, 1, 1, 0, 0
180 };
181
182 double load_kW = 0;
183 double production_kW = 0;
184 double roll = 0;
185
186 for (int i = 0; i < 48; i++) {
187     roll = (double)rand() / RAND_MAX;
188
189     if (roll >= 0.95) {
190         roll = 1.25;
191     }
192
193     load_vec_kW[i] *= roll * test_diesel_ptr->capacity_kW;
194     load_kW = load_vec_kW[i];
195
196     production_kW = test_diesel_ptr->requestProductionkW(
197         i,
198         dt_vec_hrs[i],
199         load_kW
200     );
201
202     load_kW = test_diesel_ptr->commit(
203         i,
204         dt_vec_hrs[i],
205         production_kW,
206         load_kW
207     );
208
209     // load_kW <= load_vec_kW (i.e., after vs before)
210     testLessThanOrEqualTo(
211         load_kW,
212         load_vec_kW[i],
213         __FILE__,
214         __LINE__
215     );
216
217     // production = dispatch + storage + curtailment
218     testFloatEquals(
219         test_diesel_ptr->production_vec_kW[i] -
220         test_diesel_ptr->dispatch_vec_kW[i] -
221         test_diesel_ptr->storage_vec_kW[i] -
222         test_diesel_ptr->curtailment_vec_kW[i],
223         0,
224         __FILE__,
225         __LINE__
226     );
227
228     // capacity constraint
229     if (load_vec_kW[i] > test_diesel_ptr->capacity_kW) {
230         testFloatEquals(
231             test_diesel_ptr->production_vec_kW[i],
232             test_diesel_ptr->capacity_kW,
233             __FILE__,
234             __LINE__
235         );
236     }
237
238     // minimum load ratio constraint
239     else if (
240         test_diesel_ptr->is_running and
241         test_diesel_ptr->production_vec_kW[i] > 0 and
242         load_vec_kW[i] <
243         ((Diesel*)test_diesel_ptr)->minimum_load_ratio * test_diesel_ptr->capacity_kW
244     ) {
245         testFloatEquals(
246             test_diesel_ptr->production_vec_kW[i],
247             ((Diesel*)test_diesel_ptr)->minimum_load_ratio *
248                 test_diesel_ptr->capacity_kW,
249             __FILE__,
250             __LINE__
251         );
```

```
252     }
253
254     // minimum runtime constraint
255     testFloatEquals(
256         test_diesel_ptr->is_running_vec[i],
257         expected_is_running_vec[i],
258         __FILE__,
259         __LINE__
260     );
261
262     // O&M, fuel consumption, and emissions > 0 whenever diesel is running
263     if (test_diesel_ptr->is_running) {
264         testGreaterThan(
265             test_diesel_ptr->operation_maintenance_cost_vec[i],
266             0,
267             __FILE__,
268             __LINE__
269         );
270
271         testGreaterThan(
272             test_diesel_ptr->fuel_consumption_vec_L[i],
273             0,
274             __FILE__,
275             __LINE__
276         );
277
278         testGreaterThan(
279             test_diesel_ptr->fuel_cost_vec[i],
280             0,
281             __FILE__,
282             __LINE__
283         );
284
285         testGreaterThan(
286             test_diesel_ptr->CO2_emissions_vec_kg[i],
287             0,
288             __FILE__,
289             __LINE__
290         );
291
292         testGreaterThan(
293             test_diesel_ptr->CO_emissions_vec_kg[i],
294             0,
295             __FILE__,
296             __LINE__
297         );
298
299         testGreaterThan(
300             test_diesel_ptr->NOx_emissions_vec_kg[i],
301             0,
302             __FILE__,
303             __LINE__
304         );
305
306         testGreaterThan(
307             test_diesel_ptr->SOx_emissions_vec_kg[i],
308             0,
309             __FILE__,
310             __LINE__
311         );
312
313         testGreaterThan(
314             test_diesel_ptr->CH4_emissions_vec_kg[i],
315             0,
316             __FILE__,
317             __LINE__
318         );
319
320         testGreaterThan(
321             test_diesel_ptr->PM_emissions_vec_kg[i],
322             0,
323             __FILE__,
324             __LINE__
325         );
326     }
327
328     // O&M, fuel consumption, and emissions = 0 whenever diesel is not running
329     else {
330         testFloatEquals(
331             test_diesel_ptr->operation_maintenance_cost_vec[i],
332             0,
333             __FILE__,
334             __LINE__
335         );
336
337         testFloatEquals(
338             test_diesel_ptr->fuel_consumption_vec_L[i],
```

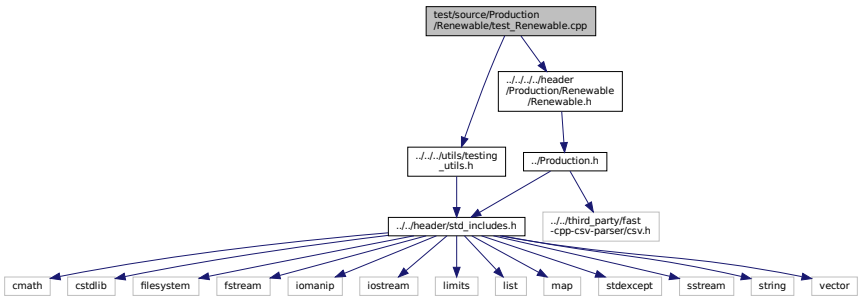
```
339             0,
340             __FILE__,
341             __LINE__
342         );
343 
344         testFloatEquals(
345             test_diesel_ptr->fuel_cost_vec[i],
346             0,
347             __FILE__,
348             __LINE__
349         );
350 
351         testFloatEquals(
352             test_diesel_ptr->CO2_emissions_vec_kg[i],
353             0,
354             __FILE__,
355             __LINE__
356         );
357 
358         testFloatEquals(
359             test_diesel_ptr->CO_emissions_vec_kg[i],
360             0,
361             __FILE__,
362             __LINE__
363         );
364 
365         testFloatEquals(
366             test_diesel_ptr->NOx_emissions_vec_kg[i],
367             0,
368             __FILE__,
369             __LINE__
370         );
371 
372         testFloatEquals(
373             test_diesel_ptr->SOx_emissions_vec_kg[i],
374             0,
375             __FILE__,
376             __LINE__
377         );
378 
379         testFloatEquals(
380             test_diesel_ptr->CH4_emissions_vec_kg[i],
381             0,
382             __FILE__,
383             __LINE__
384         );
385 
386         testFloatEquals(
387             test_diesel_ptr->PM_emissions_vec_kg[i],
388             0,
389             __FILE__,
390             __LINE__
391         );
392     }
393 }
394 
395 // ======== END METHODS ============================================================ //
396 
397 }   /* try */
398 
399 
400 catch (...) {
401     delete test_diesel_ptr;
402 
403     printGold(" ... ");
404     printRed("FAIL");
405     std::cout « std::endl;
406     throw;
407 }
408 
409 
410 delete test_diesel_ptr;
411 
412 printGold(" ... ");
413 printGreen("PASS");
414 std::cout « std::endl;
415 return 0;
416 
417 }   /* main() */
```

5.33 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

- int main (int argc, char **argv)

5.33.1 Detailed Description

Testing suite for Renewable class.

A suite of tests for the Renewable class.

5.33.2 Function Documentation

5.33.2.1 main()

```
int main (
            int argc,
            char ** argv )
27 {
28     #ifdef _WIN32
29         activateVirtualTerminal();
30     #endif  /* _WIN32 */
31
32     printGold("\tTesting Production <-- Renewable");
33
34     srand(time(NULL));
35
36
37 try {
38
39 // ======== CONSTRUCTION ========================================================== //
```

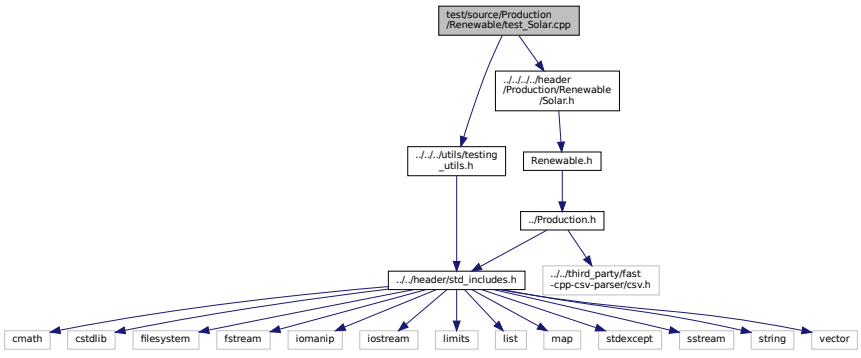
```
40
41 RenewableInputs renewable_inputs;
42
43 Renewable test_renewable(8760, 1, renewable_inputs);
44
45 // ======== END CONSTRUCTION ============================================================ //
46
47
48
49 // ======== ATTRIBUTES ================================================================== //
50
51 testTruth(
52     not renewable_inputs.production_inputs.print_flag,
53     __FILE__,
54     __LINE__
55 );
56
57 // ======== END ATTRIBUTES ============================================================== //
58
59 }   /* try */
60
61
62 catch (...) {
63     //...
64
65     printGold(" ............... ");
66     printRed("FAIL");
67     std::cout « std::endl;
68     throw;
69 }
70
71
72 printGold(" ............... ");
73 printGreen("PASS");
74 std::cout « std::endl;
75 return 0;
76 }   /* main() */
```

5.34 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

- int main (int argc, char **argv)

5.34.1 Detailed Description

Testing suite for Solar class.

A suite of tests for the Solar class.

5.34.2 Function Documentation

5.34.2.1 main()

```
int main (
              int argc,
              char ** argv )
```

```
27 {
28     #ifdef _WIN32
29         activateVirtualTerminal();
30     #endif  /* _WIN32 */
31 
32     printGold("\tTesting Production <-- Renewable <-- Solar");
33 
34     srand(time(NULL));
35 
36     Renewable* test_solar_ptr;
37 
38 try {
39 
40 // ======== CONSTRUCTION ============================================================ //
41 
42 bool error_flag = true;
43 
44 try {
45     SolarInputs bad_solar_inputs;
46     bad_solar_inputs.derating = -1;
47 
48     Solar bad_solar(8760, 1, bad_solar_inputs);
49 
50     error_flag = false;
51 } catch (...) {
52     // Task failed successfully! =P
53 }
54 if (not error_flag) {
55     expectedErrorNotDetected(__FILE__, __LINE__);
56 }
57 
58 SolarInputs solar_inputs;
59 
60 test_solar_ptr = new Solar(8760, 1, solar_inputs);
61 
62 // ======== END CONSTRUCTION ======================================================== //
63 
64 
65 
66 // ======== ATTRIBUTES ============================================================== //
67 
68 testTruth(
69     not solar_inputs.renewable_inputs.production_inputs.print_flag,
70     __FILE__,
71     __LINE__
72 );
73 
74 testFloatEquals(
75     test_solar_ptr->type,
76     RenewableType :: SOLAR,
77     __FILE__,
78     __LINE__
79 );
80 
81 testTruth(
82     test_solar_ptr->type_str == "SOLAR",
83     __FILE__,
84     __LINE__
85 );
```

