

PGMcpp: PRIMED Grid Modelling (in C++)

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# Chapter 1

## Hierarchical Index

### 1.1 Class Hierarchy

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## Chapter 2

# Class Index

### 2.1 Class List

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

<a href="#">Combustion</a>	The root of the <a href="#">Combustion</a> branch of the <a href="#">Production</a> hierarchy. This branch contains derived classes which model the production of energy by way of combustibles . . . . .	9
<a href="#">CombustionInputs</a>	A structure which bundles the necessary inputs for the <a href="#">Combustion</a> constructor. Provides default values for every necessary input. Note that this structure encapsulates <a href="#">ProductionInputs</a> . . .	24
<a href="#">Controller</a>	A class which contains a various dispatch control logic. Intended to serve as a component class of <a href="#">Model</a> . . . . .	25
<a href="#">Diesel</a>	A derived class of the <a href="#">Combustion</a> branch of <a href="#">Production</a> which models production using a diesel generator . . . . .	45
<a href="#">DieselInputs</a>	A structure which bundles the necessary inputs for the <a href="#">Diesel</a> constructor. Provides default values for every necessary input. Note that this structure encapsulates <a href="#">CombustionInputs</a> . . .	58
<a href="#">ElectricalLoad</a>	A class which contains time and electrical load data. Intended to serve as a component class of <a href="#">Model</a> . . . . .	62
<a href="#">Emissions</a>	A structure which bundles the emitted masses of various emissions chemistries . . . . .	67
<a href="#">Hydro</a>	A derived class of the <a href="#">Noncombustion</a> branch of <a href="#">Production</a> which models production using a hydroelectric asset (either with reservoir or not) . . . . .	69
<a href="#">HydroInputs</a>	A structure which bundles the necessary inputs for the <a href="#">Hydro</a> constructor. Provides default values for every necessary input. Note that this structure encapsulates <a href="#">NoncombustionInputs</a> . . . . .	88
<a href="#">Interpolator</a>	A class which contains interpolation data and functionality. Intended to serve as a component of the <a href="#">Production</a> and <a href="#">Storage</a> hierarchies . . . . .	91
<a href="#">InterpolatorStruct1D</a>	A struct which holds two parallel vectors for use in 1D interpolation . . . . .	104
<a href="#">InterpolatorStruct2D</a>	A struct which holds two parallel vectors and a matrix for use in 2D interpolation . . . . .	106
<a href="#">Lilon</a>	A derived class of <a href="#">Storage</a> which models energy storage by way of lithium-ion batteries . . . . .	109

<a href="#">LilonInputs</a>	A structure which bundles the necessary inputs for the <a href="#">Lilon</a> constructor. Provides default values for every necessary input. Note that this structure encapsulates <a href="#">StorageInputs</a> . . . . .	128
<a href="#">Model</a>	A container class which forms the centre of PGMcpp. The <a href="#">Model</a> class is intended to serve as the primary user interface with the functionality of PGMcpp, and as such it contains all other classes . . . . .	133
<a href="#">ModelInputs</a>	A structure which bundles the necessary inputs for the <a href="#">Model</a> constructor. Provides default values for every necessary input (except <code>path_2_electrical_load_time_series</code> , for which a valid input must be provided) . . . . .	152
<a href="#">Noncombustion</a>	The root of the <a href="#">Noncombustion</a> branch of the <a href="#">Production</a> hierarchy. This branch contains derived classes which model controllable production which is not based on combustion . . . . .	153
<a href="#">NoncombustionInputs</a>	A structure which bundles the necessary inputs for the <a href="#">Noncombustion</a> constructor. Provides default values for every necessary input. Note that this structure encapsulates <a href="#">ProductionInputs</a> . . . . .	161
<a href="#">Production</a>	The base class of the <a href="#">Production</a> hierarchy. This hierarchy contains derived classes which model the production of energy, be it renewable or otherwise . . . . .	162
<a href="#">ProductionInputs</a>	A structure which bundles the necessary inputs for the <a href="#">Production</a> constructor. Provides default values for every necessary input . . . . .	175
<a href="#">Renewable</a>	The root of the <a href="#">Renewable</a> branch of the <a href="#">Production</a> hierarchy. This branch contains derived classes which model the renewable production of energy . . . . .	177
<a href="#">RenewableInputs</a>	A structure which bundles the necessary inputs for the <a href="#">Renewable</a> constructor. Provides default values for every necessary input. Note that this structure encapsulates <a href="#">ProductionInputs</a> . . . . .	185
<a href="#">Resources</a>	A class which contains renewable resource data. Intended to serve as a component class of <a href="#">Model</a> . . . . .	186
<a href="#">Solar</a>	A derived class of the <a href="#">Renewable</a> branch of <a href="#">Production</a> which models solar production . . . . .	200
<a href="#">SolarInputs</a>	A structure which bundles the necessary inputs for the <a href="#">Solar</a> constructor. Provides default values for every necessary input. Note that this structure encapsulates <a href="#">RenewableInputs</a> . . . . .	208
<a href="#">Storage</a>	The base class of the <a href="#">Storage</a> hierarchy. This hierarchy contains derived classes which model the storage of energy . . . . .	210
<a href="#">StorageInputs</a>	A structure which bundles the necessary inputs for the <a href="#">Storage</a> constructor. Provides default values for every necessary input . . . . .	224
<a href="#">Tidal</a>	A derived class of the <a href="#">Renewable</a> branch of <a href="#">Production</a> which models tidal production . . . . .	226
<a href="#">TidalInputs</a>	A structure which bundles the necessary inputs for the <a href="#">Tidal</a> constructor. Provides default values for every necessary input. Note that this structure encapsulates <a href="#">RenewableInputs</a> . . . . .	237
<a href="#">Wave</a>	A derived class of the <a href="#">Renewable</a> branch of <a href="#">Production</a> which models wave production . . . . .	240
<a href="#">WaveInputs</a>	A structure which bundles the necessary inputs for the <a href="#">Wave</a> constructor. Provides default values for every necessary input. Note that this structure encapsulates <a href="#">RenewableInputs</a> . . . . .	253
<a href="#">Wind</a>	A derived class of the <a href="#">Renewable</a> branch of <a href="#">Production</a> which models wind production . . . . .	256
<a href="#">WindInputs</a>	A structure which bundles the necessary inputs for the <a href="#">Wind</a> constructor. Provides default values for every necessary input. Note that this structure encapsulates <a href="#">RenewableInputs</a> . . . . .	268

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## Chapter 4

# Class Documentation

### 4.1 Combustion Class Reference

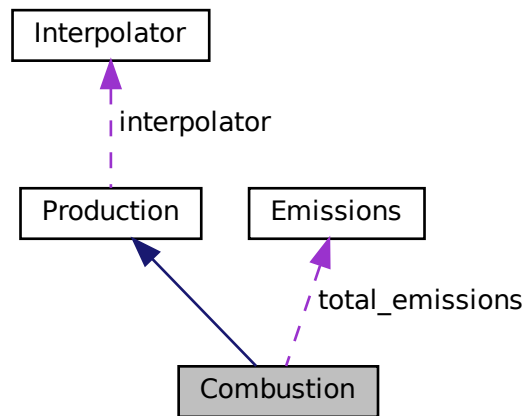
The root of the [Combustion](#) branch of the [Production](#) hierarchy. This branch contains derived classes which model the production of energy by way of combustibles.

```
#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.*
- virtual void [handleReplacement](#) (int)  
*Method to handle asset replacement and capital cost incursion, if applicable.*
- void [computeFuelAndEmissions](#) (void)  
*Helper method to compute the total fuel consumption and emissions over the [Model](#) run.*
- void [computeEconomics](#) (std::vector< double > \*)  
*Helper method to compute key economic metrics for the [Model](#) run.*
- virtual double [requestProductionkW](#) (int, double, double)
- virtual double [commit](#) (int, double, double, double)  
*Method which takes in production and load for the current timestep, computes and records dispatch and curtailment, and then returns remaining load.*
- double [getFuelConsumptionL](#) (double, double)  
*Method which takes in production and returns volume of fuel burned over the given interval of time.*
- [Emissions](#) [getEmissionskg](#) (double)  
*Method which takes in volume of fuel consumed and returns mass spectrum of resulting emissions.*
- void [writeResults](#) (std::string, std::vector< double > \*, int, int=-1)  
*Method which writes [Combustion](#) results to an output directory.*
- virtual [~Combustion](#) (void)  
*Destructor for the [Combustion](#) class.*



## Public Attributes

- [CombustionType](#) type  
*The type (CombustionType) of the asset.*
- [FuelMode](#) fuel\_mode  
*The fuel mode to use in modelling fuel consumption.*
- [Emissions](#) total\_emissions  
*An [Emissions](#) structure for holding total emissions [kg].*
- double [fuel\\_cost\\_L](#)  
*The cost of fuel [1/L] (undefined currency).*
- double [nominal\\_fuel\\_escalation\\_annual](#)  
*The nominal, annual fuel escalation rate to use in computing model economics.*
- double [real\\_fuel\\_escalation\\_annual](#)  
*The real, annual fuel escalation rate used in computing model economics. Is computed from the given nominal inflation and discount rates.*
- double [linear\\_fuel\\_slope\\_LkWh](#)  
*The slope [L/kWh] to use in computing linearized fuel consumption. This is fuel consumption per unit energy produced.*
- double [linear\\_fuel\\_intercept\\_LkWh](#)  
*The intercept [L/kWh] to use in computing linearized fuel consumption. This is fuel consumption per unit energy produced.*
- double [CO2\\_emissions\\_intensity\\_kgL](#)  
*Carbon dioxide (CO2) emissions intensity [kg/L].*
- double [CO\\_emissions\\_intensity\\_kgL](#)  
*Carbon monoxide (CO) emissions intensity [kg/L].*
- double [NOx\\_emissions\\_intensity\\_kgL](#)  
*Nitrogen oxide (NOx) emissions intensity [kg/L].*
- double [SOx\\_emissions\\_intensity\\_kgL](#)  
*Sulfur oxide (SOx) emissions intensity [kg/L].*
- double [CH4\\_emissions\\_intensity\\_kgL](#)  
*Methane (CH4) emissions intensity [kg/L].*
- double [PM\\_emissions\\_intensity\\_kgL](#)  
*Particulate Matter (PM) emissions intensity [kg/L].*
- double [total\\_fuel\\_consumed\\_L](#)  
*The total fuel consumed [L] over a model run.*
- std::string [fuel\\_mode\\_str](#)  
*A string describing the fuel mode of the asset.*
- std::vector< double > [fuel\\_consumption\\_vec\\_L](#)  
*A vector of fuel consumed [L] over each modelling time step.*
- std::vector< double > [fuel\\_cost\\_vec](#)  
*A vector of fuel costs (undefined currency) incurred over each modelling time step. These costs are not discounted (i.e., these are actual costs).*
- std::vector< double > [CO2\\_emissions\\_vec\\_kg](#)  
*A vector of carbon dioxide (CO2) emitted [kg] over each modelling time step.*
- std::vector< double > [CO\\_emissions\\_vec\\_kg](#)  
*A vector of carbon monoxide (CO) emitted [kg] over each modelling time step.*
- std::vector< double > [NOx\\_emissions\\_vec\\_kg](#)  
*A vector of nitrogen oxide (NOx) emitted [kg] over each modelling time step.*
- std::vector< double > [SOx\\_emissions\\_vec\\_kg](#)  
*A vector of sulfur oxide (SOx) emitted [kg] over each modelling time step.*
- std::vector< double > [CH4\\_emissions\\_vec\\_kg](#)  
*A vector of methane (CH4) emitted [kg] over each modelling time step.*
- std::vector< double > [PM\\_emissions\\_vec\\_kg](#)  
*A vector of particulate matter (PM) emitted [kg] over each modelling time step.*

## Private Member Functions

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

### 4.1.1 Detailed Description

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

### 4.1.2 Constructor & Destructor Documentation

#### 4.1.2.1 `Combustion()` [1/2]

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

Constructor (dummy) for the `Combustion` class.

```
77 {
78     return;
79 } /* 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

<code>n_points</code>	The number of points in the modelling time series.
<code>n_years</code>	The number of years being modelled.
<code>combustion_inputs</code>	A structure of <code>Combustion</code> constructor inputs.

```
107 :
108 Production(
109     n_points,
110     n_years,
111     combustion_inputs.production_inputs
112 )
113 {
114     // 1. check inputs
115     this->__checkInputs(combustion_inputs);
116 }
```

```

117 // 2. set attributes
118 this->fuel_mode = combustion_inputs.fuel_mode;
119
120 switch (this->fuel_mode) {
121     case (FuelMode :: FUEL_MODE_LINEAR): {
122         this->fuel_mode_str = "FUEL_MODE_LINEAR";
123
124         break;
125     }
126
127     case (FuelMode :: FUEL_MODE_LOOKUP): {
128         this->fuel_mode_str = "FUEL_MODE_LOOKUP";
129
130         this->interpolator.addData1D(
131             0,
132             combustion_inputs.path_2_fuel_interp_data
133         );
134
135         break;
136     }
137
138     default: {
139         std::string error_str = "ERROR: Combustion(): ";
140         error_str += "fuel mode ";
141         error_str += std::to_string(this->fuel_mode);
142         error_str += " not recognized";
143
144         #ifdef _WIN32
145             std::cout << error_str << std::endl;
146         #endif
147
148         throw std::runtime_error(error_str);
149
150         break;
151     }
152 }
153
154 this->fuel_cost_L = 0;
155 this->nominal_fuel_escalation_annual =
156     combustion_inputs.nominal_fuel_escalation_annual;
157
158 this->real_fuel_escalation_annual = this->computeRealDiscountAnnual(
159     combustion_inputs.nominal_fuel_escalation_annual,
160     combustion_inputs.production_inputs.nominal_discount_annual
161 );
162
163 this->linear_fuel_slope_LkWh = 0;
164 this->linear_fuel_intercept_LkWh = 0;
165
166 this->CO2_emissions_intensity_kgL = 0;
167 this->CO_emissions_intensity_kgL = 0;
168 this->NOx_emissions_intensity_kgL = 0;
169 this->SOx_emissions_intensity_kgL = 0;
170 this->CH4_emissions_intensity_kgL = 0;
171 this->PM_emissions_intensity_kgL = 0;
172
173 this->total_fuel_consumed_L = 0;
174
175 this->fuel_consumption_vec_L.resize(this->n_points, 0);
176 this->fuel_cost_vec.resize(this->n_points, 0);
177
178 this->CO2_emissions_vec_kg.resize(this->n_points, 0);
179 this->CO_emissions_vec_kg.resize(this->n_points, 0);
180 this->NOx_emissions_vec_kg.resize(this->n_points, 0);
181 this->SOx_emissions_vec_kg.resize(this->n_points, 0);
182 this->CH4_emissions_vec_kg.resize(this->n_points, 0);
183 this->PM_emissions_vec_kg.resize(this->n_points, 0);
184
185 // 3. construction print
186 if (this->print_flag) {
187     std::cout << "Combustion object constructed at " << this << std::endl;
188 }
189
190 return;
191 } /* Combustion() */

```

#### 4.1.2.3 ~Combustion()

```

Combustion::~Combustion (
    void ) [virtual]

```

Destructor for the [Combustion](#) class.

```

529 {
530     // 1. destruction print
531     if (this->print_flag) {
532         std::cout << "Combustion object at " << this << " destroyed" << std::endl;
533     }
534     return;
535 }
536 } /* ~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

<i>combustion_inputs</i>	A structure of <a href="#">Combustion</a> constructor inputs.
--------------------------	---

```

40 {
41     // 1. if FUEL_MODE_LOOKUP, check that path is given
42     if (
43         combustion_inputs.fuel_mode == FuelMode :: FUEL_MODE_LOOKUP and
44         combustion_inputs.path_2_fuel_interp_data.empty()
45     ) {
46         std::string error_str = "ERROR: Combustion() fuel mode was set to ";
47         error_str += "FuelMode::FUEL_MODE_LOOKUP, but no path to fuel interpolation ";
48         error_str += "data was given";
49
50         #ifdef _WIN32
51             std::cout << error_str << std::endl;
52         #endif
53
54         throw std::invalid_argument(error_str);
55     }
56
57     return;
58 } /* __checkInputs() */

```

### 4.1.3.2 \_\_writeSummary()

```

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

```

Reimplemented in [Diesel](#).

```

105 {return;}

```

#### 4.1.3.3 \_\_writeTimeSeries()

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

Reimplemented in [Diesel](#).

```
110         {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

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

```
321 {
322     // 1. invoke base class method
323     load_kW = Production::commit(
324         timestep,
325         dt_hrs,
326         production_kW,
327         load_kW
328     );
329
330
331     if (this->is_running) {
332         // 2. compute and record fuel consumption
333         double fuel_consumed_L = this->getFuelConsumptionL(dt_hrs, production_kW);
334         this->fuel_consumption_vec_L[timestep] = fuel_consumed_L;
335
336         // 3. compute and record emissions
337         Emissions emissions = this->getEmissionskg(fuel_consumed_L);
338         this->CO2_emissions_vec_kg[timestep] = emissions.CO2_kg;
339         this->CO_emissions_vec_kg[timestep] = emissions.CO_kg;
340         this->NOx_emissions_vec_kg[timestep] = emissions.NOx_kg;
341         this->SOx_emissions_vec_kg[timestep] = emissions.SOx_kg;
342         this->CH4_emissions_vec_kg[timestep] = emissions.CH4_kg;
343         this->PM_emissions_vec_kg[timestep] = emissions.PM_kg;
344
345         // 4. incur fuel costs

```

```

346         this->fuel_cost_vec[timestep] = fuel_consumed_L * this->fuel_cost_L;
347     }
348
349     return load_kW;
350 } /* commit() */

```

#### 4.1.3.5 computeEconomics()

```

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

```

Helper method to compute key economic metrics for the [Model](#) run.

Ref: [HOMER \[2023b\]](#)

##### Parameters

<i>time_vec_hrs_ptr</i>	A pointer to the time_vec_hrs attribute of the <a href="#">ElectricalLoad</a> .
-------------------------	---

Reimplemented from [Production](#).

```

265 {
266     // 1. account for fuel costs in net present cost
267     double t_hrs = 0;
268     double real_fuel_escalation_scalar = 0;
269
270     for (int i = 0; i < this->n_points; i++) {
271         t_hrs = time_vec_hrs_ptr->at(i);
272
273         real_fuel_escalation_scalar = 1.0 / pow(
274             1 + this->real_fuel_escalation_annual,
275             t_hrs / 8760
276         );
277
278         this->net_present_cost += real_fuel_escalation_scalar * this->fuel_cost_vec[i];
279     }
280
281     // 2. invoke base class method
282     Production::computeEconomics(time_vec_hrs_ptr);
283
284     return;
285 } /* computeEconomics() */

```

#### 4.1.3.6 computeFuelAndEmissions()

```

void Combustion::computeFuelAndEmissions (
    void )

```

Helper method to compute the total fuel consumption and emissions over the [Model](#) run.

```

233 {
234     for (int i = 0; i < n_points; i++) {
235         this->total_fuel_consumed_L += this->fuel_consumption_vec_L[i];
236
237         this->total_emissions.CO2_kg += this->CO2_emissions_vec_kg[i];
238         this->total_emissions.CO_kg += this->CO_emissions_vec_kg[i];
239         this->total_emissions.NOx_kg += this->NOx_emissions_vec_kg[i];
240         this->total_emissions.SOx_kg += this->SOx_emissions_vec_kg[i];
241         this->total_emissions.CH4_kg += this->CH4_emissions_vec_kg[i];
242         this->total_emissions.PM_kg += this->PM_emissions_vec_kg[i];
243     }
244
245     return;
246 } /* 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

<i>fuel_consumed_L</i>	The volume of fuel consumed [L].
------------------------	----------------------------------

## Returns

A structure containing the mass spectrum of resulting emissions.

```
429                                     {
430     Emissions emissions;
431
432     emissions.CO2_kg = this->CO2_emissions_intensity_kgL * fuel_consumed_L;
433     emissions.CO_kg = this->CO_emissions_intensity_kgL * fuel_consumed_L;
434     emissions.NOx_kg = this->NOx_emissions_intensity_kgL * fuel_consumed_L;
435     emissions.SOx_kg = this->SOx_emissions_intensity_kgL * fuel_consumed_L;
436     emissions.CH4_kg = this->CH4_emissions_intensity_kgL * fuel_consumed_L;
437     emissions.PM_kg = this->PM_emissions_intensity_kgL * fuel_consumed_L;
438
439     return emissions;
440 } /* 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

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

## Returns

The volume of fuel consumed [L].

```
372 {
373     double fuel_consumed_L = 0;
374
375     switch (this->fuel_mode) {
376     case (FuelMode :: FUEL_MODE_LINEAR): {
377         fuel_consumed_L = (
378             this->linear_fuel_slope_LkWh * production_kW +
379             this->linear_fuel_intercept_LkWh * this->capacity_kW
380         ) * dt_hrs;
381
382         break;
383     }
384
385     case (FuelMode :: FUEL_MODE_LOOKUP): {
```

```

386         double load_ratio = production_kW / this->capacity_kW;
387
388         fuel_consumed_L = this->interpolator.interp1D(0, load_ratio) * dt_hrs;
389
390         break;
391     }
392
393     default: {
394         std::string error_str = "ERROR: Combustion::getFuelConsumptionL(): ";
395         error_str += "fuel mode ";
396         error_str += std::to_string(this->fuel_mode);
397         error_str += " not recognized";
398
399         #ifdef _WIN32
400             std::cout << error_str << std::endl;
401         #endif
402
403         throw std::runtime_error(error_str);
404
405         break;
406     }
407 }
408
409 return fuel_consumed_L;
410 } /* getFuelConsumptionL() */

```

#### 4.1.3.9 handleReplacement()

```

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

```

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

##### Parameters

<i>timestep</i>	The current time step of the <a href="#">Model</a> run.
-----------------	---

Reimplemented from [Production](#).

Reimplemented in [Diesel](#).

```

209 {
210     // 1. reset attributes
211     //...
212
213     // 2. invoke base class method
214     Production::handleReplacement(timestep);
215
216     return;
217 } /* __handleReplacement() */

```

#### 4.1.3.10 requestProductionkW()

```

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

```

Reimplemented in [Diesel](#).

```

156 {return 0;}

```



#### 4.1.3.11 writeResults()

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

Method which writes [Combustion](#) results to an output directory.