```
86
87 testFloatEquals(
88     test_solar_ptr->capital_cost,
89     350118.723363,
90     __FILE__,
91     __LINE__
92 );
93
94 testFloatEquals(
95     test_solar_ptr->operation_maintenance_cost_kWh,
96     0.01,
97     __FILE__,
98     __LINE__
99 );
100
101 // ======== END ATTRIBUTES ============================================================ //
102
103
104
105 // ======== METHODS ================================================================== //
106
107 // test production constraints
108 testFloatEquals(
109     test_solar_ptr->computeProductionkW(0, 1, 2),
110     100,
111     __FILE__,
112     __LINE__
113 );
114
115 testFloatEquals(
116     test_solar_ptr->computeProductionkW(0, 1, -1),
117     0,
118     __FILE__,
119     __LINE__
120 );
121
122 // test commit()
123 std::vector<double> dt_vec_hrs (48, 1);
124
125 std::vector<double> load_vec_kW = {
126     1, 1, 0, 1, 0, 0, 1, 1, 1, 0, 1, 1,
127     1, 1, 1, 0, 0, 0, 0, 0, 0, 1, 1, 0,
128     1, 1, 1, 1, 1, 0, 1, 1, 1, 1, 0, 1,
129     1, 0, 0, 0, 1, 1, 1, 0, 1, 1, 0, 0
130 };
131
132 double load_kW = 0;
133 double production_kW = 0;
134 double roll = 0;
135 double solar_resource_kWm2 = 0;
136
137 for (int i = 0; i < 48; i++) {
138     roll = (double)rand() / RAND_MAX;
139
140     solar_resource_kWm2 = roll;
141
142     roll = (double)rand() / RAND_MAX;
143
144     if (roll <= 0.1) {
145         solar_resource_kWm2 = 0;
146     }
147
148     else if (roll >= 0.95) {
149         solar_resource_kWm2 = 1.25;
150     }
151
152     roll = (double)rand() / RAND_MAX;
153
154     if (roll >= 0.95) {
155         roll = 1.25;
156     }
157
158     load_vec_kW[i] *= roll * test_solar_ptr->capacity_kW;
159     load_kW = load_vec_kW[i];
160
161     production_kW = test_solar_ptr->computeProductionkW(
162         i,
163         dt_vec_hrs[i],
164         solar_resource_kWm2
165     );
166
167     load_kW = test_solar_ptr->commit(
168         i,
169         dt_vec_hrs[i],
170         production_kW,
171         load_kW
172     );
```

```
173
174     // is running (or not) as expected
175     if (solar_resource_kWm2 > 0) {
176         testTruth(
177             test_solar_ptr->is_running,
178             __FILE__,
179             __LINE__
180         );
181     }
182
183     else {
184         testTruth(
185             not test_solar_ptr->is_running,
186             __FILE__,
187             __LINE__
188         );
189     }
190
191     // load_kW <= load_vec_kW (i.e., after vs before)
192     testLessThanOrEqualTo(
193         load_kW,
194         load_vec_kW[i],
195         __FILE__,
196         __LINE__
197     );
198
199     // production = dispatch + storage + curtailment
200     testFloatEquals(
201         test_solar_ptr->production_vec_kW[i] -
202         test_solar_ptr->dispatch_vec_kW[i] -
203         test_solar_ptr->storage_vec_kW[i] -
204         test_solar_ptr->curtailment_vec_kW[i],
205         0,
206         __FILE__,
207         __LINE__
208     );
209
210     // capacity constraint
211     if (solar_resource_kWm2 > 1) {
212         testFloatEquals(
213             test_solar_ptr->production_vec_kW[i],
214             test_solar_ptr->capacity_kW,
215             __FILE__,
216             __LINE__
217         );
218     }
219
220     // resource, O&M > 0 whenever solar is running (i.e., producing)
221     if (test_solar_ptr->is_running) {
222         testGreaterThan(
223             solar_resource_kWm2,
224             0,
225             __FILE__,
226             __LINE__
227         );
228
229         testGreaterThan(
230             test_solar_ptr->operation_maintenance_cost_vec[i],
231             0,
232             __FILE__,
233             __LINE__
234         );
235     }
236
237     // resource, O&M = 0 whenever solar is not running (i.e., not producing)
238     else {
239         testFloatEquals(
240             solar_resource_kWm2,
241             0,
242             __FILE__,
243             __LINE__
244         );
245
246         testFloatEquals(
247             test_solar_ptr->operation_maintenance_cost_vec[i],
248             0,
249             __FILE__,
250             __LINE__
251         );
252     }
253 }
254
255
256 // ======== END METHODS ============================================================ //
257
258 }   /* try */
259
```

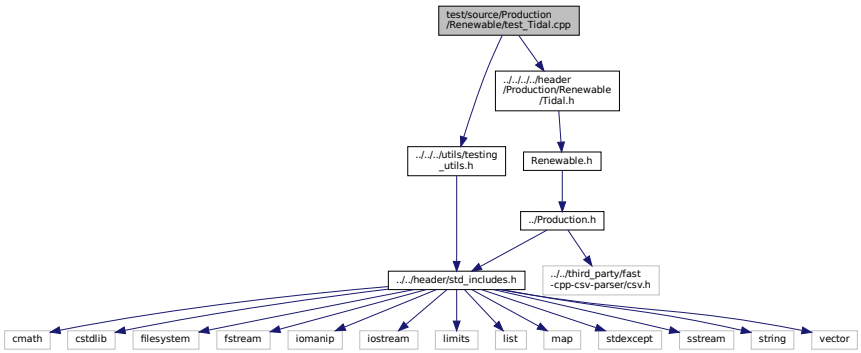
```
260
261 catch (...) {
262     delete test_solar_ptr;
263
264     printGold(" ..... ");
265     printRed("FAIL");
266     std::cout « std::endl;
267     throw;
268 }
269
270
271 delete test_solar_ptr;
272
273 printGold(" ..... ");
274 printGreen("PASS");
275 std::cout « std::endl;
276 return 0;
277 }   /* main() */
```

5.35 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

- int main (int argc, char **argv)

5.35.1 Detailed Description

Testing suite for Tidal class.

A suite of tests for the Tidal class.

5.35.2 Function Documentation

5.35.2.1 main()

```
int main (
              int argc,
              char ** argv )
{
    #ifdef _WIN32
        activateVirtualTerminal();
    #endif  /* _WIN32 */

    printGold("\tTesting Production <-- Renewable <-- Tidal");

    srand(time(NULL));

    Renewable* test_tidal_ptr;

try {

// ======== CONSTRUCTION ========================================================== //

bool error_flag = true;

try {
    TidalInputs bad_tidal_inputs;
    bad_tidal_inputs.design_speed_ms = -1;

    Tidal bad_tidal(8760, 1, bad_tidal_inputs);

    error_flag = false;
} catch (...) {
    // Task failed successfully! =P
}
if (not error_flag) {
    expectedErrorNotDetected(__FILE__, __LINE__);
}

TidalInputs tidal_inputs;

test_tidal_ptr = new Tidal(8760, 1, tidal_inputs);

// ======== END CONSTRUCTION ====================================================== //


// ======== ATTRIBUTES ============================================================ //

testTruth(
    not tidal_inputs.renewable_inputs.production_inputs.print_flag,
    __FILE__,
    __LINE__
);

testFloatEquals(
    test_tidal_ptr->type,
    RenewableType :: TIDAL,
    __FILE__,
    __LINE__
);

testTruth(
    test_tidal_ptr->type_str == "TIDAL",
    __FILE__,
    __LINE__
);

testFloatEquals(
    test_tidal_ptr->capital_cost,
    500237.446725,
    __FILE__,
    __LINE__
);

testFloatEquals(
    test_tidal_ptr->operation_maintenance_cost_kWh,
    0.069905,
    __FILE__,
    __LINE__
);

// ======== END ATTRIBUTES ======================================================== //


// ======== METHODS =============================================================== //

```

```
107 // test production constraints
108 testFloatEquals(
109     test_tidal_ptr->computeProductionkW(0, 1, 1e6),
110     0,
111     __FILE__,
112     __LINE__
113 );
114
115 testFloatEquals(
116     test_tidal_ptr->computeProductionkW(
117         0,
118         1,
119         ((Tidal*)test_tidal_ptr)->design_speed_ms
120     ),
121     test_tidal_ptr->capacity_kW,
122     __FILE__,
123     __LINE__
124 );
125
126 testFloatEquals(
127     test_tidal_ptr->computeProductionkW(0, 1, -1),
128     0,
129     __FILE__,
130     __LINE__
131 );
132
133 // test commit()
134 std::vector<double> dt_vec_hrs (48, 1);
135
136 std::vector<double> load_vec_kW = {
137     1, 1, 0, 1, 0, 0, 1, 1, 1, 0, 1, 1,
138     1, 1, 1, 0, 0, 0, 0, 0, 0, 1, 1, 0,
139     1, 1, 1, 1, 1, 0, 1, 1, 1, 1, 0, 1,
140     1, 0, 0, 0, 1, 1, 1, 0, 1, 1, 0, 0
141 };
142
143 double load_kW = 0;
144 double production_kW = 0;
145 double roll = 0;
146 double tidal_resource_ms = 0;
147
148 for (int i = 0; i < 48; i++) {
149     roll = (double)rand() / RAND_MAX;
150
151     tidal_resource_ms = roll * ((Tidal*)test_tidal_ptr)->design_speed_ms;
152
153     roll = (double)rand() / RAND_MAX;
154
155     if (roll <= 0.1) {
156         tidal_resource_ms = 0;
157     }
158
159     else if (roll >= 0.95) {
160         tidal_resource_ms = 3 * ((Tidal*)test_tidal_ptr)->design_speed_ms;
161     }
162
163     roll = (double)rand() / RAND_MAX;
164
165     if (roll >= 0.95) {
166         roll = 1.25;
167     }
168
169     load_vec_kW[i] *= roll * test_tidal_ptr->capacity_kW;
170     load_kW = load_vec_kW[i];
171
172     production_kW = test_tidal_ptr->computeProductionkW(
173         i,
174         dt_vec_hrs[i],
175         tidal_resource_ms
176     );
177
178     load_kW = test_tidal_ptr->commit(
179         i,
180         dt_vec_hrs[i],
181         production_kW,
182         load_kW
183     );
184
185     // is running (or not) as expected
186     if (production_kW > 0) {
187         testTruth(
188             test_tidal_ptr->is_running,
189             __FILE__,
190             __LINE__
191         );
192     }
193
```

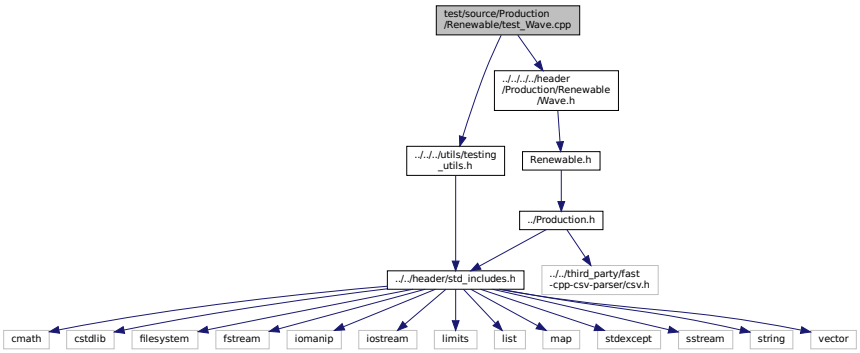
```
194     else {
195         testTruth(
196             not test_tidal_ptr->is_running,
197             __FILE__,
198             __LINE__
199         );
200     }
201 
202     // load_kW <= load_vec_kW (i.e., after vs before)
203     testLessThanOrEqualTo(
204         load_kW,
205         load_vec_kW[i],
206         __FILE__,
207         __LINE__
208     );
209 
210     // production = dispatch + storage + curtailment
211     testFloatEquals(
212         test_tidal_ptr->production_vec_kW[i] -
213         test_tidal_ptr->dispatch_vec_kW[i] -
214         test_tidal_ptr->storage_vec_kW[i] -
215         test_tidal_ptr->curtailment_vec_kW[i],
216         0,
217         __FILE__,
218         __LINE__
219     );
220 
221     // resource, O&M > 0 whenever tidal is running (i.e., producing)
222     if (test_tidal_ptr->is_running) {
223         testGreaterThan(
224             tidal_resource_ms,
225             0,
226             __FILE__,
227             __LINE__
228         );
229 
230         testGreaterThan(
231             test_tidal_ptr->operation_maintenance_cost_vec[i],
232             0,
233             __FILE__,
234             __LINE__
235         );
236     }
237 
238     // O&M = 0 whenever tidal is not running (i.e., not producing)
239     else {
240         testFloatEquals(
241             test_tidal_ptr->operation_maintenance_cost_vec[i],
242             0,
243             __FILE__,
244             __LINE__
245         );
246     }
247 }
248 
249 
250 // ======== END METHODS ============================================================ //
251 
252 }   /* try */
253 
254 
255 catch (...) {
256     delete test_tidal_ptr;
257 
258     printGold(" ..... ");
259     printRed("FAIL");
260     std::cout « std::endl;
261     throw;
262 }
263 
264 
265 delete test_tidal_ptr;
266 
267 printGold(" ..... ");
268 printGreen("PASS");
269 std::cout « std::endl;
270 return 0;
271 }   /* main() */
```

5.36 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

- int main (int argc, char **argv)

5.36.1 Detailed Description

Testing suite for Wave class.

A suite of tests for the Wave class.

5.36.2 Function Documentation

5.36.2.1 main()

```
int main (
              int argc,
              char ** argv )
27 {
28     #ifdef _WIN32
29         activateVirtualTerminal();
30     #endif  /* _WIN32 */
31
32     printGold("\tTesting Production <-- Renewable <-- Wave");
33
34     srand(time(NULL));
35
36     Renewable* test_wave_ptr;
37
38 try {
39
40 // ======== CONSTRUCTION ========================================================== //
41
42 bool error_flag = true;
43
44 try {
45     WaveInputs bad_wave_inputs;
46     bad_wave_inputs.design_significant_wave_height_m = -1;
```

```
47
48      Wave bad_wave(8760, 1, bad_wave_inputs);
49
50      error_flag = false;
51  } catch (...) {
52      // Task failed successfully! =P
53  }
54  if (not error_flag) {
55      expectedErrorNotDetected(__FILE__, __LINE__);
56  }
57
58  WaveInputs wave_inputs;
59
60  test_wave_ptr = new Wave(8760, 1, wave_inputs);
61
62  // ======== END CONSTRUCTION ============================================================ //
63
64
65
66  // ======== ATTRIBUTES ================================================================== //
67
68  testTruth(
69      not wave_inputs.renewable_inputs.production_inputs.print_flag,
70      __FILE__,
71      __LINE__
72  );
73
74  testFloatEquals(
75      test_wave_ptr->type,
76      RenewableType :: WAVE,
77      __FILE__,
78      __LINE__
79  );
80
81  testTruth(
82      test_wave_ptr->type_str == "WAVE",
83      __FILE__,
84      __LINE__
85  );
86
87  testFloatEquals(
88      test_wave_ptr->capital_cost,
89      850831.063539,
90      __FILE__,
91      __LINE__
92  );
93
94  testFloatEquals(
95      test_wave_ptr->operation_maintenance_cost_kWh,
96      0.069905,
97      __FILE__,
98      __LINE__
99  );
100
101 // ======== END ATTRIBUTES ============================================================== //
102
103
104
105 // ======== METHODS ===================================================================== //
106
107 // test production constraints
108 testFloatEquals(
109     test_wave_ptr->computeProductionkW(0, 1, 0, rand()),
110     0,
111     __FILE__,
112     __LINE__
113 );
114
115 testFloatEquals(
116     test_wave_ptr->computeProductionkW(0, 1, rand(), 0),
117     0,
118     __FILE__,
119     __LINE__
120 );
121
122 // test commit()
123 std::vector<double> dt_vec_hrs (48, 1);
124
125 std::vector<double> load_vec_kW = {
126     1, 1, 0, 1, 0, 0, 1, 1, 1, 0, 1, 1,
127     1, 1, 1, 0, 0, 0, 0, 0, 0, 1, 1, 0,
128     1, 1, 1, 1, 1, 0, 1, 1, 1, 1, 0, 1,
129     1, 0, 0, 0, 1, 1, 1, 0, 1, 1, 0, 0
130 };
131
132 double load_kW = 0;
133 double production_kW = 0;
```

```
134 double roll = 0;
135 double significant_wave_height_m = 0;
136 double energy_period_s = 0;
137
138 for (int i = 0; i < 48; i++) {
139     roll = (double)rand() / RAND_MAX;
140
141     if (roll <= 0.05) {
142         roll = 0;
143     }
144
145     significant_wave_height_m = roll *
146         ((Wave*)test_wave_ptr)->design_significant_wave_height_m;
147
148     roll = (double)rand() / RAND_MAX;
149
150     if (roll <= 0.05) {
151         roll = 0;
152     }
153
154     energy_period_s = roll * ((Wave*)test_wave_ptr)->design_energy_period_s;
155
156     roll = (double)rand() / RAND_MAX;
157
158     if (roll >= 0.95) {
159         roll = 1.25;
160     }
161
162     load_vec_kW[i] *= roll * test_wave_ptr->capacity_kW;
163     load_kW = load_vec_kW[i];
164
165     production_kW = test_wave_ptr->computeProductionkW(
166         i,
167         dt_vec_hrs[i],
168         significant_wave_height_m,
169         energy_period_s
170     );
171
172     load_kW = test_wave_ptr->commit(
173         i,
174         dt_vec_hrs[i],
175         production_kW,
176         load_kW
177     );
178
179     // is running (or not) as expected
180     if (production_kW > 0) {
181         testTruth(
182             test_wave_ptr->is_running,
183             __FILE__,
184             __LINE__
185         );
186     }
187
188     else {
189         testTruth(
190             not test_wave_ptr->is_running,
191             __FILE__,
192             __LINE__
193         );
194     }
195
196     // load_kW <= load_vec_kW (i.e., after vs before)
197     testLessThanOrEqualTo(
198         load_kW,
199         load_vec_kW[i],
200         __FILE__,
201         __LINE__
202     );
203
204     // production = dispatch + storage + curtailment
205     testFloatEquals(
206         test_wave_ptr->production_vec_kW[i] -
207         test_wave_ptr->dispatch_vec_kW[i] -
208         test_wave_ptr->storage_vec_kW[i] -
209         test_wave_ptr->curtailment_vec_kW[i],
210         0,
211         __FILE__,
212         __LINE__
213     );
214
215     // resource, O&M > 0 whenever wave is running (i.e., producing)
216     if (test_wave_ptr->is_running) {
217         testGreaterThan(
218             significant_wave_height_m,
219             0,
220             __FILE__,
```

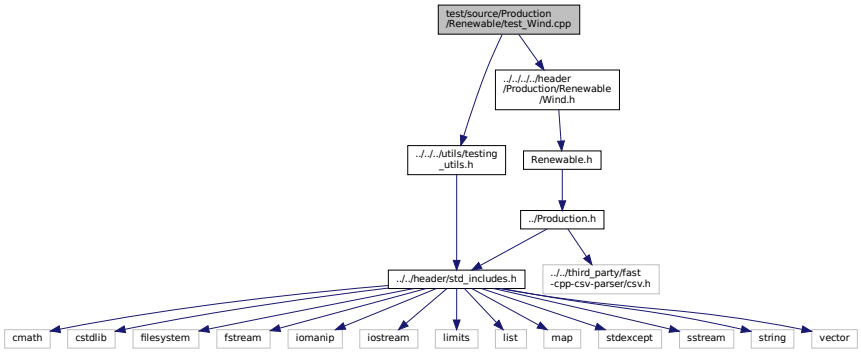
```
221             __LINE__
222         );
223
224         testGreaterThan(
225             energy_period_s,
226             0,
227             __FILE__,
228             __LINE__
229         );
230
231         testGreaterThan(
232             test_wave_ptr->operation_maintenance_cost_vec[i],
233             0,
234             __FILE__,
235             __LINE__
236         );
237     }
238
239     // O&M = 0 whenever wave is not running (i.e., not producing)
240     else {
241         testFloatEquals(
242             test_wave_ptr->operation_maintenance_cost_vec[i],
243             0,
244             __FILE__,
245             __LINE__
246         );
247     }
248 }
249 // ======== END METHODS ============================================================ //
250
251 }   /* try */
252
253
254 catch (...) {
255     delete test_wave_ptr;
256
257     printGold(" ...... ");
258     printRed("FAIL");
259     std::cout « std::endl;
260     throw;
261 }
262
263
264 delete test_wave_ptr;
265
266 printGold(" ...... ");
267 printGreen("PASS");
268 std::cout « std::endl;
269 return 0;
270 }   /* main() */
```

5.37 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

- int main (int argc, char **argv)

5.37.1 Detailed Description

Testing suite for Wind class.

A suite of tests for the Wind class.

5.37.2 Function Documentation

5.37.2.1 main()

```
int main (
              int argc,
              char ** argv )
```

```
27 {
28     #ifdef _WIN32
29         activateVirtualTerminal();
30     #endif  /* _WIN32 */
31 
32     printGold("\tTesting Production <-- Renewable <-- Wind");
33 
34     srand(time(NULL));
35 
36     Renewable* test_wind_ptr;
37 
38 try {
39 
40 // ======== CONSTRUCTION ============================================================ //
41 
42 bool error_flag = true;
43 
44 try {
45     WindInputs bad_wind_inputs;
46     bad_wind_inputs.design_speed_ms = -1;
47 
48     Wind bad_wind(8760, 1, bad_wind_inputs);
49 
50     error_flag = false;
51 } catch (...) {
52     // Task failed successfully! =P
53 }
54 if (not error_flag) {
55     expectedErrorNotDetected(__FILE__, __LINE__);
56 }
57 
58 WindInputs wind_inputs;
59 
60 test_wind_ptr = new Wind(8760, 1, wind_inputs);
61 
62 // ======== END CONSTRUCTION ======================================================== //
63 
64 
65 
66 // ======== ATTRIBUTES ============================================================== //
67 
68 testTruth(
69     not wind_inputs.renewable_inputs.production_inputs.print_flag,
70     __FILE__,
71     __LINE__
72 );
73 
74 testFloatEquals(
75     test_wind_ptr->type,
76     RenewableType :: WIND,
77     __FILE__,
```