##### Parameters

<i>write_path</i>	A path (either relative or absolute) to the directory location where results are to be written. If already exists, will overwrite.
<i>time_vec_hrs_ptr</i>	A pointer to the <code>time_vec_hrs</code> attribute of the <a href="#">ElectricalLoad</a> .
<i>combustion_index</i>	An integer which corresponds to the index of the <a href="#">Combustion</a> asset in the <a href="#">Model</a> .
<i>max_lines</i>	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.

```
476 {
477     // 1. handle sentinel
478     if (max_lines < 0) {
479         max_lines = this->n_points;
480     }
481
482     // 2. create subdirectories
483     write_path += "Production/";
484     if (not std::filesystem::is_directory(write_path)) {
485         std::filesystem::create_directory(write_path);
486     }
487
488     write_path += "Combustion/";
489     if (not std::filesystem::is_directory(write_path)) {
490         std::filesystem::create_directory(write_path);
491     }
492
493     write_path += this->type_str;
494     write_path += "_";
495     write_path += std::to_string(int(ceil(this->capacity_kW)));
496     write_path += "kW_idx";
497     write_path += std::to_string(combustion_index);
498     write_path += "/";
499     std::filesystem::create_directory(write_path);
500
501     // 3. write summary
502     this->__writeSummary(write_path);
503
504     // 4. write time series
505     if (max_lines > this->n_points) {
506         max_lines = this->n_points;
507     }
508
509     if (max_lines > 0) {
510         this->__writeTimeSeries(write_path, time_vec_hrs_ptr, max_lines);
511     }
512
513     return;
514 } /* 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 actual costs).

#### 4.1.4.10 fuel\_mode

```
FuelMode Combustion::fuel_mode
```

The fuel mode to use in modelling fuel consumption.

#### 4.1.4.11 fuel\_mode\_str

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

A string describing the fuel mode of the asset.

#### 4.1.4.12 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.

#### 4.1.4.13 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.

#### 4.1.4.14 nominal\_fuel\_escalation\_annual

```
double Combustion::nominal_fuel_escalation_annual
```

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

#### 4.1.4.15 NOx\_emissions\_intensity\_kgL

```
double Combustion::NOx_emissions_intensity_kgL
```

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

#### 4.1.4.16 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.

#### 4.1.4.17 PM\_emissions\_intensity\_kgL

```
double Combustion::PM_emissions_intensity_kgL
```

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

#### 4.1.4.18 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.

#### 4.1.4.19 real\_fuel\_escalation\_annual

```
double Combustion::real_fuel_escalation_annual
```

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

#### 4.1.4.20 SOx\_emissions\_intensity\_kgL

```
double Combustion::SOx_emissions_intensity_kgL
```

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

#### 4.1.4.21 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.

#### 4.1.4.22 total\_emissions

```
Emissions Combustion::total_emissions
```

An [Emissions](#) structure for holding total emissions [kg].

#### 4.1.4.23 total\_fuel\_consumed\_L

```
double Combustion::total_fuel_consumed_L
```

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

#### 4.1.4.24 type

```
CombustionType Combustion::type
```

The type (CombustionType) of the asset.

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

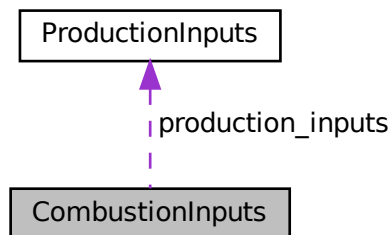
- [header/Production/Combustion/Combustion.h](#)
- [source/Production/Combustion/Combustion.cpp](#)

## 4.2 CombustionInputs Struct Reference

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

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

Collaboration diagram for CombustionInputs:



### Public Attributes

- [ProductionInputs](#) `production_inputs`  
*An encapsulated [ProductionInputs](#) instance.*
- [FuelMode](#) `fuel_mode = FuelMode :: FUEL_MODE_LINEAR`  
*The fuel mode to use in modelling fuel consumption.*
- `double nominal_fuel_escalation_annual = 0.05`  
*The nominal, annual fuel escalation rate to use in computing model economics.*
- `std::string path_2_fuel_interp_data = ""`  
*A path (either relative or absolute) to a set of fuel consumption data.*

### 4.2.1 Detailed Description

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

### 4.2.2 Member Data Documentation

#### 4.2.2.1 fuel\_mode

```
FuelMode CombustionInputs::fuel_mode = FuelMode :: FUEL\_MODE\_LINEAR
```

The fuel mode to use in modelling fuel consumption.

#### 4.2.2.2 nominal\_fuel\_escalation\_annual

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

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

#### 4.2.2.3 path\_2\_fuel\_interp\_data

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

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

#### 4.2.2.4 production\_inputs

```
ProductionInputs CombustionInputs::production_inputs
```

An encapsulated [ProductionInputs](#) instance.

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

- header/Production/Combustion/[Combustion.h](#)

## 4.3 Controller Class Reference

A class which contains a various dispatch control logic. Intended to serve as a component class of [Model](#).

```
#include <Controller.h>
```

### Public Member Functions

- [Controller](#) (void)  
*Constructor for the [Controller](#) class.*
- void [setControlMode](#) ([ControlMode](#))
- void [init](#) ([ElectricalLoad](#) \*, std::vector< [Renewable](#) \* > \*, [Resources](#) \*, std::vector< [Combustion](#) \* > \*)  
*Method to initialize the [Controller](#) component of the [Model](#).*
- void [applyDispatchControl](#) ([ElectricalLoad](#) \*, [Resources](#) \*, std::vector< [Combustion](#) \* > \*, std::vector< [Noncombustion](#) \* > \*, std::vector< [Renewable](#) \* > \*, std::vector< [Storage](#) \* > \*)  
*Method to apply dispatch control at every point in the modelling time series.*
- void [clear](#) (void)  
*Method to clear all attributes of the [Controller](#) object.*
- [~Controller](#) (void)  
*Destructor for the [Controller](#) class.*

## Public Attributes

- [ControlMode](#) `control_mode`  
The *ControlMode* that is active in the *Model*.
- `std::string` `control_string`  
A string describing the active *ControlMode*.
- `std::vector< double >` `net_load_vec_kW`  
A vector of net load values [kW] at each point in the modelling time series. Net load is defined as load minus all available *Renewable* production.
- `std::vector< double >` `missed_load_vec_kW`  
A vector of missed load values [kW] at each point in the modelling time series.
- `std::map< double, std::vector< bool > >` `combustion_map`  
A map of all possible combustion states, for use in determining optimal dispatch.

## Private Member Functions

- `void` `__computeNetLoad` (*ElectricalLoad* \*, `std::vector< Renewable * >` \*, *Resources* \*)  
Helper method to compute and populate the net load vector.
- `void` `__constructCombustionMap` (`std::vector< Combustion * >` \*)  
Helper method to construct a *Combustion* map, for use in determining.
- `void` `__applyLoadFollowingControl_CHARGING` (int, *ElectricalLoad* \*, *Resources* \*, `std::vector< Combustion * >` \*, `std::vector< Noncombustion * >` \*, `std::vector< Renewable * >` \*, `std::vector< Storage * >` \*)  
Helper method to apply load following control action for given timestep of the *Model* run when net load  $\leq 0$ .
- `void` `__applyLoadFollowingControl_DISCHARGING` (int, *ElectricalLoad* \*, *Resources* \*, `std::vector< Combustion * >` \*, `std::vector< Noncombustion * >` \*, `std::vector< Renewable * >` \*, `std::vector< Storage * >` \*)  
Helper method to apply load following control action for given timestep of the *Model* run when net load  $> 0$ .
- `void` `__applyCycleChargingControl_CHARGING` (int, *ElectricalLoad* \*, *Resources* \*, `std::vector< Combustion * >` \*, `std::vector< Noncombustion * >` \*, `std::vector< Renewable * >` \*, `std::vector< Storage * >` \*)  
Helper method to apply cycle charging control action for given timestep of the *Model* run when net load  $\leq 0$ . Simply defaults to load following control.
- `void` `__applyCycleChargingControl_DISCHARGING` (int, *ElectricalLoad* \*, *Resources* \*, `std::vector< Combustion * >` \*, `std::vector< Noncombustion * >` \*, `std::vector< Renewable * >` \*, `std::vector< Storage * >` \*)  
Helper method to apply cycle charging control action for given timestep of the *Model* run when net load  $> 0$ . Defaults to load following control if no depleted storage assets.
- `void` `__handleStorageCharging` (int, double, `std::list< Storage * >` \*, `std::vector< Combustion * >` \*, `std::vector< Noncombustion * >` \*, `std::vector< Renewable * >` \*)  
Helper method to handle the charging of the given *Storage* assets.
- `void` `__handleStorageCharging` (int, double, `std::vector< Storage * >` \*, `std::vector< Combustion * >` \*, `std::vector< Noncombustion * >` \*, `std::vector< Renewable * >` \*)  
Helper method to handle the charging of the given *Storage* assets.
- `double` `__getRenewableProduction` (int, double, *Renewable* \*, *Resources* \*)  
Helper method to compute the production from the given *Renewable* asset at the given point in time.
- `double` `__handleCombustionDispatch` (int, double, double, `std::vector< Combustion * >` \*, bool)  
*bool is\_cycle\_charging* )
- `double` `__handleNoncombustionDispatch` (int, double, double, `std::vector< Noncombustion * >` \*, *Resources* \*)
- `double` `__handleStorageDischarging` (int, double, double, `std::list< Storage * >` \*)  
Helper method to handle the discharging of the given *Storage* assets.



### 4.3.1 Detailed Description

A class which contains a various dispatch control logic. Intended to serve as a component class of [Model](#).

### 4.3.2 Constructor & Destructor Documentation

#### 4.3.2.1 Controller()

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

Constructor for the [Controller](#) class.

```
1209 {
1210     return;
1211 } /* Controller() */
```

#### 4.3.2.2 ~Controller()

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

Destructor for the [Controller](#) class.

```
1455 {
1456     this->clear();
1457
1458     return;
1459 } /* ~Controller() */
```

### 4.3.3 Member Function Documentation

#### 4.3.3.1 \_\_applyCycleChargingControl\_CHARGING()

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

Helper method to apply cycle charging control action for given timestep of the [Model](#) run when net load  $\leq 0$ . Simply defaults to load following control.

## Parameters

<i>timestep</i>	The current time step of the <a href="#">Model</a> run.
<i>electrical_load_ptr</i>	A pointer to the <a href="#">ElectricalLoad</a> component of the <a href="#">Model</a> .
<i>resources_ptr</i>	A pointer to the <a href="#">Resources</a> component of the <a href="#">Model</a> .
<i>combustion_ptr_vec_ptr</i>	A pointer to the <a href="#">Combustion</a> pointer vector of the <a href="#">Model</a> .
<i>noncombustion_ptr_vec_ptr</i>	A pointer to the <a href="#">Noncombustion</a> pointer vector of the <a href="#">Model</a> .
<i>renewable_ptr_vec_ptr</i>	A pointer to the <a href="#">Renewable</a> pointer vector of the <a href="#">Model</a> .
<i>storage_ptr_vec_ptr</i>	A pointer to the <a href="#">Storage</a> pointer vector of the <a href="#">Model</a> .

```

450 {
451     // 1. default to load following
452     this->__applyLoadFollowingControl_CHARGING(
453         timestep,
454         electrical_load_ptr,
455         resources_ptr,
456         combustion_ptr_vec_ptr,
457         noncombustion_ptr_vec_ptr,
458         renewable_ptr_vec_ptr,
459         storage_ptr_vec_ptr
460     );
461
462     return;
463 } /* __applyCycleChargingControl_CHARGING() */

```

## 4.3.3.2 \_\_applyCycleChargingControl\_DISCHARGING()

```

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

```

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

## Parameters

<i>timestep</i>	The current time step of the <a href="#">Model</a> run.
<i>electrical_load_ptr</i>	A pointer to the <a href="#">ElectricalLoad</a> component of the <a href="#">Model</a> .
<i>resources_ptr</i>	A pointer to the <a href="#">Resources</a> component of the <a href="#">Model</a> .
<i>combustion_ptr_vec_ptr</i>	A pointer to the <a href="#">Combustion</a> pointer vector of the <a href="#">Model</a> .
<i>noncombustion_ptr_vec_ptr</i>	A pointer to the <a href="#">Noncombustion</a> pointer vector of the <a href="#">Model</a> .
<i>renewable_ptr_vec_ptr</i>	A pointer to the <a href="#">Renewable</a> pointer vector of the <a href="#">Model</a> .
<i>storage_ptr_vec_ptr</i>	A pointer to the <a href="#">Storage</a> pointer vector of the <a href="#">Model</a> .

## curtailment

```

511 {
512     // 1. get dt_hrs, net load
513     double dt_hrs = electrical_load_ptr->dt_vec_hrs[timestep];
514     double net_load_kW = this->net_load_vec_kW[timestep];
515
516     // 2. partition Storage assets into depleted and non-depleted
517     std::list<Storage*> depleted_storage_ptr_list;

```

```

518     std::list<Storage*> nondepleted_storage_ptr_list;
519
520     Storage* storage_ptr;
521     for (size_t i = 0; i < storage_ptr_vec_ptr->size(); i++) {
522         storage_ptr = storage_ptr_vec_ptr->at(i);
523
524         if (storage_ptr->is_depleted) {
525             depleted_storage_ptr_list.push_back(storage_ptr);
526         }
527
528         else {
529             nondepleted_storage_ptr_list.push_back(storage_ptr);
530         }
531     }
532
533     // 3. discharge non-depleted storage assets
534     net_load_kW = this->__handleStorageDischarging(
535         timestep,
536         dt_hrs,
537         net_load_kW,
538         nondepleted_storage_ptr_list
539     );
540
541     // 4. request optimal production from all Noncombustion assets
542     net_load_kW = this->__handleNoncombustionDispatch(
543         timestep,
544         dt_hrs,
545         net_load_kW,
546         noncombustion_ptr_vec_ptr,
547         resources_ptr
548     );
549
550     // 5. request optimal production from all Combustion assets
551     // default to load following if no depleted storage
552     if (depleted_storage_ptr_list.empty()) {
553         net_load_kW = this->__handleCombustionDispatch(
554             timestep,
555             dt_hrs,
556             net_load_kW,
557             combustion_ptr_vec_ptr,
558             false // is_cycle_charging
559         );
560     }
561
562     else {
563         net_load_kW = this->__handleCombustionDispatch(
564             timestep,
565             dt_hrs,
566             net_load_kW,
567             combustion_ptr_vec_ptr,
568             true // is_cycle_charging
569         );
570     }
571
572     // 6. attempt to charge depleted Storage assets using any and all available
573     // charge priority is Combustion, then Renewable
574     this->__handleStorageCharging(
575         timestep,
576         dt_hrs,
577         depleted_storage_ptr_list,
578         combustion_ptr_vec_ptr,
579         noncombustion_ptr_vec_ptr,
580         renewable_ptr_vec_ptr
581     );
582
583
584     // 7. record any missed load
585     if (net_load_kW > 1e-6) {
586         this->missed_load_vec_kW[timestep] = net_load_kW;
587     }
588
589     return;
590 } /* __applyCycleChargingControl_DISCHARGING() */

```

#### 4.3.3.3 \_\_applyLoadFollowingControl\_CHARGING()

```

void Controller::__applyLoadFollowingControl_CHARGING (
    int timestep,
    ElectricalLoad * electrical_load_ptr,

```

```

Resources * resources_ptr,
std::vector< Combustion * > * combustion_ptr_vec_ptr,
std::vector< Noncombustion * > * noncombustion_ptr_vec_ptr,
std::vector< Renewable * > * renewable_ptr_vec_ptr,
std::vector< Storage * > * storage_ptr_vec_ptr ) [private]

```

Helper method to apply load following control action for given timestep of the [Model](#) run when net load  $\leq 0$ ;

#### Parameters

<i>timestep</i>	The current time step of the <a href="#">Model</a> run.
<i>electrical_load_ptr</i>	A pointer to the <a href="#">ElectricalLoad</a> component of the <a href="#">Model</a> .
<i>resources_ptr</i>	A pointer to the <a href="#">Resources</a> component of the <a href="#">Model</a> .
<i>combustion_ptr_vec_ptr</i>	A pointer to the <a href="#">Combustion</a> pointer vector of the <a href="#">Model</a> .
<i>noncombustion_ptr_vec_ptr</i>	A pointer to the <a href="#">Noncombustion</a> pointer vector of the <a href="#">Model</a> .
<i>renewable_ptr_vec_ptr</i>	A pointer to the <a href="#">Renewable</a> pointer vector of the <a href="#">Model</a> .
<i>storage_ptr_vec_ptr</i>	A pointer to the <a href="#">Storage</a> pointer vector of the <a href="#">Model</a> .

```

255 {
256     // 1. get dt_hrs, set net load
257     double dt_hrs = electrical_load_ptr->dt_vec_hrs[timestep];
258     double net_load_kW = 0;
259
260     // 2. request zero production from all Combustion assets
261     this->__handleCombustionDispatch(
262         timestep,
263         dt_hrs,
264         net_load_kW,
265         combustion_ptr_vec_ptr,
266         false // is_cycle_charging
267     );
268
269     // 3. request zero production from all Noncombustion assets
270     this->__handleNoncombustionDispatch(
271         timestep,
272         dt_hrs,
273         net_load_kW,
274         noncombustion_ptr_vec_ptr,
275         resources_ptr
276     );
277
278     // 4. attempt to charge all Storage assets using any and all available curtailment
279     // charge priority is Combustion, then Renewable
280     this->__handleStorageCharging(
281         timestep,
282         dt_hrs,
283         storage_ptr_vec_ptr,
284         combustion_ptr_vec_ptr,
285         noncombustion_ptr_vec_ptr,
286         renewable_ptr_vec_ptr
287     );
288
289     return;
290 } /* __applyLoadFollowingControl_CHARGING() */

```

#### 4.3.3.4 \_\_applyLoadFollowingControl\_DISCHARGING()

```

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

```

Helper method to apply load following control action for given timestep of the [Model](#) run when net load  $> 0$ ;

## Parameters

<i>timestep</i>	The current time step of the <a href="#">Model</a> run.
<i>electrical_load_ptr</i>	A pointer to the <a href="#">ElectricalLoad</a> component of the <a href="#">Model</a> .
<i>resources_ptr</i>	A pointer to the <a href="#">Resources</a> component of the <a href="#">Model</a> .
<i>combustion_ptr_vec_ptr</i>	A pointer to the <a href="#">Combustion</a> pointer vector of the <a href="#">Model</a> .
<i>noncombustion_ptr_vec_ptr</i>	A pointer to the <a href="#">Noncombustion</a> pointer vector of the <a href="#">Model</a> .
<i>renewable_ptr_vec_ptr</i>	A pointer to the <a href="#">Renewable</a> pointer vector of the <a href="#">Model</a> .
<i>storage_ptr_vec_ptr</i>	A pointer to the <a href="#">Storage</a> pointer vector of the <a href="#">Model</a> .

## curtailment

```

337 {
338     // 1. get dt_hrs, net load
339     double dt_hrs = electrical_load_ptr->dt_vec_hrs[timestep];
340     double net_load_kW = this->net_load_vec_kW[timestep];
341
342     // 2. partition Storage assets into depleted and non-depleted
343     std::list<Storage*> depleted_storage_ptr_list;
344     std::list<Storage*> nondepleted_storage_ptr_list;
345
346     Storage* storage_ptr;
347     for (size_t i = 0; i < storage_ptr_vec_ptr->size(); i++) {
348         storage_ptr = storage_ptr_vec_ptr->at(i);
349
350         if (storage_ptr->is_depleted) {
351             depleted_storage_ptr_list.push_back(storage_ptr);
352         }
353
354         else {
355             nondepleted_storage_ptr_list.push_back(storage_ptr);
356         }
357     }
358
359     // 3. discharge non-depleted storage assets
360     net_load_kW = this->__handleStorageDischarging(
361         timestep,
362         dt_hrs,
363         net_load_kW,
364         nondepleted_storage_ptr_list
365     );
366
367     // 4. request optimal production from all Noncombustion assets
368     net_load_kW = this->__handleNoncombustionDispatch(
369         timestep,
370         dt_hrs,
371         net_load_kW,
372         noncombustion_ptr_vec_ptr,
373         resources_ptr
374     );
375
376     // 5. request optimal production from all Combustion assets
377     net_load_kW = this->__handleCombustionDispatch(
378         timestep,
379         dt_hrs,
380         net_load_kW,
381         combustion_ptr_vec_ptr,
382         false // is_cycle_charging
383     );
384
385     // 6. attempt to charge depleted Storage assets using any and all available
386     // charge priority is Combustion, then Renewable
387     this->__handleStorageCharging(
388         timestep,
389         dt_hrs,
390         depleted_storage_ptr_list,
391         combustion_ptr_vec_ptr,
392         noncombustion_ptr_vec_ptr,
393         renewable_ptr_vec_ptr
394     );
395
396     // 7. record any missed load
397     if (net_load_kW > 1e-6) {
398         this->missed_load_vec_kW[timestep] = net_load_kW;
399     }
400 }
401
402 return;
403 } /* __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

<i>electrical_load_ptr</i>	A pointer to the <a href="#">ElectricalLoad</a> component of the <a href="#">Model</a> .
<i>renewable_ptr_vec_ptr</i>	A pointer to the <a href="#">Renewable</a> pointer vector of the <a href="#">Model</a> .
<i>resources_ptr</i>	A pointer to the <a href="#">Resources</a> component of the <a href="#">Model</a> .

```
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         this->net_load_vec_kW[i] = net_load_kW;
95     }
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

<code>combustion_ptr_vec_ptr</code>	A pointer to the <a href="#">Combustion</a> pointer vector of the <a href="#">Model</a> .
-------------------------------------	---

```

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     /*
182     // ==== TEST PRINT ==== //
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     // ==== END TEST PRINT ==== //
205     /**/
206
207     return;
208 } /* __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

<i>timestep</i>	The current time step of the <a href="#">Model</a> run.
<i>dt_hrs</i>	The interval of time [hrs] associated with the action.
<i>renewable_ptr</i>	A pointer to the <a href="#">Renewable</a> asset.
<i>resources_ptr</i>	A pointer to the <a href="#">Resources</a> component of the <a href="#">Model</a> .