```
78      __LINE__
79  );
80
81  testTruth(
82      test_wind_ptr->type_str == "WIND",
83      __FILE__,
84      __LINE__
85  );
86
87  testFloatEquals(
88      test_wind_ptr->capital_cost,
89      450356.170088,
90      __FILE__,
91      __LINE__
92  );
93
94  testFloatEquals(
95      test_wind_ptr->operation_maintenance_cost_kWh,
96      0.034953,
97      __FILE__,
98      __LINE__
99  );
100
101 // ======== END ATTRIBUTES ============================================================ //
102
103
104
105 // ======== METHODS ================================================================== //
106
107 // test production constraints
108 testFloatEquals(
109     test_wind_ptr->computeProductionkW(0, 1, 1e6),
110     0,
111     __FILE__,
112     __LINE__
113 );
114
115 testFloatEquals(
116     test_wind_ptr->computeProductionkW(
117         0,
118         1,
119         ((Wind*)test_wind_ptr)->design_speed_ms
120     ),
121     test_wind_ptr->capacity_kW,
122     __FILE__,
123     __LINE__
124 );
125
126 testFloatEquals(
127     test_wind_ptr->computeProductionkW(0, 1, -1),
128     0,
129     __FILE__,
130     __LINE__
131 );
132
133 // test commit()
134 std::vector<double> dt_vec_hrs (48, 1);
135
136 std::vector<double> load_vec_kW = {
137     1, 1, 0, 1, 0, 0, 1, 1, 1, 0, 1, 1,
138     1, 1, 1, 0, 0, 0, 0, 0, 0, 1, 1, 0,
139     1, 1, 1, 1, 1, 0, 1, 1, 1, 1, 0, 1,
140     1, 0, 0, 0, 1, 1, 1, 0, 1, 1, 0, 0
141 };
142
143 double load_kW = 0;
144 double production_kW = 0;
145 double roll = 0;
146 double wind_resource_ms = 0;
147
148 for (int i = 0; i < 48; i++) {
149     roll = (double)rand() / RAND_MAX;
150
151     wind_resource_ms = roll * ((Wind*)test_wind_ptr)->design_speed_ms;
152
153     roll = (double)rand() / RAND_MAX;
154
155     if (roll <= 0.1) {
156         wind_resource_ms = 0;
157     }
158
159     else if (roll >= 0.95) {
160         wind_resource_ms = 3 * ((Wind*)test_wind_ptr)->design_speed_ms;
161     }
162
163     roll = (double)rand() / RAND_MAX;
164
```

```
165     if (roll >= 0.95) {
166         roll = 1.25;
167     }
168 
169     load_vec_kW[i] *= roll * test_wind_ptr->capacity_kW;
170     load_kW = load_vec_kW[i];
171 
172     production_kW = test_wind_ptr->computeProductionkW(
173         i,
174         dt_vec_hrs[i],
175         wind_resource_ms
176     );
177 
178     load_kW = test_wind_ptr->commit(
179         i,
180         dt_vec_hrs[i],
181         production_kW,
182         load_kW
183     );
184 
185     // is running (or not) as expected
186     if (production_kW > 0) {
187         testTruth(
188             test_wind_ptr->is_running,
189             __FILE__,
190             __LINE__
191         );
192     }
193 
194     else {
195         testTruth(
196             not test_wind_ptr->is_running,
197             __FILE__,
198             __LINE__
199         );
200     }
201 
202     // load_kW <= load_vec_kW (i.e., after vs before)
203     testLessThanOrEqualTo(
204         load_kW,
205         load_vec_kW[i],
206         __FILE__,
207         __LINE__
208     );
209 
210     // production = dispatch + storage + curtailment
211     testFloatEquals(
212         test_wind_ptr->production_vec_kW[i] -
213         test_wind_ptr->dispatch_vec_kW[i] -
214         test_wind_ptr->storage_vec_kW[i] -
215         test_wind_ptr->curtailment_vec_kW[i],
216         0,
217         __FILE__,
218         __LINE__
219     );
220 
221     // resource, O&M > 0 whenever wind is running (i.e., producing)
222     if (test_wind_ptr->is_running) {
223         testGreaterThan(
224             wind_resource_ms,
225             0,
226             __FILE__,
227             __LINE__
228         );
229 
230         testGreaterThan(
231             test_wind_ptr->operation_maintenance_cost_vec[i],
232             0,
233             __FILE__,
234             __LINE__
235         );
236     }
237 
238     // O&M = 0 whenever wind is not running (i.e., not producing)
239     else {
240         testFloatEquals(
241             test_wind_ptr->operation_maintenance_cost_vec[i],
242             0,
243             __FILE__,
244             __LINE__
245         );
246     }
247 }
248 
249 
250 // ======== END METHODS ============================================================ //
251 
```

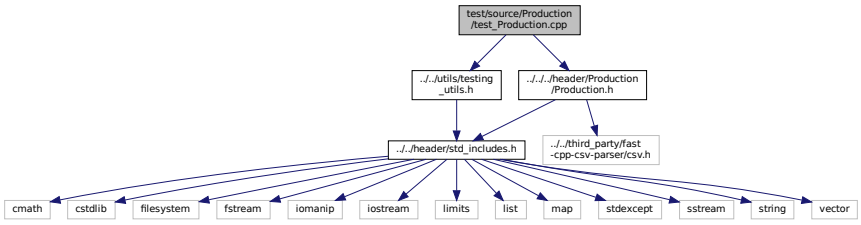
```
252 }   /* try */
253
254
255 catch (...) {
256     delete test_wind_ptr;
257
258     printGold(" ..... ");
259     printRed("FAIL");
260     std::cout « std::endl;
261     throw;
262 }
263
264
265 delete test_wind_ptr;
266
267 printGold(" ..... ");
268 printGreen("PASS");
269 std::cout « std::endl;
270 return 0;
271 }   /* main() */
```

5.38 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

- int main (int argc, char ∗∗argv)

5.38.1 Detailed Description

Testing suite for Production class.

A suite of tests for the Production class.

5.38.2 Function Documentation

5.38.2.1 main()

```
int main (
              int argc,
              char ** argv )
27 {
28     #ifdef _WIN32
29         activateVirtualTerminal();
30     #endif  /* _WIN32 */
31
32     printGold("\n\tTesting Production");
33
34     srand(time(NULL));
35
36
37 try {
38
39 // ======== CONSTRUCTION ========================================================== //
40
41 bool error_flag = true;
42
43 try {
44     ProductionInputs production_inputs;
45
46     Production bad_production(0, 1, production_inputs);
47
48     error_flag = false;
49 } catch (...) {
50     // Task failed successfully! =P
51 }
52 if (not error_flag) {
53     expectedErrorNotDetected(__FILE__, __LINE__);
54 }
55
56 ProductionInputs production_inputs;
57
58 Production test_production(8760, 1, production_inputs);
59
60 // ======== END CONSTRUCTION ====================================================== //
61
62
63
64 // ======== ATTRIBUTES ============================================================ //
65
66 testTruth(
67     not production_inputs.print_flag,
68     __FILE__,
69     __LINE__
70 );
71
72 testFloatEquals(
73     production_inputs.nominal_inflation_annual,
74     0.02,
75     __FILE__,
76     __LINE__
77 );
78
79 testFloatEquals(
80     production_inputs.nominal_discount_annual,
81     0.04,
82     __FILE__,
83     __LINE__
84 );
85
86 testFloatEquals(
87     test_production.n_points,
88     8760,
89     __FILE__,
90     __LINE__
91 );
92
93 testFloatEquals(
94     test_production.capacity_kW,
95     100,
96     __FILE__,
97     __LINE__
98 );
99
100 testFloatEquals(
101     test_production.real_discount_annual,
102     0.0196078431372549,
103     __FILE__,
104     __LINE__
105 );
106
```

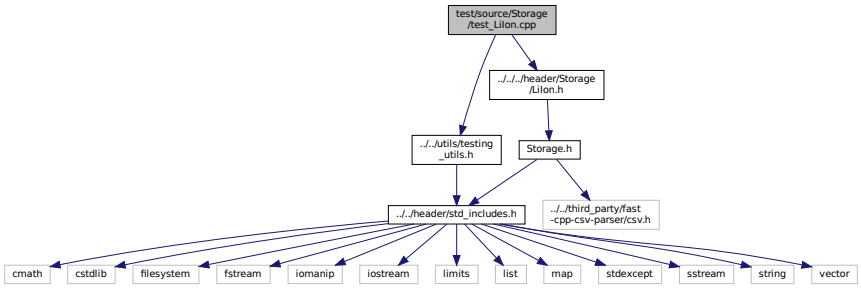
```
107 testFloatEquals(
108     test_production.production_vec_kW.size(),
109     8760,
110     __FILE__,
111     __LINE__
112 );
113
114 testFloatEquals(
115     test_production.dispatch_vec_kW.size(),
116     8760,
117     __FILE__,
118     __LINE__
119 );
120
121 testFloatEquals(
122     test_production.storage_vec_kW.size(),
123     8760,
124     __FILE__,
125     __LINE__
126 );
127
128 testFloatEquals(
129     test_production.curtailment_vec_kW.size(),
130     8760,
131     __FILE__,
132     __LINE__
133 );
134
135 testFloatEquals(
136     test_production.capital_cost_vec.size(),
137     8760,
138     __FILE__,
139     __LINE__
140 );
141
142 testFloatEquals(
143     test_production.operation_maintenance_cost_vec.size(),
144     8760,
145     __FILE__,
146     __LINE__
147 );
148
149 // ======== END ATTRIBUTES ============================================================ //
150
151 }   /* try */
152
153
154 catch (...) {
155     //...
156
157     printGold(" ............................. ");
158     printRed("FAIL");
159     std::cout « std::endl;
160     throw;
161 }
162
163
164 printGold(" ............................. ");
165 printGreen("PASS");
166 std::cout « std::endl;
167 return 0;
168
169 }   /* main() */
```

5.39 test/source/Storage/test_LiIon.cpp File Reference

Testing suite for LiIon class.

```
#include "../../utils/testing_utils.h"
#include "../../../header/Storage/LiIon.h"
```

Include dependency graph for test_LiIon.cpp:



Functions

- int main (int argc, char **argv)

5.39.1 Detailed Description

Testing suite for LiIon class.

A suite of tests for the LiIon class.

5.39.2 Function Documentation

5.39.2.1 main()

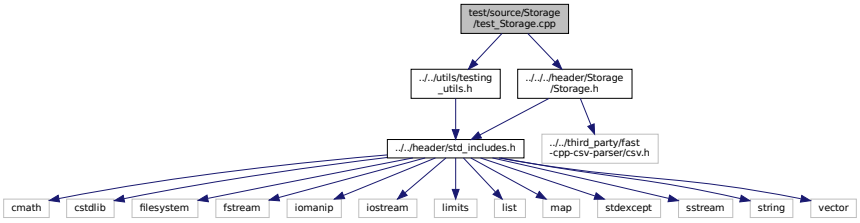
```
int main (
            int argc,
            char ** argv )
27 {
28     #ifdef _WIN32
29         activateVirtualTerminal();
30     #endif  /* _WIN32 */
31
32     printGold("\tTesting Storage <-- LiIon");
33
34     srand(time(NULL));
35
36
37     try {
38         //...
39     }
40
41     catch (...) {
42         //...
43
44         printGold(" ..................... ");
45         printRed("FAIL");
46         std::cout << std::endl;
47         throw;
48     }
49
50
51     printGold(" ..................... ");
52     printGreen("PASS");
53     std::cout << std::endl;
54     return 0;
55 }   /* main() */
```

5.40 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

- int main (int argc, char **argv)

5.40.1 Detailed Description

Testing suite for Storage class.

A suite of tests for the Storage class.

5.40.2 Function Documentation

5.40.2.1 main()

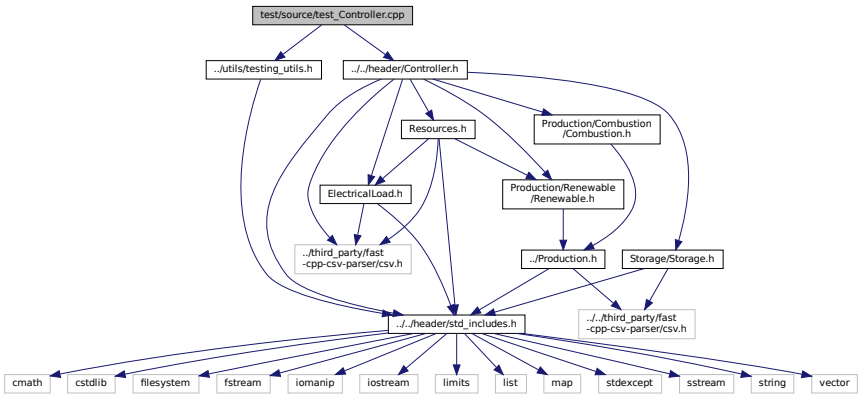
```
int main (
            int argc,
            char ** argv )
27 {
28     #ifdef _WIN32
29         activateVirtualTerminal();
30     #endif  /* _WIN32 */
31
32     printGold("\tTesting Storage");
33
34     srand(time(NULL));
35
36
37     try {
38         //...
39     }
40
41     catch (...) {
42         //...
43
44         printGold(" ..................... ");
45         printRed("FAIL");
46         std::cout << std::endl;
47         throw;
48     }
49
50
51     printGold(" ............................... ");
52     printGreen("PASS");
53     std::cout << std::endl;
54     return 0;
55 }   /* main() */
```

5.41 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

- int main (int argc, char **argv)

5.41.1 Detailed Description

Testing suite for Controller class.

A suite of tests for the Controller class.

5.41.2 Function Documentation

5.41.2.1 main()