##### Returns

The production [kW] of the [Renewable](#) asset.

```

879 {
880     double production_kW = 0;
881
882     switch (renewable_ptr->type) {
883         case (RenewableType :: SOLAR): {
884             production_kW = renewable_ptr->computeProductionkW(
885                 timestep,
886                 dt_hrs,
887                 resources_ptr->resource_map_1D[renewable_ptr->resource_key][timestep]
888             );
889
890             break;
891         }
892
893         case (RenewableType :: TIDAL): {
894             production_kW = renewable_ptr->computeProductionkW(
895                 timestep,
896                 dt_hrs,
897                 resources_ptr->resource_map_1D[renewable_ptr->resource_key][timestep]
898             );
899
900             break;
901         }
902
903         case (RenewableType :: WAVE): {
904             production_kW = renewable_ptr->computeProductionkW(
905                 timestep,
906                 dt_hrs,
907                 resources_ptr->resource_map_2D[renewable_ptr->resource_key][timestep][0],
908                 resources_ptr->resource_map_2D[renewable_ptr->resource_key][timestep][1]
909             );
910
911             break;
912         }
913
914         case (RenewableType :: WIND): {
915             production_kW = renewable_ptr->computeProductionkW(
916                 timestep,
917                 dt_hrs,
918                 resources_ptr->resource_map_1D[renewable_ptr->resource_key][timestep]

```



```

919         );
920
921         break;
922     }
923
924     default: {
925         std::string error_str = "ERROR: Controller::__getRenewableProduction(): ";
926         error_str += "renewable type ";
927         error_str += std::to_string(renewable_ptr->type);
928         error_str += " not recognized";
929
930         #ifdef _WIN32
931             std::cout << error_str << std::endl;
932         #endif
933
934         throw std::runtime_error(error_str);
935
936         break;
937     }
938 }
939
940 return production_kW;
941 } /* __getRenewableProduction() */

```

#### 4.3.3.8 \_\_handleCombustionDispatch()

```

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

```

bool is\_cycle\_charging )

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

##### Parameters

<i>timestep</i>	The current time step of the <a href="#">Model</a> run.
<i>dt_hrs</i>	The interval of time [hrs] associated with the action.
<i>net_load_kW</i>	The net load [kW] before the dispatch is deducted from it.
<i>combustion_ptr_vec_ptr</i>	A pointer to the <a href="#">Combustion</a> pointer vector of the <a href="#">Model</a> .
<i>is_cycle_charging</i>	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.

```

984 {
985     // 1. get minimal Combustion dispatch
986     double target_production_kW = 1.2 * net_load_kW;
987     double total_capacity_kW = 0;
988
989     std::map<double, std::vector<bool>::iterator> iter = this->combustion_map.begin();
990     while (iter != std::prev(this->combustion_map.end(), 1)) {
991         if (target_production_kW <= total_capacity_kW) {
992             break;
993         }
994
995         iter++;
996         total_capacity_kW = iter->first;

```

```

997     }
998
999     // 2. share load proportionally (by rated capacity) over active diesels
1000     Combustion* combustion_ptr;
1001     double production_kW = 0;
1002     double request_kW = 0;
1003     double _net_load_kW = net_load_kW;
1004
1005     for (size_t i = 0; i < this->combustion_map[total_capacity_kW].size(); i++) {
1006         combustion_ptr = combustion_ptr_vec_ptr->at(i);
1007
1008         if (total_capacity_kW > 0) {
1009             request_kW =
1010                 int(this->combustion_map[total_capacity_kW][i]) *
1011                 net_load_kW *
1012                 (combustion_ptr->capacity_kW / total_capacity_kW);
1013         }
1014
1015         else {
1016             request_kW = 0;
1017         }
1018
1019         if (is_cycle_charging and request_kW > 0) {
1020             if (request_kW < 0.85 * combustion_ptr->capacity_kW) {
1021                 request_kW = 0.85 * combustion_ptr->capacity_kW;
1022             }
1023         }
1024
1025         production_kW = combustion_ptr->requestProductionkW(
1026             timestep,
1027             dt_hrs,
1028             request_kW
1029         );
1030
1031         _net_load_kW = combustion_ptr->commit(
1032             timestep,
1033             dt_hrs,
1034             production_kW,
1035             _net_load_kW
1036         );
1037     }
1038
1039     return _net_load_kW;
1040 } /* __handleCombustionDispatch() */

```

#### 4.3.3.9 \_\_handleNoncombustionDispatch()

```

double Controller::__handleNoncombustionDispatch (
    int timestep,
    double dt_hrs,
    double net_load_kW,
    std::vector< Noncombustion * > * noncombustion_ptr_vec_ptr,
    Resources * resources_ptr ) [private]
1081 {
1082     Noncombustion* noncombustion_ptr;
1083     double production_kW = 0;
1084
1085     for (size_t i = 0; i < noncombustion_ptr_vec_ptr->size(); i++) {
1086         noncombustion_ptr = noncombustion_ptr_vec_ptr->at(i);
1087
1088         switch (noncombustion_ptr->type) {
1089             case (NoncombustionType :: HYDRO): {
1090                 production_kW = noncombustion_ptr->requestProductionkW(
1091                     timestep,
1092                     dt_hrs,
1093                     net_load_kW,
1094                     resources_ptr->resource_map_1D[noncombustion_ptr->resource_key][timestep]
1095                 );
1096
1097                 net_load_kW = noncombustion_ptr->commit(
1098                     timestep,
1099                     dt_hrs,
1100                     production_kW,
1101                     net_load_kW,
1102                     resources_ptr->resource_map_1D[noncombustion_ptr->resource_key][timestep]
1103                 );
1104

```

```

1105         break;
1106     }
1107
1108     default: {
1109         production_kW = noncombustion_ptr->requestProductionkW(
1110             timestep,
1111             dt_hrs,
1112             net_load_kW
1113         );
1114
1115         net_load_kW = noncombustion_ptr->commit(
1116             timestep,
1117             dt_hrs,
1118             production_kW,
1119             net_load_kW
1120         );
1121
1122         break;
1123     }
1124 }
1125 }
1126
1127 return net_load_kW;
1128 } /* __handleNoncombustionDispatch() */

```

#### 4.3.3.10 \_\_handleStorageCharging() [1/2]

```

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

```

Helper method to handle the charging of the given [Storage](#) assets.

##### Parameters

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

```

633 {
634     double acceptable_kW = 0;
635     double curtailment_kW = 0;
636
637     Storage* storage_ptr;
638     Combustion* combustion_ptr;
639     Noncombustion* noncombustion_ptr;
640     Renewable* renewable_ptr;
641
642     std::list<Storage*>::iterator iter;
643     for (
644         iter = storage_ptr_list.begin();
645         iter != storage_ptr_list.end();
646         iter++
647     ){
648         storage_ptr = (*iter);
649
650         // 1. attempt to charge from Combustion curtailment first
651         for (size_t i = 0; i < combustion_ptr_vec_ptr->size(); i++) {
652             combustion_ptr = combustion_ptr_vec_ptr->at(i);
653             curtailment_kW = combustion_ptr->curtailment_vec_kW[timestep];
654

```

```

655         if (curtailment_kW <= 0) {
656             continue;
657         }
658
659         acceptable_kW = storage_ptr->getAcceptablekW(dt_hrs);
660
661         if (acceptable_kW > curtailment_kW) {
662             acceptable_kW = curtailment_kW;
663         }
664
665         combustion_ptr->curtailment_vec_kW[timestep] -= acceptable_kW;
666         combustion_ptr->storage_vec_kW[timestep] += acceptable_kW;
667         storage_ptr->power_kW += acceptable_kW;
668     }
669
670     // 2. attempt to charge from Noncombustion curtailment second
671     for (size_t i = 0; i < noncombustion_ptr_vec_ptr->size(); i++) {
672         noncombustion_ptr = noncombustion_ptr_vec_ptr->at(i);
673         curtailment_kW = noncombustion_ptr->curtailment_vec_kW[timestep];
674
675         if (curtailment_kW <= 0) {
676             continue;
677         }
678
679         acceptable_kW = storage_ptr->getAcceptablekW(dt_hrs);
680
681         if (acceptable_kW > curtailment_kW) {
682             acceptable_kW = curtailment_kW;
683         }
684
685         noncombustion_ptr->curtailment_vec_kW[timestep] -= acceptable_kW;
686         noncombustion_ptr->storage_vec_kW[timestep] += acceptable_kW;
687         storage_ptr->power_kW += acceptable_kW;
688     }
689
690     // 3. attempt to charge from Renewable curtailment third
691     for (size_t i = 0; i < renewable_ptr_vec_ptr->size(); i++) {
692         renewable_ptr = renewable_ptr_vec_ptr->at(i);
693         curtailment_kW = renewable_ptr->curtailment_vec_kW[timestep];
694
695         if (curtailment_kW <= 0) {
696             continue;
697         }
698
699         acceptable_kW = storage_ptr->getAcceptablekW(dt_hrs);
700
701         if (acceptable_kW > curtailment_kW) {
702             acceptable_kW = curtailment_kW;
703         }
704
705         renewable_ptr->curtailment_vec_kW[timestep] -= acceptable_kW;
706         renewable_ptr->storage_vec_kW[timestep] += acceptable_kW;
707         storage_ptr->power_kW += acceptable_kW;
708     }
709
710     // 4. commit charge
711     storage_ptr->commitCharge(
712         timestep,
713         dt_hrs,
714         storage_ptr->power_kW
715     );
716 }
717
718 return;
719 } /* __handleStorageCharging() */

```

#### 4.3.3.11 \_\_handleStorageCharging() [2/2]

```

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

```

Helper method to handle the charging of the given [Storage](#) assets.

## Parameters

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

```

762 {
763     double acceptable_kW = 0;
764     double curtailment_kW = 0;
765
766     Storage* storage_ptr;
767     Combustion* combustion_ptr;
768     Noncombustion* noncombustion_ptr;
769     Renewable* renewable_ptr;
770
771     for (size_t j = 0; j < storage_ptr_vec_ptr->size(); j++) {
772         storage_ptr = storage_ptr_vec_ptr->at(j);
773
774         // 1. attempt to charge from Combustion curtailment first
775         for (size_t i = 0; i < combustion_ptr_vec_ptr->size(); i++) {
776             combustion_ptr = combustion_ptr_vec_ptr->at(i);
777             curtailment_kW = combustion_ptr->curtailment_vec_kW[timestep];
778
779             if (curtailment_kW <= 0) {
780                 continue;
781             }
782
783             acceptable_kW = storage_ptr->getAcceptablekW(dt_hrs);
784
785             if (acceptable_kW > curtailment_kW) {
786                 acceptable_kW = curtailment_kW;
787             }
788
789             combustion_ptr->curtailment_vec_kW[timestep] -= acceptable_kW;
790             combustion_ptr->storage_vec_kW[timestep] += acceptable_kW;
791             storage_ptr->power_kW += acceptable_kW;
792         }
793
794         // 2. attempt to charge from Noncombustion curtailment second
795         for (size_t i = 0; i < noncombustion_ptr_vec_ptr->size(); i++) {
796             noncombustion_ptr = noncombustion_ptr_vec_ptr->at(i);
797             curtailment_kW = noncombustion_ptr->curtailment_vec_kW[timestep];
798
799             if (curtailment_kW <= 0) {
800                 continue;
801             }
802
803             acceptable_kW = storage_ptr->getAcceptablekW(dt_hrs);
804
805             if (acceptable_kW > curtailment_kW) {
806                 acceptable_kW = curtailment_kW;
807             }
808
809             noncombustion_ptr->curtailment_vec_kW[timestep] -= acceptable_kW;
810             noncombustion_ptr->storage_vec_kW[timestep] += acceptable_kW;
811             storage_ptr->power_kW += acceptable_kW;
812         }
813
814         // 3. attempt to charge from Renewable curtailment third
815         for (size_t i = 0; i < renewable_ptr_vec_ptr->size(); i++) {
816             renewable_ptr = renewable_ptr_vec_ptr->at(i);
817             curtailment_kW = renewable_ptr->curtailment_vec_kW[timestep];
818
819             if (curtailment_kW <= 0) {
820                 continue;
821             }
822
823             acceptable_kW = storage_ptr->getAcceptablekW(dt_hrs);
824
825             if (acceptable_kW > curtailment_kW) {
826                 acceptable_kW = curtailment_kW;
827             }
828
829             renewable_ptr->curtailment_vec_kW[timestep] -= acceptable_kW;
830             renewable_ptr->storage_vec_kW[timestep] += acceptable_kW;
831             storage_ptr->power_kW += acceptable_kW;
832         }
833     }

```

```

834         // 4. commit charge
835         storage_ptr->commitCharge(
836             timestep,
837             dt_hrs,
838             storage_ptr->power_kW
839         );
840     }
841
842     return;
843 } /* __handleStorageCharging() */

```

#### 4.3.3.12 \_\_handleStorageDischarging()

```

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

```

Helper method to handle the discharging of the given [Storage](#) assets.

##### Parameters

<i>timestep</i>	The current time step of the <a href="#">Model</a> run.
<i>dt_hrs</i>	The interval of time [hrs] associated with the action.
<i>storage_ptr_list</i>	A list of pointers to the <a href="#">Storage</a> assets that are to be discharged.

##### Returns

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

```

1162 {
1163     double discharging_kW = 0;
1164
1165     Storage* storage_ptr;
1166
1167     std::list<Storage*>::iterator iter;
1168     for (
1169         iter = storage_ptr_list.begin();
1170         iter != storage_ptr_list.end();
1171         iter++
1172     ){
1173         storage_ptr = (*iter);
1174
1175         discharging_kW = storage_ptr->getAvailablekW(dt_hrs);
1176
1177         if (discharging_kW > net_load_kW) {
1178             discharging_kW = net_load_kW;
1179         }
1180
1181         net_load_kW = storage_ptr->commitDischarge(
1182             timestep,
1183             dt_hrs,
1184             discharging_kW,
1185             net_load_kW
1186         );
1187     }
1188
1189     return net_load_kW;
1190 } /* __handleStorageDischarging() */

```

## 4.3.3.13 applyDispatchControl()

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

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

## Parameters

<i>electrical_load_ptr</i>	A pointer to the <a href="#">ElectricalLoad</a> component of the <a href="#">Model</a> .
<i>resources_ptr</i>	A pointer to the <a href="#">Resources</a> component of the <a href="#">Model</a> .
<i>combustion_ptr_vec_ptr</i>	A pointer to the <a href="#">Combustion</a> pointer vector of the <a href="#">Model</a> .
<i>noncombustion_ptr_vec_ptr</i>	A pointer to the <a href="#">Noncombustion</a> pointer vector of the <a href="#">Model</a> .
<i>renewable_ptr_vec_ptr</i>	A pointer to the <a href="#">Renewable</a> pointer vector of the <a href="#">Model</a> .
<i>storage_ptr_vec_ptr</i>	A pointer to the <a href="#">Storage</a> pointer vector of the <a href="#">Model</a> .

```
1342 {
1343     for (int i = 0; i < electrical_load_ptr->n_points; i++) {
1344         switch (this->control_mode) {
1345             case (ControlMode :: LOAD_FOLLOWING): {
1346                 if (this->net_load_vec_kW[i] <= 0) {
1347                     this->__applyLoadFollowingControl_CHARGING(
1348                         i,
1349                         electrical_load_ptr,
1350                         resources_ptr,
1351                         combustion_ptr_vec_ptr,
1352                         noncombustion_ptr_vec_ptr,
1353                         renewable_ptr_vec_ptr,
1354                         storage_ptr_vec_ptr
1355                     );
1356                 }
1357             }
1358             else {
1359                 this->__applyLoadFollowingControl_DISCHARGING(
1360                     i,
1361                     electrical_load_ptr,
1362                     resources_ptr,
1363                     combustion_ptr_vec_ptr,
1364                     noncombustion_ptr_vec_ptr,
1365                     renewable_ptr_vec_ptr,
1366                     storage_ptr_vec_ptr
1367                 );
1368             }
1369             break;
1370         }
1371     }
1372
1373     case (ControlMode :: CYCLE_CHARGING): {
1374         if (this->net_load_vec_kW[i] <= 0) {
1375             this->__applyCycleChargingControl_CHARGING(
1376                 i,
1377                 electrical_load_ptr,
1378                 resources_ptr,
1379                 combustion_ptr_vec_ptr,
1380                 noncombustion_ptr_vec_ptr,
1381                 renewable_ptr_vec_ptr,
1382                 storage_ptr_vec_ptr
1383             );
1384         }
1385     }
1386     else {
1387         this->__applyCycleChargingControl_DISCHARGING(
1388             i,
1389             electrical_load_ptr,
1390             resources_ptr,
1391             combustion_ptr_vec_ptr,
1392             noncombustion_ptr_vec_ptr,
1393             renewable_ptr_vec_ptr,
1394             storage_ptr_vec_ptr
```

```

1395         );
1396     }
1397
1398     break;
1399 }
1400
1401     default: {
1402         std::string error_str = "ERROR: Controller :: applyDispatchControl(): ";
1403         error_str += "control mode ";
1404         error_str += std::to_string(this->control_mode);
1405         error_str += " not recognized";
1406
1407         #ifdef _WIN32
1408             std::cout << error_str << std::endl;
1409         #endif
1410
1411         throw std::runtime_error(error_str);
1412
1413         break;
1414     }
1415 }
1416 }
1417
1418     return;
1419 } /* applyDispatchControl() */

```

#### 4.3.3.14 clear()

```

void Controller::clear (
    void )

```

Method to clear all attributes of the [Controller](#) object.

```

1434 {
1435     this->net_load_vec_kW.clear();
1436     this->missed_load_vec_kW.clear();
1437     this->combustion_map.clear();
1438
1439     return;
1440 } /* clear() */

```

#### 4.3.3.15 init()

```

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

```

Method to initialize the [Controller](#) component of the [Model](#).

##### Parameters

<i>electrical_load_ptr</i>	A pointer to the <a href="#">ElectricalLoad</a> component of the <a href="#">Model</a> .
<i>renewable_ptr_vec_ptr</i>	A pointer to the <a href="#">Renewable</a> pointer vector of the <a href="#">Model</a> .
<i>resources_ptr</i>	A pointer to the <a href="#">Resources</a> component of the <a href="#">Model</a> .
<i>combustion_ptr_vec_ptr</i>	A pointer to the <a href="#">Combustion</a> pointer vector of the <a href="#">Model</a> .

```

1292 {
1293     // 1. compute net load
1294     this->__computeNetLoad(electrical_load_ptr, renewable_ptr_vec_ptr, resources_ptr);
1295 }

```



```

1296 // 2. construct Combustion table
1297 this->__constructCombustionMap(combustion_ptr_vec_ptr);
1298
1299 return;
1300 } /* init() */

```

#### 4.3.3.16 setControlMode()

```

void Controller::setControlMode (
    ControlMode control_mode )

```

##### Parameters

<i>control_mode</i>	The ControlMode which is to be active in the <a href="#">Controller</a> .
---------------------	---

```

1226 {
1227     this->control_mode = control_mode;
1228
1229     switch(control_mode) {
1230         case (ControlMode :: LOAD_FOLLOWING): {
1231             this->control_string = "LOAD_FOLLOWING";
1232
1233             break;
1234         }
1235
1236         case (ControlMode :: CYCLE_CHARGING): {
1237             this->control_string = "CYCLE_CHARGING";
1238
1239             break;
1240         }
1241
1242         default: {
1243             std::string error_str = "ERROR: Controller :: setControlMode(): ";
1244             error_str += "control mode ";
1245             error_str += std::to_string(control_mode);
1246             error_str += " not recognized";
1247
1248             #ifdef _WIN32
1249                 std::cout << error_str << std::endl;
1250             #endif
1251
1252             throw std::runtime_error(error_str);
1253
1254             break;
1255         }
1256     }
1257
1258     return;
1259 } /* 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:

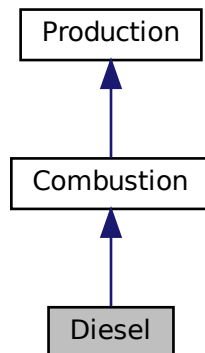
- header/[Controller.h](#)
- source/[Controller.cpp](#)

## 4.4 Diesel Class Reference

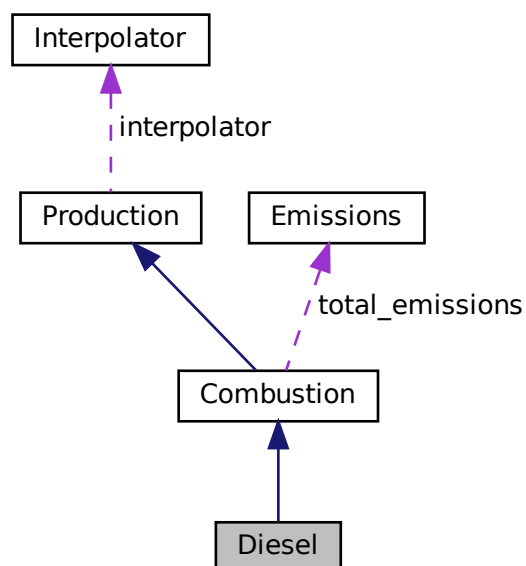
A derived class of the [Combustion](#) branch of [Production](#) which models production using a diesel generator.

```
#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.*
- void [handleReplacement](#) (int)  
*Method to handle asset replacement and capital cost incursion, if applicable.*
- double [requestProductionkW](#) (int, double, double)  
*Method which takes in production request, and then returns what the asset can deliver (subject to operating constraints, etc.).*
- double [commit](#) (int, double, double, double)  
*Method which takes in production and load for the current timestep, computes and records dispatch and curtailment, and then returns remaining load.*
- [~Diesel](#) (void)  
*Destructor for the [Diesel](#) class.*

## Public Attributes

- double [minimum\\_load\\_ratio](#)  
*The minimum load ratio of the asset. That is, when the asset is producing, it must produce at least this ratio of its rated capacity.*
- double [minimum\\_runtime\\_hrs](#)  
*The minimum runtime [hrs] of the asset. This is the minimum time that must elapse between successive starts and stops.*
- double [time\\_since\\_last\\_start\\_hrs](#)  
*The time that has elapsed [hrs] since the last start of the asset.*

## Private Member Functions

- void [\\_\\_checkInputs](#) ([DieselInputs](#))  
*Helper method to check inputs to the [Diesel](#) constructor.*
- void [\\_\\_handleStartStop](#) (int, double, double)  
*Helper method (private) to handle the starting/stopping of the diesel generator. The minimum runtime constraint is enforced in this method.*
- double [\\_\\_getGenericFuelSlope](#) (void)  
*Helper method to generate a generic, linearized fuel consumption slope for a diesel generator.*
- double [\\_\\_getGenericFuelIntercept](#) (void)  
*Helper method to generate a generic, linearized fuel consumption intercept for a diesel generator.*
- double [\\_\\_getGenericCapitalCost](#) (void)  
*Helper method to generate a generic diesel generator capital cost.*
- double [\\_\\_getGenericOpMaintCost](#) (void)  
*Helper method (private) to generate a generic diesel generator operation and maintenance cost. This is a cost incurred per unit energy produced.*
- void [\\_\\_writeSummary](#) (std::string)  
*Helper method to write summary results for [Diesel](#).*
- void [\\_\\_writeTimeSeries](#) (std::string, std::vector< double > \*, int=-1)  
*Helper method to write time series results for [Diesel](#).*

### 4.4.1 Detailed Description

A derived class of the [Combustion](#) branch of [Production](#) which models production using a diesel generator.