```
int main (
            int argc,
            char ** argv )
27 {
28     #ifdef _WIN32
29         activateVirtualTerminal();
30     #endif  /* _WIN32 */
31
32     printGold("\tTesting Controller");
33
34     srand(time(NULL));
35
36
37 try {
```

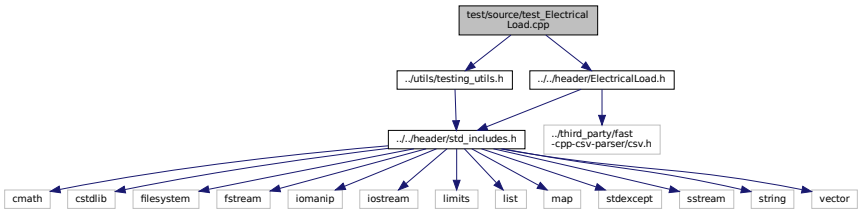
```
38
39 // ======== CONSTRUCTION ========================================================== //
40
41 Controller test_controller;
42
43 // ======== END CONSTRUCTION ======================================================//
44
45
46
47 // ======== ATTRIBUTES ============================================================ //
48
49 //...
50
51 // ======== END ATTRIBUTES ======================================================== //
52
53
54
55 // ======== METHODS =============================================================== //
56
57 //...
58
59 // ======== END METHODS ========================================================== //
60
61 }   /* try */
62
63
64 catch (...) {
65     //...
66
67     printGold(" ............................. ");
68     printRed("FAIL");
69     std::cout « std::endl;
70     throw;
71 }
72
73
74 printGold(" ............................. ");
75 printGreen("PASS");
76 std::cout « std::endl;
77 return 0;
78 }   /* main() */
```

5.42 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

- int main (int argc, char **argv)

5.42.1 Detailed Description

Testing suite for ElectricalLoad class.

A suite of tests for the ElectricalLoad class.

5.42.2 Function Documentation

5.42.2.1 main()

```
int main (
              int argc,
              char ** argv )
27 {
28     #ifdef _WIN32
29         activateVirtualTerminal();
30     #endif  /* _WIN32 */
31
32     printGold("\tTesting ElectricalLoad");
33
34     srand(time(NULL));
35
36
37 try {
38
39 // ======== CONSTRUCTION ========================================================== //
40
41 std::string path_2_electrical_load_time_series =
42     "data/test/electrical_load_generic_peak-500kW_1yr_dt-1hr.csv";
43
44 ElectricalLoad test_electrical_load(path_2_electrical_load_time_series);
45
46 // ======== END CONSTRUCTION ====================================================== //
47
48
49
50 // ======== ATTRIBUTES ============================================================ //
51
52 testTruth(
53     test_electrical_load.path_2_electrical_load_time_series ==
54     path_2_electrical_load_time_series,
55     __FILE__,
56     __LINE__
57 );
58
59 testFloatEquals(
60     test_electrical_load.n_points,
61     8760,
62     __FILE__,
63     __LINE__
64 );
65
66 testFloatEquals(
67     test_electrical_load.n_years,
68     0.999886,
69     __FILE__,
70     __LINE__
71 );
72
73 testFloatEquals(
74     test_electrical_load.min_load_kW,
75     82.1211213927802,
76     __FILE__,
77     __LINE__
78 );
79
80 testFloatEquals(
81     test_electrical_load.mean_load_kW,
82     258.373472633202,
83     __FILE__,
84     __LINE__
85 );
86
87
88 testFloatEquals(
89     test_electrical_load.max_load_kW,
90     500,
91     __FILE__,
92     __LINE__
93 );
94
95
96 std::vector<double> expected_dt_vec_hrs (48, 1);
97
```

```
98 std::vector<double> expected_time_vec_hrs = {
99       0,  1,  2,  3,  4,  5,  6,  7,  8,  9, 10, 11,
100      12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23,
101      24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35,
102      36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47
103 };
104
105 std::vector<double> expected_load_vec_kW = {
106     360.253836463674,
107     355.171277826775,
108     353.776453532298,
109     353.75405737934,
110     346.592867404975,
111     340.132411175118,
112     337.354867340578,
113     340.644115618736,
114     363.639028500678,
115     378.787797779238,
116     372.215798201712,
117     395.093925731298,
118     402.325427142659,
119     386.907725462306,
120     380.709170928091,
121     372.062070914977,
122     372.328646856954,
123     391.841444284136,
124     394.029351759596,
125     383.369407765254,
126     381.093099675206,
127     382.604158946193,
128     390.744843709034,
129     383.13949492437,
130     368.150393976985,
131     364.629744480226,
132     363.572736804082,
133     359.854924202248,
134     355.207590170267,
135     349.094656012401,
136     354.365935871597,
137     343.380608328546,
138     404.673065729266,
139     486.296896820126,
140     480.225974100847,
141     457.318764401085,
142     418.177339948609,
143     414.399018364126,
144     409.678420185754,
145     404.768766016563,
146     401.699589920585,
147     402.44339040654,
148     398.138372541906,
149     396.010498627646,
150     390.165117432277,
151     375.850429417013,
152     365.567100746484,
153     365.429624610923
154 };
155
156 for (int i = 0; i < 48; i++) {
157     testFloatEquals(
158         test_electrical_load.dt_vec_hrs[i],
159         expected_dt_vec_hrs[i],
160         __FILE__,
161         __LINE__
162     );
163
164     testFloatEquals(
165         test_electrical_load.time_vec_hrs[i],
166         expected_time_vec_hrs[i],
167         __FILE__,
168         __LINE__
169     );
170
171     testFloatEquals(
172         test_electrical_load.load_vec_kW[i],
173         expected_load_vec_kW[i],
174         __FILE__,
175         __LINE__
176     );
177 }
178
179 // ======== END ATTRIBUTES ============================================================ //
180
181 }   /* try */
182
183
184 catch (...) {
```

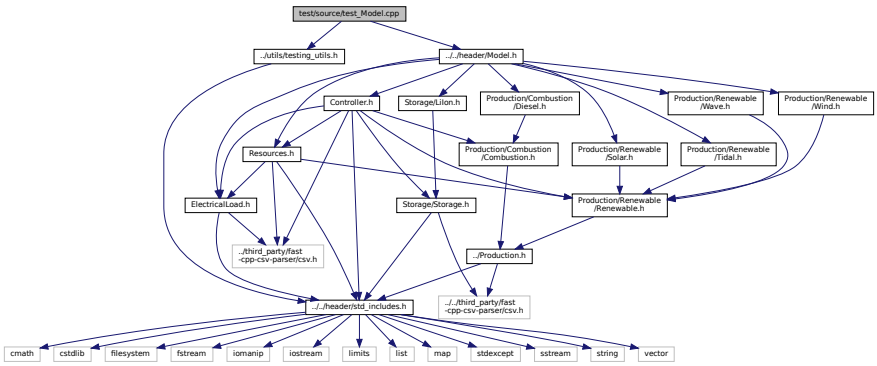
```
185     //...
186
187     printGold(" ......................... ");
188     printRed("FAIL");
189     std::cout « std::endl;
190     throw;
191 }
192
193
194 printGold(" ......................... ");
195 printGreen("PASS");
196 std::cout « std::endl;
197 return 0;
198 }   /* main() */
```

5.43 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

- int main (int argc, char ∗∗argv)

5.43.1 Detailed Description

Testing suite for Model class.

A suite of tests for the Model class.

5.43.2 Function Documentation

5.43.2.1 main()

```
int main (
             int argc,
             char ** argv )
{
    #ifdef _WIN32
        activateVirtualTerminal();
    #endif  /* _WIN32 */

    printGold("\tTesting Model");

    srand(time(NULL));


try {

// ======== CONSTRUCTION ============================================================ //

bool error_flag = true;

try {
    ModelInputs bad_model_inputs;
    bad_model_inputs.path_2_electrical_load_time_series =
        "data/test/bad_path_240984069830.csv";

    Model bad_model(bad_model_inputs);

    error_flag = false;
} catch (...) {
    // Task failed successfully! =P
}
if (not error_flag) {
    expectedErrorNotDetected(__FILE__, __LINE__);
}

std::string path_2_electrical_load_time_series =
    "data/test/electrical_load_generic_peak-500kW_1yr_dt-1hr.csv";

ModelInputs test_model_inputs;
test_model_inputs.path_2_electrical_load_time_series =
    path_2_electrical_load_time_series;

Model test_model(test_model_inputs);

// ======== END CONSTRUCTION ======================================================== //


// ======== ATTRIBUTES ============================================================== //

testTruth(
    test_model.electrical_load.path_2_electrical_load_time_series ==
    path_2_electrical_load_time_series,
    __FILE__,
    __LINE__
);

testFloatEquals(
    test_model.electrical_load.n_points,
    8760,
    __FILE__,
    __LINE__
);

testFloatEquals(
    test_model.electrical_load.n_years,
    0.999886,
    __FILE__,
    __LINE__
);

testFloatEquals(
    test_model.electrical_load.min_load_kW,
    82.1211213927802,
    __FILE__,
    __LINE__
);

testFloatEquals(
     test_model.electrical_load.mean_load_kW,
     258.373472633202,
     __FILE__,
     __LINE__
);

```

```
107
108 testFloatEquals(
109     test_model.electrical_load.max_load_kW,
110     500,
111     __FILE__,
112     __LINE__
113 );
114
115
116 std::vector<double> expected_dt_vec_hrs (48, 1);
117
118 std::vector<double> expected_time_vec_hrs = {
119      0,  1,  2,  3,  4,  5,  6,  7,  8,  9, 10, 11,
120     12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23,
121     24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35,
122     36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47
123 };
124
125 std::vector<double> expected_load_vec_kW = {
126     360.253836463674,
127     355.171277826775,
128     353.776453532298,
129     353.75405737934,
130     346.592867404975,
131     340.132411175118,
132     337.354867340578,
133     340.644115618736,
134     363.639028500678,
135     378.787797779238,
136     372.215798201712,
137     395.093925731298,
138     402.325427142659,
139     386.907725462306,
140     380.709170928091,
141     372.062070914977,
142     372.328646856954,
143     391.841444284136,
144     394.029351759596,
145     383.369407765254,
146     381.093099675206,
147     382.604158946193,
148     390.744843709034,
149     383.13949492437,
150     368.150393976985,
151     364.629744480226,
152     363.572736804082,
153     359.854924202248,
154     355.207590170267,
155     349.094656012401,
156     354.365935871597,
157     343.380608328546,
158     404.673065729266,
159     486.296896820126,
160     480.225974100847,
161     457.318764401085,
162     418.177339948609,
163     414.399018364126,
164     409.678420185754,
165     404.768766016563,
166     401.699589920585,
167     402.44339040654,
168     398.138372541906,
169     396.010498627646,
170     390.165117432277,
171     375.850429417013,
172     365.567100746484,
173     365.429624610923
174 };
175
176 for (int i = 0; i < 48; i++) {
177     testFloatEquals(
178         test_model.electrical_load.dt_vec_hrs[i],
179         expected_dt_vec_hrs[i],
180         __FILE__,
181         __LINE__
182     );
183
184     testFloatEquals(
185         test_model.electrical_load.time_vec_hrs[i],
186         expected_time_vec_hrs[i],
187         __FILE__,
188         __LINE__
189     );
190
191     testFloatEquals(
192         test_model.electrical_load.load_vec_kW[i],
193         expected_load_vec_kW[i],
```