### 4.4.2 Constructor & Destructor Documentation

#### 4.4.2.1 Diesel() [1/2]

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

Constructor (dummy) for the [Diesel](#) class.

```
596 {
597     return;
598 } /* 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

<i>n_points</i>	The number of points in the modelling time series.
<i>n_years</i>	The number of years being modelled.
<i>diesel_inputs</i>	A structure of <a href="#">Diesel</a> constructor inputs.

```
626 :
627 Combustion(
628     n_points,
629     n_years,
630     diesel_inputs.combustion_inputs
631 )
632 {
633     // 1. check inputs
634     this->__checkInputs(diesel_inputs);
635
636     // 2. set attributes
637     this->type = CombustionType :: DIESEL;
638     this->type_str = "DIESEL";
639
640     this->replace_running_hrs = diesel_inputs.replace_running_hrs;
641
642     this->fuel_cost_L = diesel_inputs.fuel_cost_L;
643
644     this->minimum_load_ratio = diesel_inputs.minimum_load_ratio;
645     this->minimum_runtime_hrs = diesel_inputs.minimum_runtime_hrs;
646     this->time_since_last_start_hrs = 0;
647
648     this->CO2_emissions_intensity_kgL = diesel_inputs.CO2_emissions_intensity_kgL;
649     this->CO_emissions_intensity_kgL = diesel_inputs.CO_emissions_intensity_kgL;
650     this->NOx_emissions_intensity_kgL = diesel_inputs.NOx_emissions_intensity_kgL;
```

```

651     this->SOx_emissions_intensity_kgL = diesel_inputs.SOx_emissions_intensity_kgL;
652     this->CH4_emissions_intensity_kgL = diesel_inputs.CH4_emissions_intensity_kgL;
653     this->PM_emissions_intensity_kgL = diesel_inputs.PM_emissions_intensity_kgL;
654
655     if (diesel_inputs.linear_fuel_slope_LkWh < 0) {
656         this->linear_fuel_slope_LkWh = this->__getGenericFuelSlope();
657     }
658
659     if (diesel_inputs.linear_fuel_intercept_LkWh < 0) {
660         this->linear_fuel_intercept_LkWh = this->__getGenericFuelIntercept();
661     }
662
663     if (diesel_inputs.capital_cost < 0) {
664         this->capital_cost = this->__getGenericCapitalCost();
665     }
666
667     if (diesel_inputs.operation_maintenance_cost_kWh < 0) {
668         this->operation_maintenance_cost_kWh = this->__getGenericOpMaintCost();
669     }
670
671     if (not this->is_sunk) {
672         this->capital_cost_vec[0] = this->capital_cost;
673     }
674
675     // 3. construction print
676     if (this->print_flag) {
677         std::cout << "Diesel object constructed at " << this << std::endl;
678     }
679
680     return;
681 } /* Diesel() */

```

#### 4.4.2.3 ~Diesel()

```

Diesel::~Diesel (
    void )

```

Destructor for the [Diesel](#) class.

```

836 {
837     // 1. destruction print
838     if (this->print_flag) {
839         std::cout << "Diesel object at " << this << " destroyed" << std::endl;
840     }
841
842     return;
843 } /* ~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

<i>diesel_inputs</i>	A structure of <a href="#">Diesel</a> 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

<i>timestep</i>	The current time step of the <a href="#">Model</a> run.
<i>dt_hrs</i>	The interval of time [hrs] associated with the action.
<i>production_kW</i>	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

<i>write_path</i>	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 « "Nominal Fuel Escalation Rate (annual): "
384     « this->nominal_fuel_escalation_annual « " \n";
385 ofs « "Real Fuel Escalation Rate (annual): "
386     « this->real_fuel_escalation_annual « " \n";
387 ofs « "\n";
388
389 ofs « "Fuel Mode: " « this->fuel_mode_str « " \n";
390 switch (this->fuel_mode) {
391     case (FuelMode :: FUEL_MODE_LINEAR): {
392         ofs « "Linear Fuel Slope: " « this->linear_fuel_slope_LkWh
393             « " L/kWh \n";
394         ofs « "Linear Fuel Intercept Coefficient: "
395             « this->linear_fuel_intercept_LkWh « " L/kWh \n";
396         ofs « "\n";
397         break;
398     }
399
400     case (FuelMode :: FUEL_MODE_LOOKUP): {
401         ofs « "Fuel Consumption Data: " « this->interpolator.path_map_1D[0]
402             « " \n";
403         break;
404     }
405
406     default: {
407         // write nothing!
408         break;
409     }
410 }
411
412 ofs « "Carbon Dioxide (CO2) Emissions Intensity: "
413     « this->CO2_emissions_intensity_kgL « " kg/L \n";
414
415 ofs « "Carbon Monoxide (CO) Emissions Intensity: "
416     « this->CO_emissions_intensity_kgL « " kg/L \n";
417
418 ofs « "Nitrogen Oxides (NOx) Emissions Intensity: "
419     « this->NOx_emissions_intensity_kgL « " kg/L \n";
420
421 ofs « "Sulfur Oxides (SOx) Emissions Intensity: "
422     « this->SOx_emissions_intensity_kgL « " kg/L \n";
423
424 ofs « "Methane (CH4) Emissions Intensity: "
425     « this->CH4_emissions_intensity_kgL « " kg/L \n";
426
427 ofs « "Particulate Matter (PM) Emissions Intensity: "
428     « this->PM_emissions_intensity_kgL « " kg/L \n";
429
430 ofs « "\n-----\n\n";
431
432 // 2.3. Diesel attributes
433 ofs « "## Diesel Attributes\n";
434 ofs « "\n";
435
436 ofs « "Minimum Load Ratio: " « this->minimum_load_ratio « " \n";
437 ofs « "Minimum Runtime: " « this->minimum_runtime_hrs « " hrs \n";
438
439 ofs « "\n-----\n\n";
440
441 // 2.4. Diesel Results
442 ofs « "## Results\n";
443 ofs « "\n";
444
445 ofs « "Net Present Cost: " « this->net_present_cost « " \n";
446 ofs « "\n";
447
448 ofs « "Total Dispatch: " « this->total_dispatch_kWh
449     « " kWh \n";
450
451 ofs « "Total Dispatch: " « this->total_dispatch_kWh
452     « " kWh \n";

```

```

453
454 ofs << "Levellized Cost of Energy: " << this->levellized_cost_of_energy_kWh
455     << " per kWh dispatched \n";
456 ofs << "\n";
457
458 ofs << "Running Hours: " << this->running_hours << " \n";
459 ofs << "Starts: " << this->n_starts << " \n";
460 ofs << "Replacements: " << this->n_replacements << " \n";
461
462 ofs << "Total Fuel Consumed: " << this->total_fuel_consumed_L << " L "
463     << "(Annual Average: " << this->total_fuel_consumed_L / this->n_years
464     << " L/yr) \n";
465 ofs << "\n";
466
467 ofs << "Total Carbon Dioxide (CO2) Emissions: " <<
468     this->total_emissions.CO2_kg << " kg "
469     << "(Annual Average: " << this->total_emissions.CO2_kg / this->n_years
470     << " kg/yr) \n";
471
472 ofs << "Total Carbon Monoxide (CO) Emissions: " <<
473     this->total_emissions.CO_kg << " kg "
474     << "(Annual Average: " << this->total_emissions.CO_kg / this->n_years
475     << " kg/yr) \n";
476
477 ofs << "Total Nitrogen Oxides (NOx) Emissions: " <<
478     this->total_emissions.NOx_kg << " kg "
479     << "(Annual Average: " << this->total_emissions.NOx_kg / this->n_years
480     << " kg/yr) \n";
481
482 ofs << "Total Sulfur Oxides (SOx) Emissions: " <<
483     this->total_emissions.SOx_kg << " kg "
484     << "(Annual Average: " << this->total_emissions.SOx_kg / this->n_years
485     << " kg/yr) \n";
486
487 ofs << "Total Methane (CH4) Emissions: " << this->total_emissions.CH4_kg << " kg "
488     << "(Annual Average: " << this->total_emissions.CH4_kg / this->n_years
489     << " kg/yr) \n";
490
491 ofs << "Total Particulate Matter (PM) Emissions: " <<
492     this->total_emissions.PM_kg << " kg "
493     << "(Annual Average: " << this->total_emissions.PM_kg / this->n_years
494     << " kg/yr) \n";
495
496 ofs << "\n-----\n\n";
497
498 ofs.close();
499 return;
500 } /* __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

<i>write_path</i>	A path (either relative or absolute) to the directory location where results are to be written. If already exists, will overwrite.
<i>time_vec_hrs_ptr</i>	A pointer to the <code>time_vec_hrs</code> attribute of the <a href="#">ElectricalLoad</a> .
<i>max_lines</i>	The maximum number of lines of output to write.

Reimplemented from [Combustion](#).

```

530 {
531     // 1. create filestream
532     write_path += "time_series_results.csv";
533     std::ofstream ofs;

```

```

534     ofs.open(write_path, std::ofstream::out);
535
536     // 2. write time series results (comma separated value)
537     ofs << "Time (since start of data) [hrs],";
538     ofs << "Production [kW],";
539     ofs << "Dispatch [kW],";
540     ofs << "Storage [kW],";
541     ofs << "Curtailement [kW],";
542     ofs << "Is Running (N = 0 / Y = 1),";
543     ofs << "Fuel Consumption [L],";
544     ofs << "Fuel Cost (actual),";
545     ofs << "Carbon Dioxide (CO2) Emissions [kg],";
546     ofs << "Carbon Monoxide (CO) Emissions [kg],";
547     ofs << "Nitrogen Oxides (NOx) Emissions [kg],";
548     ofs << "Sulfur Oxides (SOx) Emissions [kg],";
549     ofs << "Methane (CH4) Emissions [kg],";
550     ofs << "Particulate Matter (PM) Emissions [kg],";
551     ofs << "Capital Cost (actual),";
552     ofs << "Operation and Maintenance Cost (actual),";
553     ofs << "\n";
554
555     for (int i = 0; i < max_lines; i++) {
556         ofs << time_vec_hrs_ptr->at(i) << ",";
557         ofs << this->production_vec_kW[i] << ",";
558         ofs << this->dispatch_vec_kW[i] << ",";
559         ofs << this->storage_vec_kW[i] << ",";
560         ofs << this->curtailment_vec_kW[i] << ",";
561         ofs << this->is_running_vec[i] << ",";
562         ofs << this->fuel_consumption_vec_L[i] << ",";
563         ofs << this->fuel_cost_vec[i] << ",";
564         ofs << this->CO2_emissions_vec_kg[i] << ",";
565         ofs << this->CO_emissions_vec_kg[i] << ",";
566         ofs << this->NOx_emissions_vec_kg[i] << ",";
567         ofs << this->SOx_emissions_vec_kg[i] << ",";
568         ofs << this->CH4_emissions_vec_kg[i] << ",";
569         ofs << this->PM_emissions_vec_kg[i] << ",";
570         ofs << this->capital_cost_vec[i] << ",";
571         ofs << this->operation_maintenance_cost_vec[i] << ",";
572         ofs << "\n";
573     }
574
575     ofs.close();
576     return;
577 } /* __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

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

```

794 {
795     // 1. handle start/stop, enforce minimum runtime constraint
796     this->__handleStartStop(timestep, dt_hrs, production_kW);
797
798     // 2. invoke base class method
799     load_kW = Combustion::commit(
800         timestep,
801         dt_hrs,
802         production_kW,
803         load_kW
804     );
805
806     if (this->is_running) {
807         // 3. log time since last start
808         this->time_since_last_start_hrs += dt_hrs;
809
810         // 4. correct operation and maintenance costs (should be non-zero if idling)
811         if (production_kW <= 0) {
812             double produced_kWh = 0.01 * this->capacity_kW * dt_hrs;
813
814             double operation_maintenance_cost =
815                 this->operation_maintenance_cost_kWh * produced_kWh;
816             this->operation_maintenance_cost_vec[timestep] = operation_maintenance_cost;
817         }
818     }
819
820     return load_kW;
821 } /* commit() */

```

#### 4.4.3.10 handleReplacement()

```

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

```

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

##### Parameters

<i>timestep</i>	The current time step of the <a href="#">Model</a> run.
-----------------	---

Reimplemented from [Combustion](#).

```

699 {
700     // 1. reset attributes
701     this->time_since_last_start_hrs = 0;
702
703     // 2. invoke base class method
704     Combustion::handleReplacement(timestep);
705
706     return;
707 } /* __handleReplacement() */

```

#### 4.4.3.11 requestProductionkW()

```

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

```

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

## Parameters

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

## Returns

The production [kW] delivered by the diesel generator.

Reimplemented from [Combustion](#).

```

739 {
740     // 1. return on request of zero
741     if (request_kW <= 0) {
742         return 0;
743     }
744
745     double deliver_kW = request_kW;
746
747     // 2. enforce capacity constraint
748     if (deliver_kW > this->capacity_kW) {
749         deliver_kW = this->capacity_kW;
750     }
751
752     // 3. enforce minimum load ratio
753     if (deliver_kW < this->minimum_load_ratio * this->capacity_kW) {
754         deliver_kW = this->minimum_load_ratio * this->capacity_kW;
755     }
756
757     return deliver_kW;
758 } /* 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:

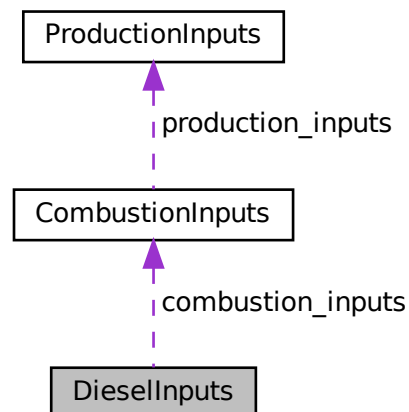
- [header/Production/Combustion/Diesel.h](#)
- [source/Production/Combustion/Diesel.cpp](#)

## 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 (CO<sub>2</sub>) 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 (NO<sub>x</sub>) emissions intensity [kg/L].

- double `SOx_emissions_intensity_kgL` = 0.0042

Sulfur oxide (SO<sub>x</sub>) emissions intensity [kg/L].

- double `CH4_emissions_intensity_kgL` = 0.0007

Methane (CH<sub>4</sub>) 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

<i>path_2_electrical_load_time_series</i>	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

<i>path_2_electrical_load_time_series</i>	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     else {
135         double dt_hrs = this->time_vec_hrs[i + 1] - this->time_vec_hrs[i];
136         this->dt_vec_hrs[i] = dt_hrs;
137     }
138 }
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:

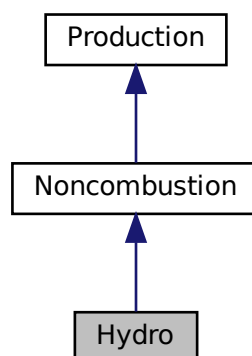
- [header/Production/Combustion/Combustion.h](#)

## 4.8 Hydro Class Reference

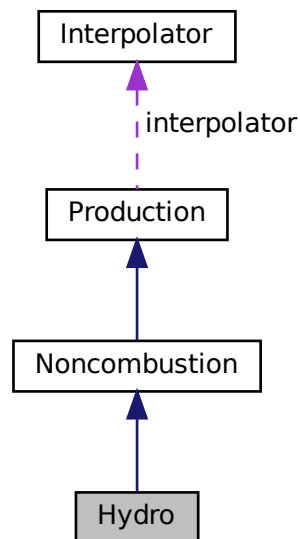
A derived class of the [Noncombustion](#) branch of [Production](#) which models production using a hydroelectric asset (either with reservoir or not).

```
#include <Hydro.h>
```

Inheritance diagram for Hydro:



Collaboration diagram for Hydro:



## Public Member Functions

- [Hydro](#) (void)  
*Constructor (dummy) for the [Hydro](#) class.*
- [Hydro](#) (int, double, [HydroInputs](#))  
*Constructor (intended) for the [Hydro](#) class.*
- void [handleReplacement](#) (int)  
*Method to handle asset replacement and capital cost incursion, if applicable.*
- double [requestProductionkW](#) (int, double, double, double)  
*Method which takes in production request, and then returns what the asset can deliver (subject to operating constraints, etc.).*
- double [commit](#) (int, double, double, double, double)  
*Method which takes in production and load for the current timestep, computes and records dispatch and curtailment, and then returns remaining load.*
- [~Hydro](#) (void)  
*Destructor for the [Hydro](#) class.*

## Public Attributes

- [HydroTurbineType](#) turbine\_type  
*The type of hydroelectric turbine model to use.*
- double [fluid\\_density\\_kgm3](#)  
*The density [kg/m3] of the hydroelectric working fluid.*
- double [net\\_head\\_m](#)  
*The net head [m] of the asset.*
- double [reservoir\\_capacity\\_m3](#)

- The capacity [m3] of the hydro reservoir.*

    - double [init\\_reservoir\\_state](#)

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

  - double [stored\\_volume\\_m3](#)
- The volume [m3] of stored fluid.*
- double [minimum\\_power\\_kW](#)
- The minimum power [kW] that the asset can produce. Corresponds to minimum productive flow.*
- double [minimum\\_flow\\_m3hr](#)
- The minimum required flow [m3/hr] for the asset to produce. Corresponds to minimum power.*
- double [maximum\\_flow\\_m3hr](#)
- The maximum productive flow [m3/hr] that the asset can support.*
- std::vector< double > [turbine\\_flow\\_vec\\_m3hr](#)
- A vector of the turbine flow [m3/hr] at each point in the modelling time series.*
- std::vector< double > [spill\\_rate\\_vec\\_m3hr](#)
- A vector of the spill rate [m3/hr] at each point in the modelling time series.*
- std::vector< double > [stored\\_volume\\_vec\\_m3](#)
- A vector of the stored volume [m3] in the reservoir at each point in the modelling time series.*

## Private Member Functions

- void [\\_\\_checkInputs](#) ([HydroInputs](#))
- Helper method to check inputs to the [Hydro](#) constructor.*
- void [\\_\\_initInterpolator](#) (void)
- Helper method to set up turbine and generator efficiency interpolation.*
- double [\\_\\_getGenericCapitalCost](#) (void)
- Helper method to generate a generic hydroelectric capital cost.*
- double [\\_\\_getGenericOpMaintCost](#) (void)
- Helper method (private) to generate a generic hydroelectric operation and maintenance cost. This is a cost incurred per unit energy produced.*
- double [\\_\\_getEfficiencyFactor](#) (double)
- Helper method to compute the efficiency factor (product of turbine and generator efficiencies).*
- double [\\_\\_getMinimumFlowm3hr](#) (void)
- Helper method to compute and return the minimum required flow for production, based on turbine type.*
- double [\\_\\_getMaximumFlowm3hr](#) (void)
- Helper method to compute and return the maximum productive flow, based on turbine type.*
- double [\\_\\_flowToPower](#) (double)
- Helper method to translate a given flow into a corresponding power output.*
- double [\\_\\_powerToFlow](#) (double)
- Helper method to translate a given power output into a corresponding flow.*
- double [\\_\\_getAvailableFlow](#) (double, double)
- Helper method to determine what flow is currently available to the turbine.*
- double [\\_\\_getAcceptableFlow](#) (double)
- Helper method to determine what flow is currently acceptable by the reservoir.*
- void [\\_\\_updateState](#) (int, double, double, double)
- Helper method to update and log flow and reservoir state.*
- void [\\_\\_writeSummary](#) (std::string)
- Helper method to write summary results for [Hydro](#).*
- void [\\_\\_writeTimeSeries](#) (std::string, std::vector< double > \*, int=-1)
- Helper method to write time series results for [Hydro](#).*

### 4.8.1 Detailed Description

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

### 4.8.2 Constructor & Destructor Documentation

#### 4.8.2.1 Hydro() [1/2]

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

Constructor (dummy) for the [Hydro](#) class.

```
808 {
809     return;
810 } /* Hydro() */
```

#### 4.8.2.2 Hydro() [2/2]

```
Hydro::Hydro (
    int n_points,
    double n_years,
    HydroInputs hydro_inputs )
```

Constructor (intended) for the [Hydro](#) class.

#### Parameters

<i>n_points</i>	The number of points in the modelling time series.
<i>n_years</i>	The number of years being modelled.
<i>hydro_inputs</i>	A structure of <a href="#">Hydro</a> constructor inputs.

```
838 :
839 Noncombustion(
840     n_points,
841     n_years,
842     hydro_inputs.noncombustion_inputs
843 )
844 {
845     // 1. check inputs
846     this->__checkInputs(hydro_inputs);
847
848     // 2. set attributes
849     this->type = NoncombustionType :: HYDRO;
850     this->type_str = "HYDRO";
851
852     this->resource_key = hydro_inputs.resource_key;
853
854     this->turbine_type = hydro_inputs.turbine_type;
855
856     this->fluid_density_kgm3 = hydro_inputs.fluid_density_kgm3;
857     this->net_head_m = hydro_inputs.net_head_m;
858
859     this->reservoir_capacity_m3 = hydro_inputs.reservoir_capacity_m3;
860     this->init_reservoir_state = hydro_inputs.init_reservoir_state;
861     this->stored_volume_m3 =
```

```

862         hydro_inputs.init_reservoir_state * hydro_inputs.reservoir_capacity_m3;
863
864     this->minimum_power_kW = 0.1 * this->capacity_kW;
865
866     this->__initInterpolator();
867
868     this->minimum_flow_m3hr = this->__getMinimumFlowm3hr();
869     this->maximum_flow_m3hr = this->__getMaximumFlowm3hr();
870
871     this->turbine_flow_vec_m3hr.resize(this->n_points, 0);
872     this->spill_rate_vec_m3hr.resize(this->n_points, 0);
873     this->stored_volume_vec_m3.resize(this->n_points, 0);
874
875     if (hydro_inputs.capital_cost < 0) {
876         this->capital_cost = this->__getGenericCapitalCost();
877     }
878
879     if (hydro_inputs.operation_maintenance_cost_kWh < 0) {
880         this->operation_maintenance_cost_kWh = this->__getGenericOpMaintCost();
881     }
882
883     if (not this->is_sunk) {
884         this->capital_cost_vec[0] = this->capital_cost;
885     }
886
887     return;
888 } /* Hydro() */

```

#### 4.8.2.3 ~Hydro()

```

Hydro::~~Hydro (
    void )

```

Destructor for the [Hydro](#) class.

```

1055 {
1056     // 1. destruction print
1057     if (this->print_flag) {
1058         std::cout << "Hydro object at " << this << " destroyed" << std::endl;
1059     }
1060
1061     return;
1062 } /* ~Hydro() */

```

### 4.8.3 Member Function Documentation

#### 4.8.3.1 \_\_checkInputs()

```

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

```

Helper method to check inputs to the [Hydro](#) constructor.

##### Parameters

<i>hydro_inputs</i>	A structure of <a href="#">Hydro</a> constructor inputs.
---------------------	--

```

39 {
40     // 1. check fluid_density_kgm3
41     if (hydro_inputs.fluid_density_kgm3 <= 0) {
42         std::string error_str = "ERROR: Hydro(): fluid_density_kgm3 must be > 0";
43     }

```

```

44     #ifdef _WIN32
45         std::cout << error_str << std::endl;
46     #endif
47
48     throw std::invalid_argument(error_str);
49 }
50
51 // 2. check net_head_m
52 if (hydro_inputs.net_head_m <= 0) {
53     std::string error_str = "ERROR: Hydro(): net_head_m must be > 0";
54
55     #ifdef _WIN32
56         std::cout << error_str << std::endl;
57     #endif
58
59     throw std::invalid_argument(error_str);
60 }
61
62 // 3. check reservoir_capacity_m3
63 if (hydro_inputs.reservoir_capacity_m3 < 0) {
64     std::string error_str = "ERROR: Hydro(): reservoir_capacity_m3 must be >= 0";
65
66     #ifdef _WIN32
67         std::cout << error_str << std::endl;
68     #endif
69
70     throw std::invalid_argument(error_str);
71 }
72
73 // 4. check init_reservoir_state
74 if (
75     hydro_inputs.init_reservoir_state < 0 or
76     hydro_inputs.init_reservoir_state > 1
77 ) {
78     std::string error_str = "ERROR: Hydro(): init_reservoir_state must be in ";
79     error_str += "the closed interval [0, 1]";
80
81     #ifdef _WIN32
82         std::cout << error_str << std::endl;
83     #endif
84
85     throw std::invalid_argument(error_str);
86 }
87
88 return;
89 } /* __checkInputs() */

```

#### 4.8.3.2 \_\_flowToPower()

```

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

```

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

Ref: [Truelove \[2023b\]](#)

##### Parameters

<i>flow_m3hr</i>	The flow [m3/hr] through the turbine.
------------------	---------------------------------------

##### Returns

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

```

415 {
416     // 1. return on less than minimum flow
417     if (flow_m3hr < this->minimum_flow_m3hr) {
418         return 0;
419     }

```



```

420
421 // 2. interpolate flow to power
422 double power_kW = this->interpolator.interp1D(
423     HydroInterpKeys :: FLOW_TO_POWER_INTERP_KEY,
424     flow_m3hr
425 );
426
427 return power_kW;
428 } /* __flowToPower() */

```

#### 4.8.3.3 \_\_getAcceptableFlow()

```

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

```

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

##### Parameters

<i>dt_hrs</i>	The interval of time [hrs] associated with the timestep.
---------------	--

##### Returns

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

```

517 {
518 // 1. if no reservoir, return
519 if (this->reservoir_capacity_m3 <= 0) {
520     return 0;
521 }
522
523 // 2. compute acceptable based on room in reservoir
524 double acceptable_m3hr = (this->reservoir_capacity_m3 - this->stored_volume_m3) /
525     dt_hrs;
526
527 return acceptable_m3hr;
528 } /* __getAcceptableFlow() */

```

#### 4.8.3.4 \_\_getAvailableFlow()

```

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

```

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

##### Parameters

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

##### Returns

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

```

484 {
485     // 1. init to flow available from stored volume in reservoir
486     double flow_m3hr = this->stored_volume_m3 / dt_hrs;
487
488     // 2. add flow available from resource
489     flow_m3hr += hydro_resource_m3hr;
490
491     // 3. cap at maximum flow
492     if (flow_m3hr > this->maximum_flow_m3hr) {
493         flow_m3hr = this->maximum_flow_m3hr;
494     }
495
496     return flow_m3hr;
497 } /* __getAvailableFlow() */

```

#### 4.8.3.5 \_\_getEfficiencyFactor()

```

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

```

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

Ref: [Truelove \[2023b\]](#)

##### Parameters

<i>power_kW</i>	The
-----------------	-----

```

322 {
323     // 1. return on zero
324     if (power_kW <= 0) {
325         return 0;
326     }
327
328     // 2. compute power ratio (clip to [0, 1])
329     double power_ratio = power_kW / this->capacity_kW;
330
331     // 3. init efficiency factor to the turbine efficiency
332     double efficiency_factor = this->interpolator.interp1D(
333         HydroInterpKeys :: TURBINE_EFFICIENCY_INTERP_KEY,
334         power_ratio
335     );
336
337     // 4. include generator efficiency
338     efficiency_factor *= this->interpolator.interp1D(
339         HydroInterpKeys :: GENERATOR_EFFICIENCY_INTERP_KEY,
340         power_ratio
341     );
342
343     return efficiency_factor;
344 } /* __getEfficiencyFactor() */

```

#### 4.8.3.6 \_\_getGenericCapitalCost()

```

double Hydro::__getGenericCapitalCost (
    void ) [private]

```

Helper method to generate a generic hydroelectric capital cost.

This model was obtained by way of ...

### Returns

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

```
274 {
275     double capital_cost_per_kW = 1000; //<-- WIP: need something better here!
276
277     return capital_cost_per_kW * this->capacity_kW + 15000000; //<-- WIP: need something better here!
278 } /* __getGenericCapitalCost() */
```

#### 4.8.3.7 \_\_getGenericOpMaintCost()

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

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

This model was obtained by way of ...

### Returns

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

```
299 {
300     double operation_maintenance_cost_kWh = 0.05; //<-- WIP: need something better here!
301
302     return operation_maintenance_cost_kWh;
303 } /* __getGenericOpMaintCost() */
```

#### 4.8.3.8 \_\_getMaximumFlowm3hr()

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

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

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

Ref: [Truelove \[2023b\]](#)

### Returns

The maximum productive flow [m<sup>3</sup>/hr].

```
392 {
393     return this->__powerToFlow(this->capacity_kW);
394 } /* __getMaximumFlowm3hr() */
```

#### 4.8.3.9 \_\_getMinimumFlowm3hr()

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

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

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

Ref: [Truelove \[2023b\]](#)

#### Returns

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

```
367 {
368     return this->__powerToFlow(this->minimum_power_kW);
369 } /* __getMinimumFlowm3hr() */
```

#### 4.8.3.10 \_\_initInterpolator()

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

Helper method to set up turbine and generator efficiency interpolation.

Ref: [Truelove \[2023b\]](#)

```
106 {
107     // 1. set up generator efficiency interpolation
108     InterpolatorStruct1D generator_interp_struct_1D;
109
110     generator_interp_struct_1D.n_points = 12;
111
112     generator_interp_struct_1D.x_vec = {
113         0, 0.1, 0.2, 0.3, 0.4, 0.5,
114         0.6, 0.7, 0.75, 0.8, 0.9, 1
115     };
116
117     generator_interp_struct_1D.min_x = 0;
118     generator_interp_struct_1D.max_x = 1;
119
120     generator_interp_struct_1D.y_vec = {
121         0.000, 0.800, 0.900, 0.913,
122         0.925, 0.943, 0.947, 0.950,
123         0.953, 0.954, 0.956, 0.958
124     };
125
126     this->interpolator.interp_map_1D.insert(
127         std::pair<int, InterpolatorStruct1D>(
128             HydroInterpKeys :: GENERATOR_EFFICIENCY_INTERP_KEY,
129             generator_interp_struct_1D
130         )
131     );
132
133     // 2. set up efficiency interpolation
134     InterpolatorStruct1D turbine_interp_struct_1D;
135
136     turbine_interp_struct_1D.n_points = 11;
137
138     turbine_interp_struct_1D.x_vec = {
139         0, 0.1, 0.2, 0.3, 0.4,
140         0.5, 0.6, 0.7, 0.8, 0.9,
141         1
142     };
143
144     turbine_interp_struct_1D.min_x = 0;
```

```

145     turbine_interp_struct_1D.max_x = 1;
146
147     std::vector<double> efficiency_vec;
148
149     switch (this->turbine_type) {
150     case (HydroTurbineType :: HYDRO_TURBINE_PELTON): {
151         efficiency_vec = {
152             0.000, 0.780, 0.855, 0.875, 0.890,
153             0.900, 0.908, 0.913, 0.918, 0.908,
154             0.880
155         };
156
157         break;
158     }
159
160     case (HydroTurbineType :: HYDRO_TURBINE_FRANCIS): {
161         efficiency_vec = {
162             0.000, 0.400, 0.625, 0.745, 0.810,
163             0.845, 0.880, 0.900, 0.910, 0.900,
164             0.850
165         };
166
167         break;
168     }
169
170     case (HydroTurbineType :: HYDRO_TURBINE_KAPLAN): {
171         efficiency_vec = {
172             0.000, 0.265, 0.460, 0.550, 0.650,
173             0.740, 0.805, 0.845, 0.900, 0.880,
174             0.850
175         };
176
177         break;
178     }
179
180     default: {
181         std::string error_str = "ERROR: Hydro(): turbine type ";
182         error_str += std::to_string(this->turbine_type);
183         error_str += " not recognized";
184
185         #ifdef _WIN32
186             std::cout << error_str << std::endl;
187         #endif
188
189         throw std::runtime_error(error_str);
190
191         break;
192     }
193 }
194
195 turbine_interp_struct_1D.y_vec = efficiency_vec;
196
197 this->interpolator.interp_map_1D.insert(
198     std::pair<int, InterpolatorStruct1D>(
199         HydroInterpKeys :: TURBINE_EFFICIENCY_INTERP_KEY,
200         turbine_interp_struct_1D
201     )
202 );
203
204 // 3. set up flow to power interpolation
205 InterpolatorStruct1D flow_to_power_interp_struct_1D;
206
207 double power_ratio = 0.1;
208 std::vector<double> power_ratio_vec (91, 0);
209
210 for (size_t i = 0; i < power_ratio_vec.size(); i++) {
211     power_ratio_vec[i] = power_ratio;
212
213     power_ratio += 0.01;
214
215     if (power_ratio < 0) {
216         power_ratio = 0;
217     }
218
219     else if (power_ratio > 1) {
220         power_ratio = 1;
221     }
222 }
223
224 flow_to_power_interp_struct_1D.n_points = power_ratio_vec.size();
225
226 std::vector<double> flow_vec_m3hr;
227 std::vector<double> power_vec_kW;
228 flow_vec_m3hr.resize(power_ratio_vec.size(), 0);
229 power_vec_kW.resize(power_ratio_vec.size(), 0);
230
231 for (size_t i = 0; i < power_ratio_vec.size(); i++) {

```

```

232         flow_vec_m3hr[i] = this->__powerToFlow(power_ratio_vec[i] * this->capacity_kW);
233         power_vec_kW[i] = power_ratio_vec[i] * this->capacity_kW;
234         /*
235         std::cout << flow_vec_m3hr[i] << "\t" << power_vec_kW[i] << " (" <<
236         power_ratio_vec[i] << ")" << std::endl;
237         */
238     }
239
240     flow_to_power_interp_struct_1D.x_vec = flow_vec_m3hr;
241
242     flow_to_power_interp_struct_1D.min_x = flow_vec_m3hr[0];
243     flow_to_power_interp_struct_1D.max_x = flow_vec_m3hr[flow_vec_m3hr.size() - 1];
244
245     flow_to_power_interp_struct_1D.y_vec = power_vec_kW;
246
247     this->interpolator.interp_map_1D.insert(
248         std::pair<int, InterpolatorStruct1D>(
249             HydroInterpKeys :: FLOW_TO_POWER_INTERP_KEY,
250             flow_to_power_interp_struct_1D
251         )
252     );
253
254     return;
255 } /* __initInterpolator() */

```

#### 4.8.3.11 \_\_powerToFlow()

```

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

```

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

Ref: [Truelove \[2023b\]](#)

##### Parameters

<i>power_kW</i>	The power output [kW] of the hydroelectric generator.
-----------------	---

##### Returns

```

449 {
450     // 1. return on zero power
451     if (power_kW <= 0) {
452         return 0;
453     }
454
455     // 2. get efficiency factor
456     double efficiency_factor = this->__getEfficiencyFactor(power_kW);
457
458     // 3. compute flow
459     double flow_m3hr = 3600 * 1000 * power_kW;
460     flow_m3hr /= efficiency_factor * this->fluid_density_kgm3 * 9.81 * this->net_head_m;
461
462     return flow_m3hr;
463 } /* __powerToFlow() */

```

#### 4.8.3.12 \_\_updateState()

```

void Hydro::__updateState (
    int timestep,

```

```
double dt_hrs,
double production_kW,
double hydro_resource_m3hr ) [private]
```

Helper method to update and log flow and reservoir state.

#### Parameters

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

```
561 {
562     // 1. get turbine flow, log
563     double flow_m3hr = 0;
564
565     if (production_kW >= this->minimum_power_kW) {
566         flow_m3hr = this->__powerToFlow(production_kW);
567     }
568
569     this->turbine_flow_vec_m3hr[timestep] = flow_m3hr;
570
571     // 3. compute net reservoir flow
572     double net_flow_m3hr = hydro_resource_m3hr - flow_m3hr;
573
574     // 4. compute flow acceptable by reservoir
575     double acceptable_flow_m3hr = this->__getAcceptableFlow(dt_hrs);
576
577     // 5. compute spill, update net flow (if applicable), log
578     double spill_m3hr = 0;
579
580     if (acceptable_flow_m3hr < net_flow_m3hr) {
581         spill_m3hr = net_flow_m3hr - acceptable_flow_m3hr;
582         net_flow_m3hr = acceptable_flow_m3hr;
583     }
584
585     this->spill_rate_vec_m3hr[timestep] = spill_m3hr;
586
587     // 6. update reservoir state, log
588     this->stored_volume_m3 += net_flow_m3hr;
589     this->stored_volume_vec_m3[timestep] = this->stored_volume_m3;
590
591     return;
592 } /* __updateState() */
```

#### 4.8.3.13 \_\_writeSummary()

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

Helper method to write summary results for [Hydro](#).

#### Parameters

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

Reimplemented from [Noncombustion](#).

```
610 {
611     // 1. create filestream
612     write_path += "summary_results.md";
613     std::ofstream ofs;
614     ofs.open(write_path, std::ofstream::out);
615 }
```

```

616 // 2. write to summary results (markdown)
617 ofs << " # ";
618 ofs << std::to_string(int(ceil(this->capacity_kW)));
619 ofs << " kW HYDRO Summary Results\n";
620 ofs << "\n-----\n\n";
621
622 // 2.1. Production attributes
623 ofs << "## Production Attributes\n";
624 ofs << "\n";
625
626 ofs << "Capacity: " << this->capacity_kW << " kW \n";
627 ofs << "\n";
628
629 ofs << "Sunk Cost (N = 0 / Y = 1): " << this->is_sunk << " \n";
630 ofs << "Capital Cost: " << this->capital_cost << " \n";
631 ofs << "Operation and Maintenance Cost: " << this->operation_maintenance_cost_kWh
632 << " per kWh produced \n";
633 ofs << "Nominal Inflation Rate (annual): " << this->nominal_inflation_annual
634 << " \n";
635 ofs << "Nominal Discount Rate (annual): " << this->nominal_discount_annual
636 << " \n";
637 ofs << "Real Discount Rate (annual): " << this->real_discount_annual << " \n";
638 ofs << "\n";
639
640 ofs << "Replacement Running Hours: " << this->replace_running_hrs << " \n";
641 ofs << "\n-----\n\n";
642
643 // 2.2. Noncombustion attributes
644 ofs << "## Noncombustion Attributes\n";
645 ofs << "\n";
646
647 //...
648
649 ofs << "\n-----\n\n";
650
651 // 2.3. Hydro attributes
652 ofs << "## Hydro Attributes\n";
653 ofs << "\n";
654
655 ofs << "Fluid Density: " << this->fluid_density_kgm3 << " kg/m3 \n";
656 ofs << "Net Head: " << this->net_head_m << " m \n";
657 ofs << "\n";
658
659 ofs << "Reservoir Volume: " << this->reservoir_capacity_m3 << " m3 \n";
660 ofs << "Reservoir Initial State: " << this->init_reservoir_state << " \n";
661 ofs << "\n";
662
663 ofs << "Turbine Type: ";
664 switch(this->turbine_type) {
665     case(HydroTurbineType :: HYDRO_TURBINE_PELTON): {
666         ofs << "PELTON";
667
668         break;
669     }
670
671     case(HydroTurbineType :: HYDRO_TURBINE_FRANCIS): {
672         ofs << "FRANCIS";
673
674         break;
675     }
676
677     case(HydroTurbineType :: HYDRO_TURBINE_KAPLAN): {
678         ofs << "KAPLAN";
679
680         break;
681     }
682
683     default: {
684         // write nothing!
685
686         break;
687     }
688 }
689 ofs << " \n";
690 ofs << "\n";
691 ofs << "Minimum Flow: " << this->minimum_flow_m3hr << " m3/hr \n";
692 ofs << "Maximum Flow: " << this->maximum_flow_m3hr << " m3/hr \n";
693 ofs << "\n";
694 ofs << "Minimum Production: " << this->minimum_power_kW << " kW \n";
695 ofs << "\n";
696
697 ofs << "\n-----\n\n";
698
699 // 2.4. Hydro Results
700 ofs << "## Results\n";
701 ofs << "\n";
702

```



```

703     ofs << "Net Present Cost: " << this->net_present_cost << " \n";
704     ofs << "\n";
705
706     ofs << "Total Dispatch: " << this->total_dispatch_kWh
707         << " kWh \n";
708
709     ofs << "Levellized Cost of Energy: " << this->levellized_cost_of_energy_kWh
710         << " per kWh dispatched \n";
711     ofs << "\n";
712
713     ofs << "Running Hours: " << this->running_hours << " \n";
714     ofs << "Replacements: " << this->n_replacements << " \n";
715
716     //...
717
718     ofs << "\n-----\n\n";
719
720     ofs.close();
721     return;
722 } /* __writeSummary() */

```

#### 4.8.3.14 \_\_writeTimeSeries()

```

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

```

Helper method to write time series results for [Hydro](#).

##### Parameters

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

Reimplemented from [Noncombustion](#).

```

752 {
753     // 1. create filestream
754     write_path += "time_series_results.csv";
755     std::ofstream ofs;
756     ofs.open(write_path, std::ofstream::out);
757
758     // 2. write time series results (comma separated value)
759     ofs << "Time (since start of data) [hrs],";
760     ofs << "Production [kW],";
761     ofs << "Dispatch [kW],";
762     ofs << "Storage [kW],";
763     ofs << "Curtailment [kW],";
764     ofs << "Is Running (N = 0 / Y = 1),";
765     ofs << "Turbine Flow [m3/hr],";
766     ofs << "Spill Rate [m3/hr],";
767     ofs << "Stored Volume [m3],";
768     ofs << "Capital Cost (actual),";
769     ofs << "Operation and Maintenance Cost (actual),";
770     ofs << "\n";
771
772     for (int i = 0; i < max_lines; i++) {
773         ofs << time_vec_hrs_ptr->at(i) << ",";
774         ofs << this->production_vec_kW[i] << ",";
775         ofs << this->dispatch_vec_kW[i] << ",";
776         ofs << this->storage_vec_kW[i] << ",";
777         ofs << this->curtailment_vec_kW[i] << ",";
778         ofs << this->is_running_vec[i] << ",";
779         ofs << this->turbine_flow_vec_m3hr[i] << ",";
780         ofs << this->spill_rate_vec_m3hr[i] << ",";
781         ofs << this->stored_volume_vec_m3[i] << ",";
782         ofs << this->capital_cost_vec[i] << ",";
783         ofs << this->operation_maintenance_cost_vec[i] << ",";

```

```

784         ofs « "\n";
785     }
786
787     ofs.close();
788     return;
789 } /* __writeTimeSeries() */

```

#### 4.8.3.15 commit()

```

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

```

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

##### Parameters

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

##### Returns

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

Reimplemented from [Noncombustion](#).

```

1022 {
1023     // 1. invoke base class method
1024     load_kW = Noncombustion::commit(
1025         timestep,
1026         dt_hrs,
1027         production_kW,
1028         load_kW
1029     );
1030
1031     // 2. update state and record
1032     this->__updateState(
1033         timestep,
1034         dt_hrs,
1035         production_kW,
1036         hydro_resource_m3hr
1037     );
1038
1039     return load_kW;
1040 } /* commit() */

```

#### 4.8.3.16 handleReplacement()

```

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

```

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

## Parameters

<i>timestep</i>	The current time step of the <a href="#">Model</a> run.
-----------------	---

Reimplemented from [Noncombustion](#).

```

906 {
907     // 1. reset attributes
908     //...
909
910     // 2. invoke base class method
911     Noncombustion::handleRequest(timestep);
912
913     return;
914 } /* __handleRequest() */

```

## 4.8.3.17 requestProductionkW()

```

double Hydro::requestProductionkW (
    int timestep,
    double dt_hrs,
    double request_kW,
    double hydro_resource_m3hr ) [virtual]

```

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

## Parameters

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

## Returns

The production [kW] delivered by the hydro generator.

Reimplemented from [Noncombustion](#).

```

950 {
951     // 1. return on request of zero
952     if (request_kW <= 0) {
953         return 0;
954     }
955
956     // 2. if request is less than minimum power, set to minimum power
957     if (request_kW < this->minimum_power_kW) {
958         request_kW = this->minimum_power_kW;
959     }
960
961     // 3. check available flow, return if less than minimum flow
962     double available_flow_m3hr = this->__getAvailableFlow(dt_hrs, hydro_resource_m3hr);
963
964     if (available_flow_m3hr < this->minimum_flow_m3hr) {
965         return 0;
966     }
967
968     // 4. init production to request, enforce capacity constraint (which also accounts
969     //     for maximum flow constraint).
970     double production_kW = request_kW;
971
972     if (production_kW > this->capacity_kW) {

```

```

973         production_kW = this->capacity_kW;
974     }
975
976     // 5. map production to flow
977     double flow_m3hr = this->__powerToFlow(production_kW);
978
979     // 6. if flow is in excess of available, then adjust production accordingly
980     if (flow_m3hr > available_flow_m3hr) {
981         production_kW = this->__flowToPower(available_flow_m3hr);
982     }
983
984     return production_kW;
985 } /* requestProductionkW() */

```

## 4.8.4 Member Data Documentation

### 4.8.4.1 fluid\_density\_kgm3

```
double Hydro::fluid_density_kgm3
```

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

### 4.8.4.2 init\_reservoir\_state

```
double Hydro::init_reservoir_state
```

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

### 4.8.4.3 maximum\_flow\_m3hr

```
double Hydro::maximum_flow_m3hr
```

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

### 4.8.4.4 minimum\_flow\_m3hr

```
double Hydro::minimum_flow_m3hr
```

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

#### 4.8.4.5 minimum\_power\_kW

```
double Hydro::minimum_power_kW
```

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

#### 4.8.4.6 net\_head\_m

```
double Hydro::net_head_m
```

The net head [m] of the asset.