```
194         __FILE__,
195         __LINE__
196     );
197 }
198
199 // ======== END ATTRIBUTES ============================================================ //
200
201
202
203 // ======== METHODS ================================================================== //
204
205 //  add Solar resource
206 int solar_resource_key = 0;
207 std::string path_2_solar_resource_data =
208     "data/test/solar_GHI_peak-1kWm2_1yr_dt-1hr.csv";
209
210 test_model.addResource(
211     RenewableType :: SOLAR,
212     path_2_solar_resource_data,
213     solar_resource_key
214 );
215
216 std::vector<double> expected_solar_resource_vec_kWm2 = {
217     0,
218     0,
219     0,
220     0,
221     0,
222     0,
223     8.51702662684015E-05,
224     0.000348341567045,
225     0.00213793728593,
226     0.004099863613322,
227     0.000997135230553,
228     0.009534527624657,
229     0.022927996790616,
230     0.0136071715294,
231     0.002535134127751,
232     0.005206897515821,
233     0.005627658648597,
234     0.000701186722215,
235     0.00017119827089,
236     0,
237     0,
238     0,
239     0,
240     0,
241     0,
242     0,
243     0,
244     0,
245     0,
246     0,
247     0,
248     0.000141055102242,
249     0.00084525014743,
250     0.024893647822702,
251     0.091245556190749,
252     0.158722176731637,
253     0.152859680515876,
254     0.149922903895116,
255     0.13049996570866,
256     0.03081254222795,
257     0.001218928911125,
258     0.000206092647423,
259     0,
260     0,
261     0,
262     0,
263     0,
264     0
265 };
266
267 for (size_t i = 0; i < expected_solar_resource_vec_kWm2.size(); i++) {
268     testFloatEquals(
269         test_model.resources.resource_map_1D[solar_resource_key][i],
270         expected_solar_resource_vec_kWm2[i],
271         __FILE__,
272         __LINE__
273     );
274 }
275
276
277 //  add Tidal resource
278 int tidal_resource_key = 1;
279 std::string path_2_tidal_resource_data =
280     "data/test/tidal_speed_peak-3ms_1yr_dt-1hr.csv";
```

```
281
282 test_model.addResource(
283     RenewableType :: TIDAL,
284     path_2_tidal_resource_data,
285     tidal_resource_key
286 );
287
288
289 //  add Wave resource
290 int wave_resource_key = 2;
291 std::string path_2_wave_resource_data =
292     "data/test/waves_H_s_peak-8m_T_e_peak-15s_1yr_dt-1hr.csv";
293
294 test_model.addResource(
295     RenewableType :: WAVE,
296     path_2_wave_resource_data,
297     wave_resource_key
298 );
299
300
301 //  add Wind resource
302 int wind_resource_key = 3;
303 std::string path_2_wind_resource_data =
304     "data/test/wind_speed_peak-25ms_1yr_dt-1hr.csv";
305
306 test_model.addResource(
307     RenewableType :: WIND,
308     path_2_wind_resource_data,
309     wind_resource_key
310 );
311
312
313 //  add Diesel assets
314 DieselInputs diesel_inputs;
315 diesel_inputs.combustion_inputs.production_inputs.capacity_kW = 100;
316 diesel_inputs.combustion_inputs.production_inputs.is_sunk = true;
317
318 test_model.addDiesel(diesel_inputs);
319
320 testFloatEquals(
321     test_model.combustion_ptr_vec.size(),
322     1,
323     __FILE__,
324     __LINE__
325 );
326
327 testFloatEquals(
328     test_model.combustion_ptr_vec[0]->type,
329     CombustionType :: DIESEL,
330     __FILE__,
331     __LINE__
332 );
333
334 diesel_inputs.combustion_inputs.production_inputs.capacity_kW = 150;
335
336 test_model.addDiesel(diesel_inputs);
337
338 diesel_inputs.combustion_inputs.production_inputs.capacity_kW = 250;
339
340 test_model.addDiesel(diesel_inputs);
341
342 testFloatEquals(
343     test_model.combustion_ptr_vec.size(),
344     3,
345     __FILE__,
346     __LINE__
347 );
348
349 std::vector<int> expected_diesel_capacity_vec_kW = {100, 150, 250};
350
351 for (int i = 0; i < 3; i++) {
352     testFloatEquals(
353         test_model.combustion_ptr_vec[i]->capacity_kW,
354         expected_diesel_capacity_vec_kW[i],
355         __FILE__,
356         __LINE__
357     );
358 }
359
360 diesel_inputs.combustion_inputs.production_inputs.capacity_kW = 100;
361
362 for (int i = 0; i < 2 * ((double)rand() / RAND_MAX); i++) {
363     test_model.addDiesel(diesel_inputs);
364 }
365
366
367 //  add Solar asset
```

```
368 SolarInputs solar_inputs;
369 solar_inputs.resource_key = solar_resource_key;
370
371 test_model.addSolar(solar_inputs);
372
373 testFloatEquals(
374     test_model.renewable_ptr_vec.size(),
375     1,
376     __FILE__,
377     __LINE__
378 );
379
380 testFloatEquals(
381     test_model.renewable_ptr_vec[0]->type,
382     RenewableType :: SOLAR,
383     __FILE__,
384     __LINE__
385 );
386
387
388 //  add Tidal asset
389 TidalInputs tidal_inputs;
390 tidal_inputs.resource_key = tidal_resource_key;
391
392 test_model.addTidal(tidal_inputs);
393
394 testFloatEquals(
395     test_model.renewable_ptr_vec.size(),
396     2,
397     __FILE__,
398     __LINE__
399 );
400
401 testFloatEquals(
402     test_model.renewable_ptr_vec[1]->type,
403     RenewableType :: TIDAL,
404     __FILE__,
405     __LINE__
406 );
407
408
409 //  add Wave asset
410 WaveInputs wave_inputs;
411 wave_inputs.resource_key = wave_resource_key;
412
413 test_model.addWave(wave_inputs);
414
415 testFloatEquals(
416     test_model.renewable_ptr_vec.size(),
417     3,
418     __FILE__,
419     __LINE__
420 );
421
422 testFloatEquals(
423     test_model.renewable_ptr_vec[2]->type,
424     RenewableType :: WAVE,
425     __FILE__,
426     __LINE__
427 );
428
429
430 //  add Wind asset
431 WindInputs wind_inputs;
432 wind_inputs.resource_key = wind_resource_key;
433
434 test_model.addWind(wind_inputs);
435
436 testFloatEquals(
437     test_model.renewable_ptr_vec.size(),
438     4,
439     __FILE__,
440     __LINE__
441 );
442
443 testFloatEquals(
444     test_model.renewable_ptr_vec[3]->type,
445     RenewableType :: WIND,
446     __FILE__,
447     __LINE__
448 );
449
450
451 //  run
452 test_model.run();
453
454
```

```
455 //  write results
456 test_model.writeResults("test/test_results/");
457
458
459 //  test post-run attributes
460 for (int i = 0; i < test_model.electrical_load.n_points; i++) {
461     testLessThanOrEqualTo(
462         test_model.controller.net_load_vec_kW[i],
463         test_model.electrical_load.max_load_kW,
464         __FILE__,
465         __LINE__
466     );
467 }
468
469 testGreaterThan(
470     test_model.net_present_cost,
471     0,
472     __FILE__,
473     __LINE__
474 );
475
476 testFloatEquals(
477     test_model.total_dispatch_discharge_kWh,
478     2263351.62026685,
479     __FILE__,
480     __LINE__
481 );
482
483 testGreaterThan(
484     test_model.levellized_cost_of_energy_kWh,
485     0,
486     __FILE__,
487     __LINE__
488 );
489
490 testGreaterThan(
491     test_model.total_fuel_consumed_L,
492     0,
493     __FILE__,
494     __LINE__
495 );
496
497 testGreaterThan(
498     test_model.total_emissions.CO2_kg,
499     0,
500     __FILE__,
501     __LINE__
502 );
503
504 testGreaterThan(
505     test_model.total_emissions.CO_kg,
506     0,
507     __FILE__,
508     __LINE__
509 );
510
511 testGreaterThan(
512     test_model.total_emissions.NOx_kg,
513     0,
514     __FILE__,
515     __LINE__
516 );
517
518 testGreaterThan(
519     test_model.total_emissions.SOx_kg,
520     0,
521     __FILE__,
522     __LINE__
523 );
524
525 testGreaterThan(
526     test_model.total_emissions.CH4_kg,
527     0,
528     __FILE__,
529     __LINE__
530 );
531
532 testGreaterThan(
533     test_model.total_emissions.PM_kg,
534     0,
535     __FILE__,
536     __LINE__
537 );
538
539 // ======== END METHODS ============================================================ //
540
541 }   /* try */
```

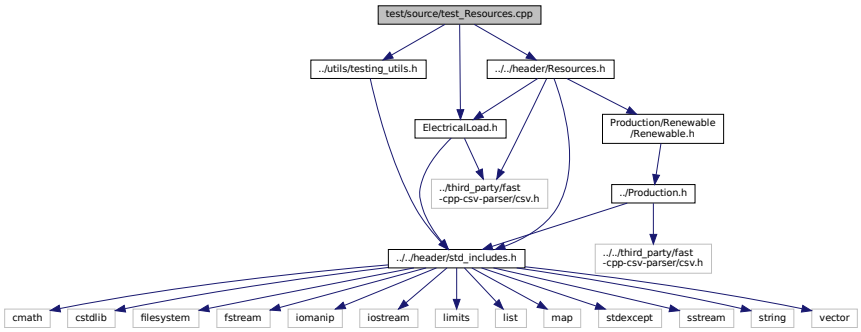
```
542
543
544 catch (...) {
545     //...
546
547     printGold(" ................................. ");
548     printRed("FAIL");
549     std::cout « std::endl;
550     throw;
551 }
552
553
554 printGold(" ................................. ");
555 printGreen("PASS");
556 std::cout « std::endl;
557 return 0;
558 }   /* main() */
```

5.44 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

- int main (int argc, char **argv)

5.44.1 Detailed Description

Testing suite for Resources class.

A suite of tests for the Resources class.

5.44.2 Function Documentation

5.44.2.1 main()