#### 4.8.4.7 reservoir\_capacity\_m3

```
double Hydro::reservoir_capacity_m3
```

The capacity [m3] of the hydro reservoir.

#### 4.8.4.8 spill\_rate\_vec\_m3hr

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

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

#### 4.8.4.9 stored\_volume\_m3

```
double Hydro::stored_volume_m3
```

The volume [m3] of stored fluid.

#### 4.8.4.10 stored\_volume\_vec\_m3

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

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

#### 4.8.4.11 turbine\_flow\_vec\_m3hr

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

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

#### 4.8.4.12 turbine\_type

```
HydroTurbineType Hydro::turbine_type
```

The type of hydroelectric turbine model to use.

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

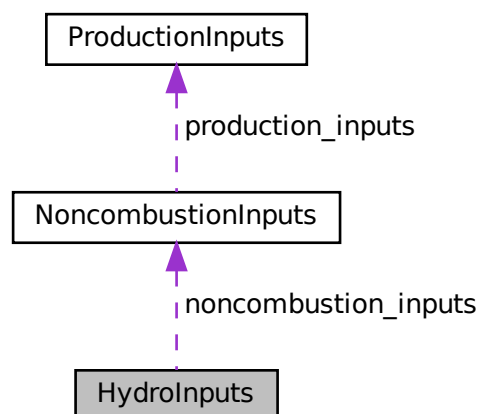
- header/Production/Noncombustion/[Hydro.h](#)
- source/Production/Noncombustion/[Hydro.cpp](#)

## 4.9 HydroInputs Struct Reference

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

```
#include <Hydro.h>
```

Collaboration diagram for HydroInputs:



## Public Attributes

- [NoncombustionInputs](#) `noncombustion_inputs`  
An encapsulated [NoncombustionInputs](#) instance.
- `int resource_key = 0`  
A key used to index into the [Resources](#) object, to associate this asset with the appropriate resource time series.
- `double capital_cost = -1`  
The capital cost of the asset (undefined currency). -1 is a sentinel value, which triggers a generic cost model on construction (in fact, any negative value here will trigger). Note that the generic cost model is in terms of Canadian dollars [CAD].
- `double operation_maintenance_cost_kWh = -1`  
The operation and maintenance cost of the asset [1/kWh] (undefined currency). This is a cost incurred per unit of energy produced. -1 is a sentinel value, which triggers a generic cost model on construction (in fact, any negative value here will trigger). Note that the generic cost model is in terms of Canadian dollars [CAD/kWh].
- `double fluid_density_kgm3 = 1000`  
The density [kg/m3] of the hydroelectric working fluid.
- `double net_head_m = 500`  
The net head [m] of the asset.
- `double reservoir_capacity_m3 = 0`  
The capacity [m3] of the hydro reservoir.
- `double init_reservoir_state = 0`  
The initial state of the reservoir (where state is volume of stored fluid divided by capacity).
- [HydroTurbineType](#) `turbine_type = HydroTurbineType :: HYDRO_TURBINE_PELTON`  
The type of hydroelectric turbine model to use.

### 4.9.1 Detailed Description

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

### 4.9.2 Member Data Documentation

#### 4.9.2.1 capital\_cost

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

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

#### 4.9.2.2 fluid\_density\_kgm3

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

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

#### 4.9.2.3 init\_reservoir\_state

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

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

#### 4.9.2.4 net\_head\_m

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

The net head [m] of the asset.

#### 4.9.2.5 noncombustion\_inputs

```
NoncombustionInputs HydroInputs::noncombustion_inputs
```

An encapsulated [NoncombustionInputs](#) instance.

#### 4.9.2.6 operation\_maintenance\_cost\_kWh

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

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

#### 4.9.2.7 reservoir\_capacity\_m3

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

The capacity [m3] of the hydro reservoir.

#### 4.9.2.8 resource\_key

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

A key used to index into the [Resources](#) object, to associate this asset with the appropriate resource time series.



#### 4.9.2.9 turbine\_type

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

The type of hydroelectric turbine model to use.

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

- header/Production/Noncombustion/[Hydro.h](#)

## 4.10 Interpolator Class Reference

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

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

### Public Member Functions

- [Interpolator](#) (void)  
*Constructor for the [Interpolator](#) class.*
- void [addData1D](#) (int, std::string)  
*Method to add 1D interpolation data to the [Interpolator](#).*
- void [addData2D](#) (int, std::string)  
*Method to add 2D interpolation data to the [Interpolator](#).*
- double [interp1D](#) (int, double)  
*Method to perform a 1D interpolation.*
- double [interp2D](#) (int, double, double)  
*Method to perform a 2D interpolation.*
- [~Interpolator](#) (void)  
*Destructor for the [Interpolator](#) class.*

### Public Attributes

- std::map< int, [InterpolatorStruct1D](#) > [interp\\_map\\_1D](#)  
*A map <int, [InterpolatorStruct1D](#)> of given 1D interpolation data.*
- std::map< int, std::string > [path\\_map\\_1D](#)  
*A map <int, string> of the paths (either relative or absolute) to the given 1D interpolation data.*
- std::map< int, [InterpolatorStruct2D](#) > [interp\\_map\\_2D](#)  
*A map <int, [InterpolatorStruct2D](#)> of given 2D interpolation data.*
- std::map< int, std::string > [path\\_map\\_2D](#)  
*A map <int, string> of the paths (either relative or absolute) to the given 2D interpolation data.*

## Private Member Functions

- void [\\_\\_checkDataKey1D](#) (int)  
*Helper method to check if given data key (1D) is already in use.*
- void [\\_\\_checkDataKey2D](#) (int)  
*Helper method to check if given data key (2D) is already in use.*
- void [\\_\\_checkBounds1D](#) (int, double)  
*Helper method to check that the given 1D interpolation value is contained within the given corresponding data domain. Also checks that the data key has been registered.*
- void [\\_\\_checkBounds2D](#) (int, double, double)  
*Helper method to check that the given 2D interpolation value is contained within the given corresponding data domain. Also checks that the data key has been registered.*
- void [\\_\\_throwReadError](#) (std::string, int)  
*Helper method to throw a read error whenever non-numeric data is encountered where only numeric data should be.*
- bool [\\_\\_isNonNumeric](#) (std::string)  
*Helper method to determine if given string is non-numeric (i.e., contains.*
- int [\\_\\_getInterpolationIndex](#) (double, std::vector< double > \*)  
*Helper method to get appropriate interpolation index into given vector.*
- std::vector< std::string > [\\_\\_splitCommaSeparatedString](#) (std::string, std::string="|")  
*Helper method to split a comma-separated string into a vector of substrings.*
- std::vector< std::vector< std::string > > [\\_\\_getDataStringMatrix](#) (std::string)
- void [\\_\\_readData1D](#) (int, std::string)  
*Helper method to read the given 1D interpolation data into [Interpolator](#).*
- void [\\_\\_readData2D](#) (int, std::string)  
*Helper method to read the given 2D interpolation data into [Interpolator](#).*

### 4.10.1 Detailed Description

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

### 4.10.2 Constructor & Destructor Documentation

#### 4.10.2.1 Interpolator()

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

Constructor for the [Interpolator](#) class.

```
682 {
683     //...
684
685     return;
686 } /* Interpolator() */
```

### 4.10.2.2 ~Interpolator()

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

Destructor for the [Interpolator](#) class.

```
868 {
869     //...
870
871     return;
872 } /* ~Interpolator() */
```

## 4.10.3 Member Function Documentation

### 4.10.3.1 \_\_checkBounds1D()

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

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

#### Parameters

<i>data_key</i>	A key associated with the given interpolation data.
<i>interp_x</i>	The query value to be interpolated.

```
108 {
109     // 1. key error
110     if (this->interp_map_1D.count(data_key) == 0) {
111         std::string error_str = "ERROR: Interpolator::interp1D() ";
112         error_str += "data key ";
113         error_str += std::to_string(data_key);
114         error_str += " has not been registered";
115
116         #ifdef _WIN32
117             std::cout << error_str << std::endl;
118         #endif
119
120         throw std::invalid_argument(error_str);
121     }
122
123     // 2. bounds error
124     if (
125         interp_x < this->interp_map_1D[data_key].min_x or
126         interp_x > this->interp_map_1D[data_key].max_x
127     ) {
128         std::string error_str = "ERROR: Interpolator::interp1D() ";
129         error_str += "interpolation value ";
130         error_str += std::to_string(interp_x);
131         error_str += " is outside of the given interpolation data domain [";
132         error_str += std::to_string(this->interp_map_1D[data_key].min_x);
133         error_str += " , ";
134         error_str += std::to_string(this->interp_map_1D[data_key].max_x);
135         error_str += " ]";
136
137         #ifdef _WIN32
138             std::cout << error_str << std::endl;
139         #endif
140
141         throw std::invalid_argument(error_str);
142     }
143 }
```

```

144     return;
145 } /* __checkBounds1D() */

```

#### 4.10.3.2 \_\_checkBounds2D()

```

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

```

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

##### Parameters

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

```

168 {
169     // 1. key error
170     if (this->interp_map_2D.count(data_key) == 0) {
171         std::string error_str = "ERROR: Interpolator::interp2D() ";
172         error_str += "data key ";
173         error_str += std::to_string(data_key);
174         error_str += " has not been registered";
175
176         #ifdef _WIN32
177             std::cout << error_str << std::endl;
178         #endif
179
180         throw std::invalid_argument(error_str);
181     }
182
183     // 2. bounds error (x_interp)
184     if (
185         interp_x < this->interp_map_2D[data_key].min_x or
186         interp_x > this->interp_map_2D[data_key].max_x
187     ) {
188         std::string error_str = "ERROR: Interpolator::interp2D() ";
189         error_str += "interpolation value interp_x = ";
190         error_str += std::to_string(interp_x);
191         error_str += " is outside of the given interpolation data domain [";
192         error_str += std::to_string(this->interp_map_2D[data_key].min_x);
193         error_str += " , ";
194         error_str += std::to_string(this->interp_map_2D[data_key].max_x);
195         error_str += " ]";
196
197         #ifdef _WIN32
198             std::cout << error_str << std::endl;
199         #endif
200
201         throw std::invalid_argument(error_str);
202     }
203
204     // 2. bounds error (y_interp)
205     if (
206         interp_y < this->interp_map_2D[data_key].min_y or
207         interp_y > this->interp_map_2D[data_key].max_y
208     ) {
209         std::string error_str = "ERROR: Interpolator::interp2D() ";
210         error_str += "interpolation value interp_y = ";
211         error_str += std::to_string(interp_y);
212         error_str += " is outside of the given interpolation data domain [";
213         error_str += std::to_string(this->interp_map_2D[data_key].min_y);
214         error_str += " , ";
215         error_str += std::to_string(this->interp_map_2D[data_key].max_y);
216         error_str += " ]";
217

```

```

218         #ifdef _WIN32
219             std::cout << error_str << std::endl;
220         #endif
221
222         throw std::invalid_argument(error_str);
223     }
224
225     return;
226 } /* __checkBounds2D() */

```

#### 4.10.3.3 \_\_checkDataKey1D()

```

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

```

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

##### Parameters

<i>data_key</i>	The key associated with the given 1D interpolation data.
-----------------	--

```

40 {
41     if (this->interp_map_1D.count(data_key) > 0) {
42         std::string error_str = "ERROR: Interpolator::addData1D() ";
43         error_str += "data key (1D) ";
44         error_str += std::to_string(data_key);
45         error_str += " is already in use";
46
47         #ifdef _WIN32
48             std::cout << error_str << std::endl;
49         #endif
50
51         throw std::invalid_argument(error_str);
52     }
53
54     return;
55 } /* __checkDataKey1D() */

```

#### 4.10.3.4 \_\_checkDataKey2D()

```

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

```

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

##### Parameters

<i>data_key</i>	The key associated with the given 2D interpolation data.
-----------------	--

```

72 {
73     if (this->interp_map_2D.count(data_key) > 0) {
74         std::string error_str = "ERROR: Interpolator::addData2D() ";
75         error_str += "data key (2D) ";
76         error_str += std::to_string(data_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 } /* __checkDataKey2D() */

```

#### 4.10.3.5 \_\_getDataStringMatrix()

```

std::vector< std::vector< std::string > > Interpolator::__getDataStringMatrix (
    std::string path_2_data ) [private]
401 {
402     // 1. create input file stream
403     std::ifstream ifs;
404     ifs.open(path_2_data);
405
406     // 2. check that open() worked
407     if (not ifs.is_open()) {
408         std::string error_str = "ERROR: Interpolator::__getDataStringMatrix() ";
409         error_str += " failed to open ";
410         error_str += path_2_data;
411
412         #ifdef _WIN32
413             std::cout << error_str << std::endl;
414         #endif
415
416         throw std::invalid_argument(error_str);
417     }
418
419     // 3. read file line by line
420     bool is_header = true;
421     std::string line;
422     std::vector<std::string> line_split_vec;
423     std::vector<std::vector<std::string>> string_matrix;
424
425     while (not ifs.eof()) {
426         std::getline(ifs, line);
427
428         if (is_header) {
429             is_header = false;
430             continue;
431         }
432
433         line_split_vec = this->__splitCommaSeparatedString(line);
434
435         if (not line_split_vec.empty()) {
436             string_matrix.push_back(line_split_vec);
437         }
438     }
439
440     ifs.close();
441     return string_matrix;
442 } /* __getDataStringMatrix() */

```

#### 4.10.3.6 \_\_getInterpolationIndex()

```

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

```

Helper method to get appropriate interpolation index into given vector.

##### Parameters

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

**Returns**

The appropriate interpolation index into the given vector.

```

318 {
319     int idx = 0;
320     while (
321         not (interp_x >= x_vec_ptr->at(idx) and interp_x <= x_vec_ptr->at(idx + 1))
322     ) {
323         idx++;
324     }
325
326     return idx;
327 } /* __getInterpolationIndex() */

```

**4.10.3.7 \_\_isNonNumeric()**

```

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

```

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

**Parameters**

<i>str</i>	The string being tested.
------------	--------------------------

**Returns**

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

```

283 {
284     for (size_t i = 0; i < str.size(); i++) {;
285         if (isalpha(str[i])) {
286             return true;
287         }
288     }
289
290     return false;
291 } /* __isAlpha() */

```

**4.10.3.8 \_\_readData1D()**

```

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

```

Helper method to read the given 1D interpolation data into [Interpolator](#).

**Parameters**

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

```

462 {
463     // 1. get string matrix
464     std::vector<std::vector<std::string>> string_matrix =
465         this->__getDataStringMatrix(path_2_data);

```

```

466
467 // 2. read string matrix contents into 1D interpolation struct
468 InterpolatorStruct1D interp_struct_1D;
469
470 interp_struct_1D.n_points = string_matrix.size();
471 interp_struct_1D.x_vec.resize(interp_struct_1D.n_points, 0);
472 interp_struct_1D.y_vec.resize(interp_struct_1D.n_points, 0);
473
474 for (int i = 0; i < interp_struct_1D.n_points; i++) {
475     try {
476         interp_struct_1D.x_vec[i] = std::stod(string_matrix[i][0]);
477         interp_struct_1D.y_vec[i] = std::stod(string_matrix[i][1]);
478     }
479
480     catch (...) {
481         this->__throwReadError(path_2_data, 1);
482     }
483 }
484
485 interp_struct_1D.min_x = interp_struct_1D.x_vec[0];
486 interp_struct_1D.max_x = interp_struct_1D.x_vec[interp_struct_1D.n_points - 1];
487
488 // 3. write struct to map
489 this->interp_map_1D.insert(
490     std::pair<int, InterpolatorStruct1D>(data_key, interp_struct_1D)
491 );
492
493 /*
494 // ==== TEST PRINT ==== //
495 std::cout << std::endl;
496 std::cout << path_2_data << std::endl;
497 std::cout << "-----" << std::endl;
498
499 std::cout << "n_points: " << this->interp_map_1D[data_key].n_points << std::endl;
500
501 std::cout << "x_vec: [";
502 for (
503     int i = 0;
504     i < this->interp_map_1D[data_key].n_points;
505     i++
506 ) {
507     std::cout << this->interp_map_1D[data_key].x_vec[i] << ", ";
508 }
509 std::cout << "]" << std::endl;
510
511 std::cout << "y_vec: [";
512 for (
513     int i = 0;
514     i < this->interp_map_1D[data_key].n_points;
515     i++
516 ) {
517     std::cout << this->interp_map_1D[data_key].y_vec[i] << ", ";
518 }
519 std::cout << "]" << std::endl;
520
521 std::cout << std::endl;
522 // ==== END TEST PRINT ==== //
523 */
524
525 return;
526 } /* __readData1D() */

```

#### 4.10.3.9 \_\_readData2D()

```

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

```

Helper method to read the given 2D interpolation data into [Interpolator](#).

##### Parameters

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



```

546 {
547     // 1. get string matrix
548     std::vector<std::vector<std::string>> string_matrix =
549         this->__getDataStringMatrix(path_2_data);
550
551     // 2. read string matrix contents into 2D interpolation map
552     InterpolatorStruct2D interp_struct_2D;
553
554     interp_struct_2D.n_rows = string_matrix.size() - 1;
555     interp_struct_2D.n_cols = string_matrix[0].size() - 1;
556
557     interp_struct_2D.x_vec.resize(interp_struct_2D.n_cols, 0);
558     interp_struct_2D.y_vec.resize(interp_struct_2D.n_rows, 0);
559
560     interp_struct_2D.z_matrix.resize(interp_struct_2D.n_rows, {});
561
562     for (int i = 0; i < interp_struct_2D.n_rows; i++) {
563         interp_struct_2D.z_matrix[i].resize(interp_struct_2D.n_cols, 0);
564     }
565
566     for (size_t i = 1; i < string_matrix[0].size(); i++) {
567         try {
568             interp_struct_2D.x_vec[i - 1] = std::stod(string_matrix[0][i]);
569         }
570
571         catch (...) {
572             this->__throwReadError(path_2_data, 2);
573         }
574     }
575
576     interp_struct_2D.min_x = interp_struct_2D.x_vec[0];
577     interp_struct_2D.max_x = interp_struct_2D.x_vec[interp_struct_2D.n_cols - 1];
578
579     for (size_t i = 1; i < string_matrix.size(); i++) {
580         try {
581             interp_struct_2D.y_vec[i - 1] = std::stod(string_matrix[i][0]);
582         }
583
584         catch (...) {
585             this->__throwReadError(path_2_data, 2);
586         }
587     }
588
589     interp_struct_2D.min_y = interp_struct_2D.y_vec[0];
590     interp_struct_2D.max_y = interp_struct_2D.y_vec[interp_struct_2D.n_rows - 1];
591
592     for (size_t i = 1; i < string_matrix.size(); i++) {
593         for (size_t j = 1; j < string_matrix[0].size(); j++) {
594             try {
595                 interp_struct_2D.z_matrix[i - 1][j - 1] = std::stod(string_matrix[i][j]);
596             }
597
598             catch (...) {
599                 this->__throwReadError(path_2_data, 2);
600             }
601         }
602     }
603
604     // 3. write struct to map
605     this->interp_map_2D.insert(
606         std::pair<int, InterpolatorStruct2D>(data_key, interp_struct_2D)
607     );
608
609     /*
610     // ==== TEST PRINT ==== //
611     std::cout << std::endl;
612     std::cout << path_2_data << std::endl;
613     std::cout << "-----" << std::endl;
614
615     std::cout << "n_rows: " << this->interp_map_2D[data_key].n_rows << std::endl;
616     std::cout << "n_cols: " << this->interp_map_2D[data_key].n_cols << std::endl;
617
618     std::cout << "x_vec: [";
619     for (
620         int i = 0;
621         i < this->interp_map_2D[data_key].n_cols;
622         i++
623     ) {
624         std::cout << this->interp_map_2D[data_key].x_vec[i] << ", ";
625     }
626     std::cout << "]" << std::endl;
627
628     std::cout << "y_vec: [";
629     for (
630         int i = 0;
631         i < this->interp_map_2D[data_key].n_rows;
632         i++

```

```

633     ) {
634         std::cout << this->interp_map_2D[data_key].y_vec[i] << ", ";
635     }
636     std::cout << "]" << std::endl;
637
638     std::cout << "z_matrix:" << std::endl;
639     for (
640         int i = 0;
641         i < this->interp_map_2D[data_key].n_rows;
642         i++
643     ) {
644         std::cout << "\t[";
645
646         for (
647             int j = 0;
648             j < this->interp_map_2D[data_key].n_cols;
649             j++
650         ) {
651             std::cout << this->interp_map_2D[data_key].z_matrix[i][j] << ", ";
652         }
653
654         std::cout << "]" << std::endl;
655     }
656     std::cout << std::endl;
657
658     std::cout << std::endl;
659     // ==== END TEST PRINT ==== //
660     /**/
661
662     return;
663 } /* __readData2D() */

```

#### 4.10.3.10 \_\_splitCommaSeparatedString()

```

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

```

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

##### Parameters

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

##### Returns

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

```

356 {
357     std::vector<std::string> str_split_vec;
358
359     size_t idx = 0;
360     std::string substr;
361
362     while ((idx = str.find(',', idx)) != std::string::npos) {
363         substr = str.substr(0, idx);
364
365         if (substr == break_str) {
366             break;
367         }
368
369         str_split_vec.push_back(substr);
370
371         str.erase(0, idx + 1);
372     }
373
374     return str_split_vec;
375 } /* __splitCommaSeparatedString() */

```

**4.10.3.11 \_\_throwReadError()**

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

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

**Parameters**

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

```
247 {
248     std::string error_str = "ERROR: Interpolator::addData";
249     error_str += std::to_string(dimensions);
250     error_str += "D() ";
251     error_str += " failed to read ";
252     error_str += path_2_data;
253     error_str += " (this is probably a std::stod() error; is there non-numeric ";
254     error_str += "data where only numeric data should be?)";
255
256     #ifdef _WIN32
257         std::cout << error_str << std::endl;
258     #endif
259
260     throw std::runtime_error(error_str);
261
262     return;
263 } /* __throwReadError() */
```

**4.10.3.12 addData1D()**

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

Method to add 1D interpolation data to the [Interpolator](#).

**Parameters**

<i>data_key</i>	A key used to index into the <a href="#">Interpolator</a> .
<i>path_2_data</i>	A path (either relative or absolute) to the given 1D interpolation data.

```
706 {
707     // 1. check key
708     this->__checkDataKey1D(data_key);
709
710     // 2. read data into map
711     this->__readData1D(data_key, path_2_data);
712
713     // 3. record path
714     this->path_map_1D.insert(std::pair<int, std::string>(data_key, path_2_data));
715
716     return;
717 } /* addData1D() */
```

#### 4.10.3.13 addData2D()

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

Method to add 2D interpolation data to the [Interpolator](#).

##### Parameters

<i>data_key</i>	A key used to index into the <a href="#">Interpolator</a> .
<i>path_2_data</i>	A path (either relative or absolute) to the given 2D interpolation data.

```
737 {
738     // 1. check key
739     this->__checkDataKey2D(data_key);
740
741     // 2. read data into map
742     this->__readData2D(data_key, path_2_data);
743
744     // 3. record path
745     this->path_map_2D.insert(std::pair<int, std::string>(data_key, path_2_data));
746
747     return;
748 } /* addData2D() */
```

#### 4.10.3.14 interp1D()

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

Method to perform a 1D interpolation.

##### Parameters

<i>data_key</i>	A key used to index into the <a href="#">Interpolator</a> .
<i>interp_x</i>	The query value to be interpolated. If this value is outside the domain of the associated interpolation data, then an error will occur.

##### Returns

An interpolation of the given query value.

```
770 {
771     // 1. check bounds
772     this->__checkBounds1D(data_key, interp_x);
773
774     // 2. get interpolation index
775     int idx = this->__getInterpolationIndex(
776         interp_x,
777         &(this->interp_map_1D[data_key].x_vec)
778     );
779
780     // 3. perform interpolation
781     double x_0 = this->interp_map_1D[data_key].x_vec[idx];
782     double x_1 = this->interp_map_1D[data_key].x_vec[idx + 1];
783
784     double y_0 = this->interp_map_1D[data_key].y_vec[idx];
785     double y_1 = this->interp_map_1D[data_key].y_vec[idx + 1];
786
787     double interp_y = ((y_1 - y_0) / (x_1 - x_0)) * (interp_x - x_0) + y_0;
```

```

788
789     return interp_y;
790 }    /* interp1D() */

```

#### 4.10.3.15 interp2D()

```

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

```

Method to perform a 2D interpolation.

##### Parameters

<i>data_key</i>	A key used to index into the <a href="#">Interpolator</a> .
<i>interp_x</i>	The first query value to be interpolated. If this value is outside the domain of the associated interpolation data, then an error will occur.
<i>interp_y</i>	The second query value to be interpolated. If this value is outside the domain of the associated interpolation data, then an error will occur.

##### Returns

An interpolation of the given query values.

```

815 {
816     // 1. check bounds
817     this->__checkBounds2D(data_key, interp_x, interp_y);
818
819     // 2. get interpolation indices
820     int idx_x = this->__getInterpolationIndex(
821         interp_x,
822         &(this->interp_map_2D[data_key].x_vec)
823     );
824
825     int idx_y = this->__getInterpolationIndex(
826         interp_y,
827         &(this->interp_map_2D[data_key].y_vec)
828     );
829
830     // 3. perform first horizontal interpolation
831     double x_0 = this->interp_map_2D[data_key].x_vec[idx_x];
832     double x_1 = this->interp_map_2D[data_key].x_vec[idx_x + 1];
833
834     double z_0 = this->interp_map_2D[data_key].z_matrix[idx_y][idx_x];
835     double z_1 = this->interp_map_2D[data_key].z_matrix[idx_y][idx_x + 1];
836
837     double interp_z_0 = ((z_1 - z_0) / (x_1 - x_0)) * (interp_x - x_0) + z_0;
838
839     // 4. perform second horizontal interpolation
840     z_0 = this->interp_map_2D[data_key].z_matrix[idx_y + 1][idx_x];
841     z_1 = this->interp_map_2D[data_key].z_matrix[idx_y + 1][idx_x + 1];
842
843     double interp_z_1 = ((z_1 - z_0) / (x_1 - x_0)) * (interp_x - x_0) + z_0;
844
845     // 5. perform vertical interpolation
846     double y_0 = this->interp_map_2D[data_key].y_vec[idx_y];
847     double y_1 = this->interp_map_2D[data_key].y_vec[idx_y + 1];
848
849     double interp_z =
850         ((interp_z_1 - interp_z_0) / (y_1 - y_0)) * (interp_y - y_0) + interp_z_0;
851
852     return interp_z;
853 }    /* interp2D() */

```

## 4.10.4 Member Data Documentation

### 4.10.4.1 interp\_map\_1D

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

A map <int, [InterpolatorStruct1D](#)> of given 1D interpolation data.

### 4.10.4.2 interp\_map\_2D

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

A map <int, [InterpolatorStruct2D](#)> of given 2D interpolation data.

### 4.10.4.3 path\_map\_1D

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

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

### 4.10.4.4 path\_map\_2D

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

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

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

- header/[Interpolator.h](#)
- source/[Interpolator.cpp](#)

## 4.11 InterpolatorStruct1D Struct Reference

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

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

## Public Attributes

- int `n_points` = 0  
*The number of data points in each parallel vector.*
- `std::vector< double > x_vec` = {}  
*A vector of independent data.*
- double `min_x` = 0  
*The minimum (i.e., first) element of `x_vec`.*
- double `max_x` = 0  
*The maximum (i.e., last) element of `x_vec`.*
- `std::vector< double > y_vec` = {}  
*A vector of dependent data.*

### 4.11.1 Detailed Description

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

### 4.11.2 Member Data Documentation

#### 4.11.2.1 `max_x`

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

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

#### 4.11.2.2 `min_x`

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

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

#### 4.11.2.3 `n_points`

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

The number of data points in each parallel vector.

#### 4.11.2.4 x\_vec

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

A vector of independent data.

#### 4.11.2.5 y\_vec

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

A vector of dependent data.

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

- header/[Interpolator.h](#)

## 4.12 InterpolatorStruct2D Struct Reference

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

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

### Public Attributes

- int [n\\_rows](#) = 0  
*The number of rows in the matrix (also the length of y\_vec)*
- int [n\\_cols](#) = 0  
*The number of cols in the matrix (also the length of x\_vec)*
- std::vector< double > [x\\_vec](#) = {}  
*A vector of independent data (columns).*
- double [min\\_x](#) = 0  
*The minimum (i.e., first) element of x\_vec.*
- double [max\\_x](#) = 0  
*The maximum (i.e., last) element of x\_vec.*
- std::vector< double > [y\\_vec](#) = {}  
*A vector of independent data (rows).*
- double [min\\_y](#) = 0  
*The minimum (i.e., first) element of y\_vec.*
- double [max\\_y](#) = 0  
*The maximum (i.e., last) element of y\_vec.*
- std::vector< std::vector< double > > [z\\_matrix](#) = {}  
*A matrix of dependent data.*

#### 4.12.1 Detailed Description

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



## 4.12.2 Member Data Documentation

### 4.12.2.1 max\_x

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

The maximum (i.e., last) element of x\_vec.

### 4.12.2.2 max\_y

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

The maximum (i.e., last) element of y\_vec.

### 4.12.2.3 min\_x

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

The minimum (i.e., first) element of x\_vec.

### 4.12.2.4 min\_y

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

The minimum (i.e., first) element of y\_vec.

### 4.12.2.5 n\_cols

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

The number of cols in the matrix (also the length of x\_vec)

#### 4.12.2.6 n\_rows

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

The number of rows in the matrix (also the length of y\_vec)

#### 4.12.2.7 x\_vec

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

A vector of independent data (columns).

#### 4.12.2.8 y\_vec

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

A vector of independent data (rows).

#### 4.12.2.9 z\_matrix

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

A matrix of dependent data.

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

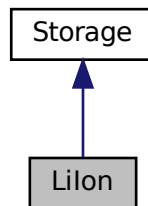
- header/[Interpolator.h](#)

## 4.13 Lilon Class Reference

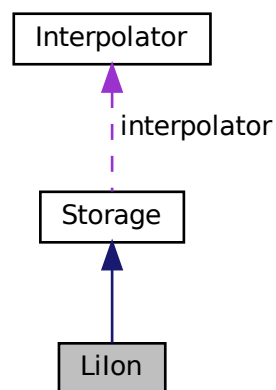
A derived class of [Storage](#) which models energy storage by way of lithium-ion batteries.

```
#include <LiIon.h>
```

Inheritance diagram for Lilon:



Collaboration diagram for Lilon:



### Public Member Functions

- [Lilon](#) (void)  
*Constructor (dummy) for the [Lilon](#) class.*
- [Lilon](#) (int, double, [LilonInputs](#))  
*Constructor (intended) for the [Lilon](#) class.*
- void [handleReplacement](#) (int)  
*Method to handle asset replacement and capital cost incursion, if applicable.*
- double [getAvailablekW](#) (double)

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

  - double [getAcceptablekW](#) (double)

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

  - void [commitCharge](#) (int, double, double)

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

  - double [commitDischarge](#) (int, double, double, double)

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

  - [~Lilon](#) (void)

*Destructor for the [Lilon](#) class.*

## Public Attributes

- double [dynamic\\_energy\\_capacity\\_kWh](#)

*The dynamic (i.e. degrading) energy capacity [kWh] of the asset.*
- double [SOH](#)

*The state of health of the asset.*
- double [replace\\_SOH](#)

*The state of health at which the asset is considered "dead" and must be replaced.*
- double [degradation\\_alpha](#)

*A dimensionless acceleration coefficient used in modelling energy capacity degradation.*
- double [degradation\\_beta](#)

*A dimensionless acceleration exponent used in modelling energy capacity degradation.*
- double [degradation\\_B\\_hat\\_cal\\_0](#)

*A reference (or base) pre-exponential factor [1/sqrt(hrs)] used in modelling energy capacity degradation.*
- double [degradation\\_r\\_cal](#)

*A dimensionless constant used in modelling energy capacity degradation.*
- double [degradation\\_Ea\\_cal\\_0](#)

*A reference (or base) activation energy [J/mol] used in modelling energy capacity degradation.*
- double [degradation\\_a\\_cal](#)

*A pre-exponential factor [J/mol] used in modelling energy capacity degradation.*
- double [degradation\\_s\\_cal](#)

*A dimensionless constant used in modelling energy capacity degradation.*
- double [gas\\_constant\\_JmolK](#)

*The universal gas constant [J/mol.K].*
- double [temperature\\_K](#)

*The absolute environmental temperature [K] of the lithium ion battery energy storage system.*
- double [init\\_SOC](#)

*The initial state of charge of the asset.*
- double [min\\_SOC](#)

*The minimum state of charge of the asset. Will toggle `is_depleted` when reached.*
- double [hysteresis\\_SOC](#)

*The state of charge the asset must achieve to toggle `is_depleted`.*
- double [max\\_SOC](#)

*The maximum state of charge of the asset.*
- double [charging\\_efficiency](#)

*The charging efficiency of the asset.*
- double [discharging\\_efficiency](#)

*The discharging efficiency of the asset.*
- `std::vector< double >` [SOH\\_vec](#)

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

## Private Member Functions

- void [\\_\\_checkInputs](#) ([LilonInputs](#))  
*Helper method to check inputs to the [Lilon](#) constructor.*
- double [\\_\\_getGenericCapitalCost](#) (void)  
*Helper method to generate a generic lithium ion battery energy storage system capital cost.*
- double [\\_\\_getGenericOpMaintCost](#) (void)  
*Helper method to generate a generic lithium ion battery energy storage system operation and maintenance cost. This is a cost incurred per unit energy charged/discharged.*
- void [\\_\\_toggleDepleted](#) (void)  
*Helper method to toggle the `is_depleted` attribute of [Lilon](#).*
- void [\\_\\_handleDegradation](#) (int, double, double)  
*Helper method to apply degradation modelling and update attributes.*
- void [\\_\\_modelDegradation](#) (double, double)  
*Helper method to model energy capacity degradation as a function of operating state.*
- double [\\_\\_getBcal](#) (double)  
*Helper method to compute and return the base pre-exponential factor for a given state of charge.*
- double [\\_\\_getEacal](#) (double)  
*Helper method to compute and return the activation energy value for a given state of charge.*
- void [\\_\\_writeSummary](#) (std::string)  
*Helper method to write summary results for [Lilon](#).*
- void [\\_\\_writeTimeSeries](#) (std::string, std::vector< double > \*, int=-1)  
*Helper method to write time series results for [Lilon](#).*

### 4.13.1 Detailed Description

A derived class of [Storage](#) which models energy storage by way of lithium-ion batteries.

### 4.13.2 Constructor & Destructor Documentation

#### 4.13.2.1 [Lilon\(\)](#) [1/2]

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

Constructor (dummy) for the [Lilon](#) class.

```
646 {
647     return;
648 } /* LiIon() */
```

#### 4.13.2.2 [Lilon\(\)](#) [2/2]

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

Constructor (intended) for the [Lilon](#) class.

## Parameters

<i>n_points</i>	The number of points in the modelling time series.
<i>n_years</i>	The number of years being modelled.
<i>liion_inputs</i>	A structure of <a href="#">Lilion</a> constructor inputs.

```

676 :
677 Storage(
678     n_points,
679     n_years,
680     liion_inputs.storage_inputs
681 )
682 {
683     // 1. check inputs
684     this->__checkInputs(liion_inputs);
685
686     // 2. set attributes
687     this->type = StorageType :: LIION;
688     this->type_str = "LIION";
689
690     this->dynamic_energy_capacity_kWh = this->energy_capacity_kWh;
691     this->SOH = 1;
692     this->replace_SOH = liion_inputs.replace_SOH;
693
694     this->degradation_alpha = liion_inputs.degradation_alpha;
695     this->degradation_beta = liion_inputs.degradation_beta;
696     this->degradation_B_hat_cal_0 = liion_inputs.degradation_B_hat_cal_0;
697     this->degradation_r_cal = liion_inputs.degradation_r_cal;
698     this->degradation_Ea_cal_0 = liion_inputs.degradation_Ea_cal_0;
699     this->degradation_a_cal = liion_inputs.degradation_a_cal;
700     this->degradation_s_cal = liion_inputs.degradation_s_cal;
701     this->gas_constant_JmolK = liion_inputs.gas_constant_JmolK;
702     this->temperature_K = liion_inputs.temperature_K;
703
704     this->init_SOC = liion_inputs.init_SOC;
705     this->charge_kWh = this->init_SOC * this->energy_capacity_kWh;
706
707     this->min_SOC = liion_inputs.min_SOC;
708     this->hysteresis_SOC = liion_inputs.hysteresis_SOC;
709     this->max_SOC = liion_inputs.max_SOC;
710
711     this->charging_efficiency = liion_inputs.charging_efficiency;
712     this->discharging_efficiency = liion_inputs.discharging_efficiency;
713
714     if (liion_inputs.capital_cost < 0) {
715         this->capital_cost = this->__getGenericCapitalCost();
716     }
717
718     if (liion_inputs.operation_maintenance_cost_kWh < 0) {
719         this->operation_maintenance_cost_kWh = this->__getGenericOpMaintCost();
720     }
721
722     if (not this->is_sunk) {
723         this->capital_cost_vec[0] = this->capital_cost;
724     }
725
726     this->SOH_vec.resize(this->n_points, 0);
727
728     // 3. construction print
729     if (this->print_flag) {
730         std::cout << "LiIon object constructed at " << this << std::endl;
731     }
732
733     return;
734 } /* LiIon() */

```

## 4.13.2.3 ~Lilion()

```

LiIon::~LiIon (
    void )

```

Destructor for the [Lilion](#) class.

```

990 {
991     // 1. destruction print

```

```

992     if (this->print_flag) {
993         std::cout << "LiIon object at " << this << " destroyed" << std::endl;
994     }
995     return;
996 } /* ~LiIon() */
997 }

```

### 4.13.3 Member Function Documentation

#### 4.13.3.1 \_\_checkInputs()

```

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

```

Helper method to check inputs to the [Lilon](#) constructor.

##### Parameters

<i>liion_inputs</i>	A structure of <a href="#">Lilon</a> constructor inputs.
---------------------	--

```

39 {
40     // 1. check replace_SOH
41     if (liion_inputs.replace_SOH < 0 or liion_inputs.replace_SOH > 1) {
42         std::string error_str = "ERROR: LiIon(): replace_SOH must be in the closed ";
43         error_str += "interval [0, 1]";
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 init_SOC
53     if (liion_inputs.init_SOC < 0 or liion_inputs.init_SOC > 1) {
54         std::string error_str = "ERROR: LiIon(): init_SOC must be in the closed ";
55         error_str += "interval [0, 1]";
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 min_SOC
65     if (liion_inputs.min_SOC < 0 or liion_inputs.min_SOC > 1) {
66         std::string error_str = "ERROR: LiIon(): min_SOC must be in the closed ";
67         error_str += "interval [0, 1]";
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 hysteresis_SOC
77     if (liion_inputs.hysteresis_SOC < 0 or liion_inputs.hysteresis_SOC > 1) {
78         std::string error_str = "ERROR: LiIon(): hysteresis_SOC must be in the closed ";
79         error_str += "interval [0, 1]";
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 max_SOC
89     if (liion_inputs.max_SOC < 0 or liion_inputs.max_SOC > 1) {

```

```

90     std::string error_str = "ERROR: LiIon(): max_SOC must be in the closed ";
91     error_str += "interval [0, 1]";
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 charging_efficiency
101 if (liion_inputs.charging_efficiency <= 0 or liion_inputs.charging_efficiency > 1) {
102     std::string error_str = "ERROR: LiIon(): charging_efficiency must be in the ";
103     error_str += "half-open interval (0, 1]";
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 discharging_efficiency
113 if (
114     liion_inputs.discharging_efficiency <= 0 or
115     liion_inputs.discharging_efficiency > 1
116 ) {
117     std::string error_str = "ERROR: LiIon(): discharging_efficiency must be in the ";
118     error_str += "half-open interval (0, 1]";
119
120     #ifdef _WIN32
121         std::cout << error_str << std::endl;
122     #endif
123
124     throw std::invalid_argument(error_str);
125 }
126
127 // 8. check degradation_alpha
128 if (liion_inputs.degradation_alpha <= 0) {
129     std::string error_str = "ERROR: LiIon(): degradation_alpha must be > 0";
130
131     #ifdef _WIN32
132         std::cout << error_str << std::endl;
133     #endif
134
135     throw std::invalid_argument(error_str);
136 }
137
138 // 9. check degradation_beta
139 if (liion_inputs.degradation_beta <= 0) {
140     std::string error_str = "ERROR: LiIon(): degradation_beta must be > 0";
141
142     #ifdef _WIN32
143         std::cout << error_str << std::endl;
144     #endif
145
146     throw std::invalid_argument(error_str);
147 }
148
149 // 10. check degradation_B_hat_cal_0
150 if (liion_inputs.degradation_B_hat_cal_0 <= 0) {
151     std::string error_str = "ERROR: LiIon(): degradation_B_hat_cal_0 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 // 11. check degradation_r_cal
161 if (liion_inputs.degradation_r_cal < 0) {
162     std::string error_str = "ERROR: LiIon(): degradation_r_cal must be >= 0";
163
164     #ifdef _WIN32
165         std::cout << error_str << std::endl;
166     #endif
167
168     throw std::invalid_argument(error_str);
169 }
170
171 // 12. check degradation_Ea_cal_0
172 if (liion_inputs.degradation_Ea_cal_0 <= 0) {
173     std::string error_str = "ERROR: LiIon(): degradation_Ea_cal_0 must be > 0";
174
175     #ifdef _WIN32
176         std::cout << error_str << std::endl;

```



```

177         #endif
178
179         throw std::invalid_argument(error_str);
180     }
181
182     // 13. check degradation_a_cal
183     if (lilion_inputs.degradation_a_cal < 0) {
184         std::string error_str = "ERROR: LiIon(): degradation_a_cal must be >= 0";
185
186         #ifdef _WIN32
187             std::cout << error_str << std::endl;
188         #endif
189
190         throw std::invalid_argument(error_str);
191     }
192
193     // 14. check degradation_s_cal
194     if (lilion_inputs.degradation_s_cal < 0) {
195         std::string error_str = "ERROR: LiIon(): degradation_s_cal must be >= 0";
196
197         #ifdef _WIN32
198             std::cout << error_str << std::endl;
199         #endif
200
201         throw std::invalid_argument(error_str);
202     }
203
204     // 15. check gas_constant_JmolK
205     if (lilion_inputs.gas_constant_JmolK <= 0) {
206         std::string error_str = "ERROR: LiIon(): gas_constant_JmolK must be > 0";
207
208         #ifdef _WIN32
209             std::cout << error_str << std::endl;
210         #endif
211
212         throw std::invalid_argument(error_str);
213     }
214
215     // 16. check temperature_K
216     if (lilion_inputs.temperature_K < 0) {
217         std::string error_str = "ERROR: LiIon(): temperature_K must be >= 0";
218
219         #ifdef _WIN32
220             std::cout << error_str << std::endl;
221         #endif
222
223         throw std::invalid_argument(error_str);
224     }
225
226     return;
227 } /* __checkInputs() */

```

#### 4.13.3.2 \_\_getBcal()

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

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

Ref: [Truelove \[2023a\]](#)

##### Parameters

SOC	The current state of charge of the asset.
-----	---

##### Returns

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

```

427 {
428     double B_cal = this->degradation_B_hat_cal_0 *
429         exp(this->degradation_r_cal * SOC);
430
431     return B_cal;
432 } /* __getBcal() */

```

#### 4.13.3.3 \_\_getEacal()

```

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

```

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

Ref: [Truelove \[2023a\]](#)

##### Parameters

<i>SOC</i>	The current state of charge of the asset.
------------	---

##### Returns

The activation energy value for the given state of charge.

```

454 {
455     double Ea_cal = this->degradation_Ea_cal_0;
456
457     Ea_cal -= this->degradation_a_cal *
458         (exp(this->degradation_s_cal * SOC) - 1);
459
460     return Ea_cal;
461 } /* __getEacal() */

```

#### 4.13.3.4 \_\_getGenericCapitalCost()

```

double LiIon::__getGenericCapitalCost (
    void ) [private]

```

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

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

##### Returns

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

```

250 {
251     double capital_cost_per_kWh = 250 * pow(this->energy_capacity_kWh, -0.15) + 650;
252
253     return capital_cost_per_kWh * this->energy_capacity_kWh;
254 } /* __getGenericCapitalCost() */

```

#### 4.13.3.5 `__getGenericOpMaintCost()`

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

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

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

##### Returns

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

```
278 {
279     return 0.01;
280 } /* __getGenericOpMaintCost() */
```

#### 4.13.3.6 `__handleDegradation()`

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

Helper method to apply degradation modelling and update attributes.