```
int main (
             int argc,
             char ** argv )
28 {
29     #ifdef _WIN32
30         activateVirtualTerminal();
31     #endif  /* _WIN32 */
32 
33     printGold("\tTesting Resources");
34 
35     srand(time(NULL));
36 
37 
38 try {
39 
40 // ======== CONSTRUCTION ========================================================== //
41 
42 std::string path_2_electrical_load_time_series =
43     "data/test/electrical_load_generic_peak-500kW_1yr_dt-1hr.csv";
44 
45 ElectricalLoad test_electrical_load(path_2_electrical_load_time_series);
46 
47 Resources test_resources;
48 
49 // ======== END CONSTRUCTION ====================================================== //
50 
51 
52 
53 // ======== ATTRIBUTES ============================================================ //
54 
55 testFloatEquals(
56     test_resources.resource_map_1D.size(),
57     0,
58     __FILE__,
59     __LINE__
60 );
61 
62 testFloatEquals(
63     test_resources.path_map_1D.size(),
64     0,
65     __FILE__,
66     __LINE__
67 );
68 
69 testFloatEquals(
70     test_resources.resource_map_2D.size(),
71     0,
72     __FILE__,
73     __LINE__
74 );
75 
76 testFloatEquals(
77     test_resources.path_map_2D.size(),
78     0,
79     __FILE__,
80     __LINE__
81 );
82 
83 // ======== END ATTRIBUTES ======================================================== //
84 
85 
86 // ======== METHODS =============================================================== //
87 
88 int solar_resource_key = 0;
89 std::string path_2_solar_resource_data =
90     "data/test/solar_GHI_peak-1kWm2_1yr_dt-1hr.csv";
91 
92 test_resources.addResource(
93     RenewableType::SOLAR,
94     path_2_solar_resource_data,
95     solar_resource_key,
96     &test_electrical_load
97 );
98 
99 bool error_flag = true;
100 try {
101     test_resources.addResource(
102         RenewableType::SOLAR,
103         path_2_solar_resource_data,
104         solar_resource_key,
105         &test_electrical_load
106     );
107 
```

```
108     error_flag = false;
109 } catch (...) {
110     // Task failed successfully! =P
111 }
112 if (not error_flag) {
113     expectedErrorNotDetected(__FILE__, __LINE__);
114 }
115
116
117 try {
118     std::string path_2_solar_resource_data_BAD_TIMES =
119         "data/test/solar_GHI_peak-1kWm2_1yr_dt-1hr_BAD_TIMES.csv";
120
121     test_resources.addResource(
122         RenewableType::SOLAR,
123         path_2_solar_resource_data_BAD_TIMES,
124         -1,
125         &test_electrical_load
126     );
127
128     error_flag = false;
129 } catch (...) {
130     // Task failed successfully! =P
131 }
132 if (not error_flag) {
133     expectedErrorNotDetected(__FILE__, __LINE__);
134 }
135
136
137 try {
138     std::string path_2_solar_resource_data_BAD_LENGTH =
139         "data/test/solar_GHI_peak-1kWm2_1yr_dt-1hr_BAD_LENGTH.csv";
140
141     test_resources.addResource(
142         RenewableType::SOLAR,
143         path_2_solar_resource_data_BAD_LENGTH,
144         -2,
145         &test_electrical_load
146     );
147
148     error_flag = false;
149 } catch (...) {
150     // Task failed successfully! =P
151 }
152 if (not error_flag) {
153     expectedErrorNotDetected(__FILE__, __LINE__);
154 }
155
156 std::vector<double> expected_solar_resource_vec_kWm2 = {
157     0,
158     0,
159     0,
160     0,
161     0,
162     0,
163     8.51702662684015E-05,
164     0.000348341567045,
165     0.00213793728593,
166     0.004099863613322,
167     0.000997135230553,
168     0.009534527624657,
169     0.022927996790616,
170     0.0136071715294,
171     0.002535134127751,
172     0.005206897515821,
173     0.005627658648597,
174     0.000701186722215,
175     0.00017119827089,
176     0,
177     0,
178     0,
179     0,
180     0,
181     0,
182     0,
183     0,
184     0,
185     0,
186     0,
187     0,
188     0.000141055102242,
189     0.00084525014743,
190     0.024893647822702,
191     0.091245556190749,
192     0.158722176731637,
193     0.152859680515876,
194     0.149922903895116,
```

```
195     0.13049996570866,
196     0.03081254222795,
197     0.001218928911125,
198     0.000206092647423,
199     0,
200     0,
201     0,
202     0,
203     0,
204     0
205 };
206
207 for (size_t i = 0; i < expected_solar_resource_vec_kWm2.size(); i++) {
208     testFloatEquals(
209         test_resources.resource_map_1D[solar_resource_key][i],
210         expected_solar_resource_vec_kWm2[i],
211         __FILE__,
212         __LINE__
213     );
214 }
215
216
217 int tidal_resource_key = 1;
218 std::string path_2_tidal_resource_data =
219     "data/test/tidal_speed_peak-3ms_1yr_dt-1hr.csv";
220
221 test_resources.addResource(
222     RenewableType::TIDAL,
223     path_2_tidal_resource_data,
224     tidal_resource_key,
225     &test_electrical_load
226 );
227
228 std::vector<double> expected_tidal_resource_vec_ms = {
229     0.347439913040533,
230     0.770545522195602,
231     0.731352084836198,
232     0.293389814389542,
233     0.209959110813115,
234     0.610609623896497,
235     1.78067162013604,
236     2.53522775118089,
237     2.75966627832024,
238     2.52101111143895,
239     2.05389330201031,
240     1.3461515862445,
241     0.28909254878384,
242     0.897754086048563,
243     1.71406453837407,
244     1.85047408742869,
245     1.71507908595979,
246     1.33540349705416,
247     0.434586143463003,
248     0.500623815700637,
249     1.37172172646733,
250     1.68294125491228,
251     1.56101300975417,
252     1.04925834219412,
253     0.211395463930223,
254     1.03720048903385,
255     1.85059536356448,
256     1.85203242794517,
257     1.4091471616277,
258     0.767776539039899,
259     0.251464906990961,
260     1.47018469375652,
261     2.36260493698197,
262     2.46653750048625,
263     2.12851908739291,
264     1.62783753197988,
265     0.734594890957439,
266     0.441886297300355,
267     1.6574418350918,
268     2.0684558286637,
269     1.87717416992136,
270     1.58871262337931,
271     1.03451227609235,
272     0.193371305159817,
273     0.976400122458815,
274     1.6583227369707,
275     1.76690616570953,
276     1.54801328553115
277 };
278
279 for (size_t i = 0; i < expected_tidal_resource_vec_ms.size(); i++) {
280     testFloatEquals(
281         test_resources.resource_map_1D[tidal_resource_key][i],
```

```
282         expected_tidal_resource_vec_ms[i],
283         __FILE__,
284         __LINE__
285     );
286 }
287
288
289 int wave_resource_key = 2;
290 std::string path_2_wave_resource_data =
291     "data/test/waves_H_s_peak-8m_T_e_peak-15s_1yr_dt-1hr.csv";
292
293 test_resources.addResource(
294     RenewableType::WAVE,
295     path_2_wave_resource_data,
296     wave_resource_key,
297     &test_electrical_load
298 );
299
300 std::vector<double> expected_significant_wave_height_vec_m = {
301     4.26175222125028,
302     4.25020976167872,
303     4.25656524330349,
304     4.27193854786718,
305     4.28744955711233,
306     4.29421815278154,
307     4.2839937266082,
308     4.25716982457976,
309     4.22419391611483,
310     4.19588925217606,
311     4.17338788587412,
312     4.14672746914214,
313     4.10560041173665,
314     4.05074966447193,
315     3.9953696962433,
316     3.95316976150866,
317     3.92771018142378,
318     3.91129562488595,
319     3.89558312094911,
320     3.87861093931749,
321     3.86538307240754,
322     3.86108961027929,
323     3.86459448853189,
324     3.86796474016882,
325     3.86357412779993,
326     3.85554872014731,
327     3.86044266668675,
328     3.89445961915999,
329     3.95554798115731,
330     4.02265508610476,
331     4.07419587011404,
332     4.10314247143958,
333     4.11738045085928,
334     4.12554995596708,
335     4.12923992001675,
336     4.1229292327442,
337     4.10123955307441,
338     4.06748827895363,
339     4.0336230651344,
340     4.01134236393876,
341     4.00136570034559,
342     3.99368787690411,
343     3.97820924247644,
344     3.95369335178055,
345     3.92742545608532,
346     3.90683362771686,
347     3.89331520944006,
348     3.88256045801583
349 };
350
351 std::vector<double> expected_energy_period_vec_s = {
352     10.4456008226821,
353     10.4614151137651,
354     10.4462827795433,
355     10.4127692097884,
356     10.3734397942723,
357     10.3408599227669,
358     10.32637292093,
359     10.3245412676322,
360     10.310409818185,
361     10.2589529840966,
362     10.1728100603103,
363     10.0862908658929,
364     10.03480243813,
365     10.023673635806,
366     10.0243418565116,
367     10.0063487117653,
368     9.96050302286607,
```

```
369     9.9011999635568,
370     9.84451822125472,
371     9.79726875879626,
372     9.75614594835158,
373     9.7173447961368,
374     9.68342904390577,
375     9.66380508567062,
376     9.6674009575699,
377     9.68927134575103,
378     9.70979984863046,
379     9.70967357906908,
380     9.68983025704562,
381     9.6722855524805,
382     9.67973599910003,
383     9.71977125328293,
384     9.78450442291421,
385     9.86532355233449,
386     9.96158937600019,
387     10.0807018356507,
388     10.2291022504937,
389     10.39458528356,
390     10.5464393581004,
391     10.6553277500484,
392     10.7245553190084,
393     10.7893127285064,
394     10.8846512240849,
395     11.0148158739075,
396     11.1544325654719,
397     11.2772785848343,
398     11.3744362756187,
399     11.4533643503183
400 };
401
402 for (size_t i = 0; i < expected_significant_wave_height_vec_m.size(); i++) {
403     testFloatEquals(
404         test_resources.resource_map_2D[wave_resource_key][i][0],
405         expected_significant_wave_height_vec_m[i],
406         __FILE__,
407         __LINE__
408     );
409
410     testFloatEquals(
411         test_resources.resource_map_2D[wave_resource_key][i][1],
412         expected_energy_period_vec_s[i],
413         __FILE__,
414         __LINE__
415     );
416 }
417
418
419 int wind_resource_key = 3;
420 std::string path_2_wind_resource_data =
421     "data/test/wind_speed_peak-25ms_1yr_dt-1hr.csv";
422
423 test_resources.addResource(
424     RenewableType::WIND,
425     path_2_wind_resource_data,
426     wind_resource_key,
427     &test_electrical_load
428 );
429
430 std::vector<double> expected_wind_resource_vec_ms = {
431     6.88566688469997,
432     5.02177105466549,
433     3.74211715899568,
434     5.67169579985362,
435     4.90670669971858,
436     4.29586955031368,
437     7.41155377205065,
438     10.2243290476943,
439     13.1258696725555,
440     13.7016198628274,
441     16.2481482330233,
442     16.5096744355418,
443     13.4354482206162,
444     14.0129230731609,
445     14.5554549260515,
446     13.4454539065912,
447     13.3447169512094,
448     11.7372615098554,
449     12.7200070078013,
450     10.6421127908149,
451     6.09869498990661,
452     5.66355596602321,
453     4.97316966910831,
454     3.48937138360567,
455     2.15917470979169,
```

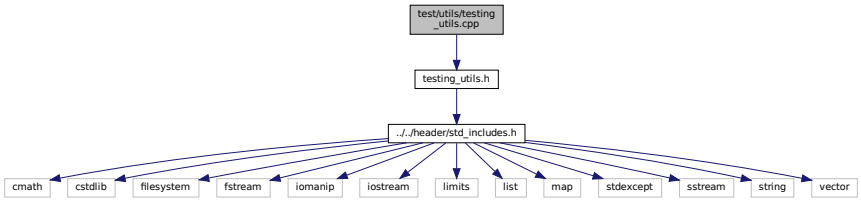
```
456     1.29061103587027,
457     3.43475751425219,
458     4.11706326260927,
459     4.28905275747408,
460     5.75850263196241,
461     8.98293663055264,
462     11.7069822941315,
463     12.4031987075858,
464     15.4096570910089,
465     16.6210843829552,
466     13.3421219142573,
467     15.2112831900548,
468     18.350864533037,
469     15.8751799822971,
470     15.3921198799796,
471     15.9729192868434,
472     12.4728950178772,
473     10.177050481096,
474     10.7342247355551,
475     8.98846695631389,
476     4.14671169124739,
477     3.17256452697149,
478     3.40036336968628
479 };
480
481 for (size_t i = 0; i < expected_wind_resource_vec_ms.size(); i++) {
482     testFloatEquals(
483         test_resources.resource_map_1D[wind_resource_key][i],
484         expected_wind_resource_vec_ms[i],
485         __FILE__,
486         __LINE__
487     );
488 }
489
490 // ======== END METHODS ============================================================ //
491
492 }   /* try */
493
494
495 catch (...) {
496     printGold(" ............................. ");
497     printRed("FAIL");
498     std::cout « std::endl;
499     throw;
500 }
501
502
503 printGold(" ............................. ");
504 printGreen("PASS");
505 std::cout « std::endl;
506 return 0;
507 }   /* main() */
```

5.45 test/utils/testing_utils.cpp File Reference

Header 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.

5.45.1 Detailed Description

Header file for various PGMcpp testing utilities.

This is a library of utility functions used throughout the various test suites.

5.45.2 Function Documentation

5.45.2.1 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__").

```
432 {
433     std::string error_str = "\n ERROR  failed to throw expected error prior to line ";
434     error_str += std::to_string(line);
```

```
435     error_str += " of ";
436     error_str += file;
437
438     #ifdef _WIN32
439         std::cout « error_str « std::endl;
440     #endif
441
442     throw std::runtime_error(error_str);
443     return;
444 }   /* expectedErrorNotDetected() */
```

5.45.2.2 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.

```
84 {
85     std::cout « "\x1B[33m" « input_str « "\033[0m";
86     return;
87 }   /* printGold() */
```

5.45.2.3 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.

```
64 {
65     std::cout « "\x1B[32m" « input_str « "\033[0m";
66     return;
67 }   /* printGreen() */
```

5.45.2.4 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.

```
104 {
105     std::cout « "\x1B[31m" « input_str « "\033[0m";
106     return;
107 }   /* printRed() */
```

5.45.2.5 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__").

```
138 {
139     if (fabs(x - y) <= FLOAT_TOLERANCE) {
140         return;
141     }
142 
143     std::string error_str = "ERROR: testFloatEquals():\t in ";
144     error_str += file;
145     error_str += "\tline ";
146     error_str += std::to_string(line);
147     error_str += ":\t\n";
148     error_str += std::to_string(x);
149     error_str += " and ";
150     error_str += std::to_string(y);
151     error_str += " are not equal to within +/- ";
152     error_str += std::to_string(FLOAT_TOLERANCE);
153     error_str += "\n";
154 
155     #ifdef _WIN32
156         std::cout « error_str « std::endl;
157     #endif
158 
159     throw std::runtime_error(error_str);
160     return;
161 }   /* testFloatEquals() */
```

5.45.2.6 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__").

```
191 {
192     if (x > y) {
193         return;
194     }
195
196     std::string error_str = "ERROR: testGreaterThan():\t in ";
197     error_str += file;
198     error_str += "\tline ";
199     error_str += std::to_string(line);
200     error_str += ":\t\n";
201     error_str += std::to_string(x);
202     error_str += " is not greater than ";
203     error_str += std::to_string(y);
204     error_str += "\n";
205
206     #ifdef _WIN32
207         std::cout « error_str « std::endl;
208     #endif
209
210     throw std::runtime_error(error_str);
211     return;
212 }   /* testGreaterThan() */
```

5.45.2.7 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__").

```
242 {
243     if (x >= y) {
244         return;
245     }
246
247     std::string error_str = "ERROR: testGreaterThanOrEqualTo():\t in ";
248     error_str += file;
249     error_str += "\tline ";
250     error_str += std::to_string(line);
251     error_str += ":\t\n";
252     error_str += std::to_string(x);
253     error_str += " is not greater than or equal to ";
254     error_str += std::to_string(y);
255     error_str += "\n";
256
257     #ifdef _WIN32
258         std::cout « error_str « std::endl;
259     #endif
260
261     throw std::runtime_error(error_str);
```

```
262     return;
263 }   /* testGreaterThanOrEqualTo() */
```

5.45.2.8 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__").

```
293 {
294     if (x < y) {
295         return;
296     }
297
298     std::string error_str = "ERROR: testLessThan():\t in ";
299     error_str += file;
300     error_str += "\tline ";
301     error_str += std::to_string(line);
302     error_str += ":\t\n";
303     error_str += std::to_string(x);
304     error_str += " is not less than ";
305     error_str += std::to_string(y);
306     error_str += "\n";
307
308     #ifdef _WIN32
309         std::cout « error_str « std::endl;
310     #endif
311
312     throw std::runtime_error(error_str);
313     return;
314 }   /* testLessThan() */
```

5.45.2.9 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__").

```
344 {
345     if (x <= y) {
346         return;
347     }
348 
349     std::string error_str = "ERROR: testLessThanOrEqualTo():\t in ";
350     error_str += file;
351     error_str += "\tline ";
352     error_str += std::to_string(line);
353     error_str += ":\t\n";
354     error_str += std::to_string(x);
355     error_str += " is not less than or equal to ";
356     error_str += std::to_string(y);
357     error_str += "\n";
358 
359     #ifdef _WIN32
360         std::cout « error_str « std::endl;
361     #endif
362 
363     throw std::runtime_error(error_str);
364     return;
365 }   /* testLessThanOrEqualTo() */
```

5.45.2.10 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__").

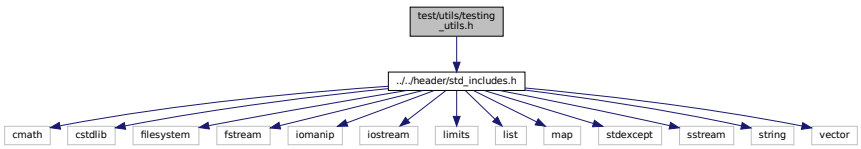
```
392 {
393     if (statement) {
394         return;
395     }
396 
397     std::string error_str = "ERROR: testTruth():\t in ";
398     error_str += file;
399     error_str += "\tline ";
400     error_str += std::to_string(line);
401     error_str += ":\t\n";
402     error_str += "Given statement is not true";
403 
404     #ifdef _WIN32
405         std::cout « error_str « std::endl;
406     #endif
407 
408     throw std::runtime_error(error_str);
409     return;
410 }   /* testTruth() */
```

5.46 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.

5.46.1 Detailed Description

Header file for various PGMcpp testing utilities.

This is a library of utility functions used throughout the various test suites.

5.46.2 Macro Definition Documentation

5.46.2.1 FLOAT_TOLERANCE

```
#define FLOAT_TOLERANCE 1e-6
```

A tolerance for application to floating point equality tests.

5.46.3 Function Documentation

5.46.3.1 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__").

```
432 {
433     std::string error_str = "\n ERROR  failed to throw expected error prior to line ";
434     error_str += std::to_string(line);
435     error_str += " of ";
436     error_str += file;
437 
438     #ifdef _WIN32
439         std::cout « error_str « std::endl;
440     #endif
441 
442     throw std::runtime_error(error_str);
443     return;
444 }   /* expectedErrorNotDetected() */
```

5.46.3.2 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.

```
84 {
85     std::cout « "\x1B[33m" « input_str « "\033[0m";
86     return;
87 }   /* printGold() */
```

5.46.3.3 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.

```
64 {
65     std::cout « "\x1B[32m" « input_str « "\033[0m";
66     return;
67 }   /* printGreen() */
```

5.46.3.4 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.

```
104 {
105     std::cout « "\x1B[31m" « input_str « "\033[0m";
106     return;
107 }   /* printRed() */
```

5.46.3.5 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.

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__").

```
138 {
139     if (fabs(x - y) <= FLOAT_TOLERANCE) {
140         return;
141     }
142 
143     std::string error_str = "ERROR: testFloatEquals():\t in ";
144     error_str += file;
145     error_str += "\tline ";
146     error_str += std::to_string(line);
147     error_str += ":\t\n";
148     error_str += std::to_string(x);
149     error_str += " and ";
150     error_str += std::to_string(y);
151     error_str += " are not equal to within +/- ";
152     error_str += std::to_string(FLOAT_TOLERANCE);
153     error_str += "\n";
154 
155     #ifdef _WIN32
156         std::cout << error_str << std::endl;
157     #endif
158 
159     throw std::runtime_error(error_str);
160     return;
161 }   /* testFloatEquals() */
```

5.46.3.6 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__").

```
191 {
192     if (x > y) {
193         return;
194     }
195 
196     std::string error_str = "ERROR: testGreaterThan():\t in ";
197     error_str += file;
198     error_str += "\tline ";
199     error_str += std::to_string(line);
200     error_str += ":\t\n";
201     error_str += std::to_string(x);
202     error_str += " is not greater than ";
203     error_str += std::to_string(y);
204     error_str += "\n";
205 
206     #ifdef _WIN32
207         std::cout << error_str << std::endl;
208     #endif
209 
```

```
210     throw std::runtime_error(error_str);
211     return;
212 }   /* testGreaterThan() */
```

5.46.3.7 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__").

```
242 {
243     if (x >= y) {
244         return;
245     }
246 
247     std::string error_str = "ERROR: testGreaterThanOrEqualTo():\t in ";
248     error_str += file;
249     error_str += "\tline ";
250     error_str += std::to_string(line);
251     error_str += ":\t\n";
252     error_str += std::to_string(x);
253     error_str += " is not greater than or equal to ";
254     error_str += std::to_string(y);
255     error_str += "\n";
256 
257     #ifdef _WIN32
258         std::cout << error_str << std::endl;
259     #endif
260 
261     throw std::runtime_error(error_str);
262     return;
263 }   /* testGreaterThanOrEqualTo() */
```

5.46.3.8 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.
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__").

```
293 {
294     if (x < y) {
295         return;
296     }
297 
298     std::string error_str = "ERROR: testLessThan():\t in ";
299     error_str += file;
300     error_str += "\tline ";
301     error_str += std::to_string(line);
302     error_str += ":\t\n";
303     error_str += std::to_string(x);
304     error_str += " is not less than ";
305     error_str += std::to_string(y);
306     error_str += "\n";
307 
308     #ifdef _WIN32
309         std::cout « error_str « std::endl;
310     #endif
311 
312     throw std::runtime_error(error_str);
313     return;
314 }   /* testLessThan() */
```

5.46.3.9 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__").

```
344 {
345     if (x <= y) {
346         return;
347     }
348 
349     std::string error_str = "ERROR: testLessThanOrEqualTo():\t in ";
350     error_str += file;
351     error_str += "\tline ";
352     error_str += std::to_string(line);
353     error_str += ":\t\n";
354     error_str += std::to_string(x);
355     error_str += " is not less than or equal to ";
356     error_str += std::to_string(y);
357     error_str += "\n";
358 
359     #ifdef _WIN32
360         std::cout « error_str « std::endl;
361     #endif
362 
363     throw std::runtime_error(error_str);
364     return;
365 }   /* testLessThanOrEqualTo() */
```

5.46.3.10 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__").

```
392 {
393     if (statement) {
394         return;
395     }
396
397     std::string error_str = "ERROR: testTruth():\t in ";
398     error_str += file;
399     error_str += "\tline ";
400     error_str += std::to_string(line);
401     error_str += ":\t\n";
402     error_str += "Given statement is not true";
403
404     #ifdef _WIN32
405         std::cout « error_str « std::endl;
406     #endif
407
408     throw std::runtime_error(error_str);
409     return;
410 }   /* testTruth() */
```

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