##### Parameters

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

```
348 {
349     // 1. model degradation
350     this->__modelDegradation(dt_hrs, charging_discharging_kW);
351
352     // 2. update and record
353     this->SOH_vec[timestep] = this->SOH;
354     this->dynamic_energy_capacity_kWh = this->SOH * this->energy_capacity_kWh;
355
356     return;
357 } /* __handleDegradation() */
```

#### 4.13.3.7 `__modelDegradation()`

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

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

Ref: [Truelove](#) [2023a]

## Parameters

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

```

380 {
381     // 1. compute SOC
382     double SOC = this->charge_kWh / this->energy_capacity_kWh;
383
384     // 2. compute C-rate and corresponding acceleration factor
385     double C_rate = charging_discharging_kW / this->power_capacity_kW;
386
387     double C_acceleration_factor =
388         1 + this->degradation_alpha * pow(C_rate, this->degradation_beta);
389
390     // 3. compute dSOH / dt
391     double B_cal = __getBcal(SOC);
392     double Ea_cal = __getEa_cal(SOC);
393
394     double dSOH_dt = B_cal *
395         exp((-1 * Ea_cal) / (this->gas_constant_JmolK * this->temperature_K));
396
397     dSOH_dt *= dSOH_dt;
398     dSOH_dt *= 1 / (2 * this->SOH);
399     dSOH_dt *= C_acceleration_factor;
400
401     // 4. update state of health
402     this->SOH -= dSOH_dt * dt_hrs;
403
404     return;
405 } /* __modelDegradation() */

```

## 4.13.3.8 \_\_toggleDepleted()

```

void LiIon::__toggleDepleted (
    void ) [private]

```

Helper method to toggle the is\_depleted attribute of [Lilon](#).

```

295 {
296     if (this->is_depleted) {
297         double hysteresis_charge_kWh = this->hysteresis_SOC * this->energy_capacity_kWh;
298
299         if (hysteresis_charge_kWh > this->dynamic_energy_capacity_kWh) {
300             hysteresis_charge_kWh = this->dynamic_energy_capacity_kWh;
301         }
302
303         if (this->charge_kWh >= hysteresis_charge_kWh) {
304             this->is_depleted = false;
305         }
306     }
307
308     else {
309         double min_charge_kWh = this->min_SOC * this->energy_capacity_kWh;
310
311         if (this->charge_kWh <= min_charge_kWh) {
312             this->is_depleted = true;
313         }
314     }
315
316     return;
317 } /* __toggleDepleted() */

```

## 4.13.3.9 \_\_writeSummary()

```

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

```

Helper method to write summary results for [Lilon](#).

## Parameters

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

Reimplemented from [Storage](#).

```

479 {
480     // 1. create filestream
481     write_path += "summary_results.md";
482     std::ofstream ofs;
483     ofs.open(write_path, std::ofstream::out);
484
485     // 2. write summary results (markdown)
486     ofs << "# ";
487     ofs << std::to_string(int(ceil(this->power_capacity_kW)));
488     ofs << " kW ";
489     ofs << std::to_string(int(ceil(this->energy_capacity_kWh)));
490     ofs << " kWh LIIION Summary Results\n";
491     ofs << "\n-----\n\n";
492
493     // 2.1. Storage attributes
494     ofs << "## Storage Attributes\n";
495     ofs << "\n";
496     ofs << "Power Capacity: " << this->power_capacity_kW << "kW \n";
497     ofs << "Energy Capacity: " << this->energy_capacity_kWh << "kWh \n";
498     ofs << "\n";
499
500     ofs << "Sunk Cost (N = 0 / Y = 1): " << this->is_sunk << " \n";
501     ofs << "Capital Cost: " << this->capital_cost << " \n";
502     ofs << "Operation and Maintenance Cost: " << this->operation_maintenance_cost_kWh
503         << " per kWh charged/discharged \n";
504     ofs << "Nominal Inflation Rate (annual): " << this->nominal_inflation_annual
505         << " \n";
506     ofs << "Nominal Discount Rate (annual): " << this->nominal_discount_annual
507         << " \n";
508     ofs << "Real Discount Rate (annual): " << this->real_discount_annual << " \n";
509
510     ofs << "\n-----\n\n";
511
512     // 2.2. LiIon attributes
513     ofs << "## LiIon Attributes\n";
514     ofs << "\n";
515
516     ofs << "Charging Efficiency: " << this->charging_efficiency << " \n";
517     ofs << "Discharging Efficiency: " << this->discharging_efficiency << " \n";
518     ofs << "\n";
519
520     ofs << "Initial State of Charge: " << this->init_SOC << " \n";
521     ofs << "Minimum State of Charge: " << this->min_SOC << " \n";
522     ofs << "Hyteresis State of Charge: " << this->hysteresis_SOC << " \n";
523     ofs << "Maximum State of Charge: " << this->max_SOC << " \n";
524     ofs << "\n";
525
526     ofs << "Replacement State of Health: " << this->replace_SOH << " \n";
527     ofs << "\n";
528
529     ofs << "Degradation Acceleration Coeff.: " << this->degradation_alpha << " \n";
530     ofs << "Degradation Acceleration Exp.: " << this->degradation_beta << " \n";
531     ofs << "Degradation Base Pre-Exponential Factor: "
532         << this->degradation_B_hat_cal_0 << " 1/sqrt(hrs) \n";
533     ofs << "Degradation Dimensionless Constant (r_cal): "
534         << this->degradation_r_cal << " \n";
535     ofs << "Degradation Base Activation Energy: "
536         << this->degradation_Ea_cal_0 << " J/mol \n";
537     ofs << "Degradation Pre-Exponential Factor: "
538         << this->degradation_a_cal << " J/mol \n";
539     ofs << "Degradation Dimensionless Constant (s_cal): "
540         << this->degradation_s_cal << " \n";
541     ofs << "Universal Gas Constant: " << this->gas_constant_JmolK
542         << " J/mol.K \n";
543     ofs << "Absolute Environmental Temperature: " << this->temperature_K << " K \n";
544     ofs << "\n";
545
546     ofs << "\n-----\n\n";
547
548     // 2.3. LiIon Results
549     ofs << "## Results\n";
550     ofs << "\n";
551
552     ofs << "Net Present Cost: " << this->net_present_cost << " \n";
553     ofs << "\n";
554
555     ofs << "Total Discharge: " << this->total_discharge_kWh

```

```

556         « " kWh  \n";
557
558     ofs « "Levellized Cost of Energy: " « this->levellized_cost_of_energy_kWh
559         « " per kWh dispatched  \n";
560     ofs « "\n";
561
562     ofs « "Replacements: " « this->n_replacements « "  \n";
563
564     ofs « "\n-----\n\n";
565     ofs.close();
566     return;
567 } /* __writeSummary() */

```

#### 4.13.3.10 \_\_writeTimeSeries()

```

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

```

Helper method to write time series results for [Lilon](#).

##### Parameters

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

Reimplemented from [Storage](#).

```

598 {
599     // 1. create filestream
600     write_path += "time_series_results.csv";
601     std::ofstream ofs;
602     ofs.open(write_path, std::ofstream::out);
603
604     // 2. write time series results (comma separated value)
605     ofs « "Time (since start of data) [hrs],";
606     ofs « "Charging Power [kW],";
607     ofs « "Discharging Power [kW],";
608     ofs « "Charge (at end of timestep) [kWh],";
609     ofs « "State of Health (at end of timestep) [ ],";
610     ofs « "Capital Cost (actual),";
611     ofs « "Operation and Maintenance Cost (actual),";
612     ofs « "\n";
613
614     for (int i = 0; i < max_lines; i++) {
615         ofs « time_vec_hrs_ptr->at(i) « ",";
616         ofs « this->charging_power_vec_kW[i] « ",";
617         ofs « this->discharging_power_vec_kW[i] « ",";
618         ofs « this->charge_vec_kWh[i] « ",";
619         ofs « this->SOH_vec[i] « ",";
620         ofs « this->capital_cost_vec[i] « ",";
621         ofs « this->operation_maintenance_cost_vec[i] « ",";
622         ofs « "\n";
623     }
624
625     ofs.close();
626     return;
627 } /* __writeTimeSeries() */

```

#### 4.13.3.11 commitCharge()

```

void LiIon::commitCharge (
    int timestep,

```

```
double dt_hrs,
double charge_kW ) [virtual]
```

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

#### Parameters

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

Reimplemented from [Storage](#).

```
881 {
882     // 1. record charging power
883     this->charging_power_vec_kW[timestep] = charging_kW;
884
885     // 2. update charge and record
886     this->charge_kWh += this->charging_efficiency * charging_kW * dt_hrs;
887     this->charge_vec_kWh[timestep] = this->charge_kWh;
888
889     // 3. toggle depleted flag (if applicable)
890     this->__toggleDepleted();
891
892     // 4. model degradation
893     this->__handleDegradation(timestep, dt_hrs, charging_kW);
894
895     // 5. trigger replacement (if applicable)
896     if (this->SOH <= this->replace_SOH) {
897         this->handleReplacement(timestep);
898     }
899
900     // 6. capture operation and maintenance costs (if applicable)
901     if (charging_kW > 0) {
902         this->operation_maintenance_cost_vec[timestep] = charging_kW * dt_hrs *
903             this->operation_maintenance_cost_kWh;
904     }
905
906     this->power_kW = 0;
907     return;
908 } /* commitCharge() */
```

#### 4.13.3.12 commitDischarge()

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

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

#### Parameters

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



**Returns**

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

Reimplemented from [Storage](#).

```

944 {
945     // 1. record discharging power, update total
946     this->discharging_power_vec_kW[timestep] = discharging_kW;
947     this->total_discharge_kWh += discharging_kW * dt_hrs;
948
949     // 2. update charge and record
950     this->charge_kWh -= (discharging_kW * dt_hrs) / this->discharging_efficiency;
951     this->charge_vec_kWh[timestep] = this->charge_kWh;
952
953     // 3. update load
954     load_kW -= discharging_kW;
955
956     // 4. toggle depleted flag (if applicable)
957     this->__toggleDepleted();
958
959     // 5. model degradation
960     this->__handleDegradation(timestep, dt_hrs, discharging_kW);
961
962     // 6. trigger replacement (if applicable)
963     if (this->SOH <= this->replace_SOH) {
964         this->handleReplacement(timestep);
965     }
966
967     // 7. capture operation and maintenance costs (if applicable)
968     if (discharging_kW > 0) {
969         this->operation_maintenance_cost_vec[timestep] = discharging_kW * dt_hrs *
970             this->operation_maintenance_cost_kWh;
971     }
972
973     this->power_kW = 0;
974     return load_kW;
975 } /* commitDischarge() */

```

**4.13.3.13 getAcceptablekW()**

```

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

```

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

**Parameters**

<i>dt_hrs</i>	The interval of time [hrs] associated with the timestep.
---------------	--

**Returns**

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

Reimplemented from [Storage](#).

```

825 {
826     // 1. get max charge
827     double max_charge_kWh = this->max_SOC * this->energy_capacity_kWh;
828
829     if (max_charge_kWh > this->dynamic_energy_capacity_kWh) {
830         max_charge_kWh = this->dynamic_energy_capacity_kWh;
831     }
832
833     // 2. compute acceptable power
834     // (accounting for the power currently being charged/discharged by the asset)
835     double acceptable_kW =
836         (max_charge_kWh - this->charge_kWh) /
837         (this->charging_efficiency * dt_hrs);

```

```

838
839     acceptable_kW -= this->power_kW;
840
841     if (acceptable_kW <= 0) {
842         return 0;
843     }
844
845     // 3. apply power constraint
846     if (acceptable_kW > this->power_capacity_kW) {
847         acceptable_kW = this->power_capacity_kW;
848     }
849
850     return acceptable_kW;
851 } /* getAcceptablekW( */

```

#### 4.13.3.14 getAvailablekW()

```

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

```

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

##### Parameters

<i>dt_hrs</i>	The interval of time [hrs] associated with the timestep.
---------------	--

##### Returns

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

Reimplemented from [Storage](#).

```

784 {
785     // 1. get min charge
786     double min_charge_kWh = this->min_SOC * this->energy_capacity_kWh;
787
788     // 2. compute available power
789     // (accounting for the power currently being charged/discharged by the asset)
790     double available_kW =
791         ((this->charge_kWh - min_charge_kWh) * this->discharging_efficiency) /
792         dt_hrs;
793
794     available_kW -= this->power_kW;
795
796     if (available_kW <= 0) {
797         return 0;
798     }
799
800     // 3. apply power constraint
801     if (available_kW > this->power_capacity_kW) {
802         available_kW = this->power_capacity_kW;
803     }
804
805     return available_kW;
806 } /* getAvailablekW() */

```

#### 4.13.3.15 handleReplacement()

```

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

```

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

## Parameters

<i>timestep</i>	The current time step of the <a href="#">Model</a> run.
-----------------	---

Reimplemented from [Storage](#).

```

752 {
753     // 1. reset attributes
754     this->dynamic_energy_capacity_kWh = this->energy_capacity_kWh;
755     this->SOH = 1;
756
757     // 2. invoke base class method
758     Storage::handleReplacement(timestep);
759
760     // 3. correct attributes
761     this->charge_kWh = this->init_SOC * this->energy_capacity_kWh;
762     this->is_depleted = false;
763
764     return;
765 } /* __handleReplacement() */

```

## 4.13.4 Member Data Documentation

### 4.13.4.1 charging\_efficiency

```
double LiIon::charging_efficiency
```

The charging efficiency of the asset.

### 4.13.4.2 degradation\_a\_cal

```
double LiIon::degradation_a_cal
```

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

### 4.13.4.3 degradation\_alpha

```
double LiIon::degradation_alpha
```

A dimensionless acceleration coefficient used in modelling energy capacity degradation.

### 4.13.4.4 degradation\_B\_hat\_cal\_0

```
double LiIon::degradation_B_hat_cal_0
```

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

#### 4.13.4.5 degradation\_beta

```
double LiIon::degradation_beta
```

A dimensionless acceleration exponent used in modelling energy capacity degradation.

#### 4.13.4.6 degradation\_Ea\_cal\_0

```
double LiIon::degradation_Ea_cal_0
```

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

#### 4.13.4.7 degradation\_r\_cal

```
double LiIon::degradation_r_cal
```

A dimensionless constant used in modelling energy capacity degradation.

#### 4.13.4.8 degradation\_s\_cal

```
double LiIon::degradation_s_cal
```

A dimensionless constant used in modelling energy capacity degradation.

#### 4.13.4.9 discharging\_efficiency

```
double LiIon::discharging_efficiency
```

The discharging efficiency of the asset.

#### 4.13.4.10 dynamic\_energy\_capacity\_kWh

```
double LiIon::dynamic_energy_capacity_kWh
```

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

**4.13.4.11 gas\_constant\_JmolK**

```
double LiIon::gas_constant_JmolK
```

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

**4.13.4.12 hysteresis\_SOC**

```
double LiIon::hysteresis_SOC
```

The state of charge the asset must achieve to toggle is\_depleted.

**4.13.4.13 init\_SOC**

```
double LiIon::init_SOC
```

The initial state of charge of the asset.

**4.13.4.14 max\_SOC**

```
double LiIon::max_SOC
```

The maximum state of charge of the asset.

**4.13.4.15 min\_SOC**

```
double LiIon::min_SOC
```

The minimum state of charge of the asset. Will toggle is\_depleted when reached.

**4.13.4.16 replace\_SOH**

```
double LiIon::replace_SOH
```

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

#### 4.13.4.17 SOH

```
double LiIon::SOH
```

The state of health of the asset.

#### 4.13.4.18 SOH\_vec

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

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

#### 4.13.4.19 temperature\_K

```
double LiIon::temperature_K
```

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

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

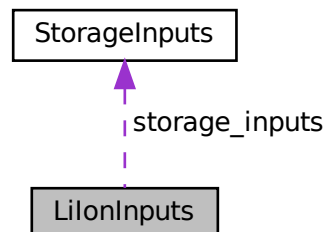
- header/Storage/[Lilon.h](#)
- source/Storage/[Lilon.cpp](#)

## 4.14 LilonInputs Struct Reference

A structure which bundles the necessary inputs for the [Lilon](#) constructor. Provides default values for every necessary input. Note that this structure encapsulates [StorageInputs](#).

```
#include <LiIon.h>
```

Collaboration diagram for LilonInputs:



## Public Attributes

- [StorageInputs storage\\_inputs](#)  
An encapsulated [StorageInputs](#) instance.
- double [capital\\_cost](#) = -1  
The capital cost of the asset (undefined currency). -1 is a sentinel value, which triggers a generic cost model on construction (in fact, any negative value here will trigger). Note that the generic cost model is in terms of Canadian dollars [CAD].
- double [operation\\_maintenance\\_cost\\_kWh](#) = -1  
The operation and maintenance cost of the asset [1/kWh] (undefined currency). This is a cost incurred per unit of energy charged/discharged. -1 is a sentinel value, which triggers a generic cost model on construction (in fact, any negative value here will trigger). Note that the generic cost model is in terms of Canadian dollars [CAD/kWh].
- double [init\\_SOC](#) = 0.5  
The initial state of charge of the asset.
- double [min\\_SOC](#) = 0.15  
The minimum state of charge of the asset. Will toggle `is_depleted` when reached.
- double [hysteresis\\_SOC](#) = 0.5  
The state of charge the asset must achieve to toggle `is_depleted`.
- double [max\\_SOC](#) = 0.9  
The maximum state of charge of the asset.
- double [charging\\_efficiency](#) = 0.9  
The charging efficiency of the asset.
- double [discharging\\_efficiency](#) = 0.9  
The discharging efficiency of the asset.
- double [replace\\_SOH](#) = 0.8  
The state of health at which the asset is considered "dead" and must be replaced.
- double [degradation\\_alpha](#) = 8.935  
A dimensionless acceleration coefficient used in modelling energy capacity degradation.
- double [degradation\\_beta](#) = 1  
A dimensionless acceleration exponent used in modelling energy capacity degradation.
- double [degradation\\_B\\_hat\\_cal\\_0](#) = 5.22226e6  
A reference (or base) pre-exponential factor [1/sqrt(hrs)] used in modelling energy capacity degradation.
- double [degradation\\_r\\_cal](#) = 0.4361  
A dimensionless constant used in modelling energy capacity degradation.
- double [degradation\\_Ea\\_cal\\_0](#) = 5.279e4  
A reference (or base) activation energy [J/mol] used in modelling energy capacity degradation.
- double [degradation\\_a\\_cal](#) = 100  
A pre-exponential factor [J/mol] used in modelling energy capacity degradation.
- double [degradation\\_s\\_cal](#) = 2  
A dimensionless constant used in modelling energy capacity degradation.
- double [gas\\_constant\\_JmolK](#) = 8.31446  
The universal gas constant [J/mol.K].
- double [temperature\\_K](#) = 273 + 20  
The absolute environmental temperature [K] of the lithium ion battery energy storage system.

### 4.14.1 Detailed Description

A structure which bundles the necessary inputs for the [Lilon](#) constructor. Provides default values for every necessary input. Note that this structure encapsulates [StorageInputs](#).

Ref: [Truelove \[2023a\]](#)

## 4.14.2 Member Data Documentation

### 4.14.2.1 capital\_cost

```
double LiIonInputs::capital_cost = -1
```

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

### 4.14.2.2 charging\_efficiency

```
double LiIonInputs::charging_efficiency = 0.9
```

The charging efficiency of the asset.

### 4.14.2.3 degradation\_a\_cal

```
double LiIonInputs::degradation_a_cal = 100
```

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

### 4.14.2.4 degradation\_alpha

```
double LiIonInputs::degradation_alpha = 8.935
```

A dimensionless acceleration coefficient used in modelling energy capacity degradation.

### 4.14.2.5 degradation\_B\_hat\_cal\_0

```
double LiIonInputs::degradation_B_hat_cal_0 = 5.22226e6
```

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



#### 4.14.2.6 degradation\_beta

```
double LiIonInputs::degradation_beta = 1
```

A dimensionless acceleration exponent used in modelling energy capacity degradation.

#### 4.14.2.7 degradation\_Ea\_cal\_0

```
double LiIonInputs::degradation_Ea_cal_0 = 5.279e4
```

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

#### 4.14.2.8 degradation\_r\_cal

```
double LiIonInputs::degradation_r_cal = 0.4361
```

A dimensionless constant used in modelling energy capacity degradation.

#### 4.14.2.9 degradation\_s\_cal

```
double LiIonInputs::degradation_s_cal = 2
```

A dimensionless constant used in modelling energy capacity degradation.

#### 4.14.2.10 discharging\_efficiency

```
double LiIonInputs::discharging_efficiency = 0.9
```

The discharging efficiency of the asset.

#### 4.14.2.11 gas\_constant\_JmolK

```
double LiIonInputs::gas_constant_JmolK = 8.31446
```

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

#### 4.14.2.12 hysteresis\_SOC

```
double LiIonInputs::hysteresis_SOC = 0.5
```

The state of charge the asset must achieve to toggle is\_depleted.

#### 4.14.2.13 init\_SOC

```
double LiIonInputs::init_SOC = 0.5
```

The initial state of charge of the asset.

#### 4.14.2.14 max\_SOC

```
double LiIonInputs::max_SOC = 0.9
```

The maximum state of charge of the asset.

#### 4.14.2.15 min\_SOC

```
double LiIonInputs::min_SOC = 0.15
```

The minimum state of charge of the asset. Will toggle is\_depleted when reached.

#### 4.14.2.16 operation\_maintenance\_cost\_kWh

```
double LiIonInputs::operation_maintenance_cost_kWh = -1
```

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

#### 4.14.2.17 replace\_SOH

```
double LiIonInputs::replace_SOH = 0.8
```

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

#### 4.14.2.18 storage\_inputs

```
StorageInputs LiIonInputs::storage_inputs
```

An encapsulated [StorageInputs](#) instance.

#### 4.14.2.19 temperature\_K

```
double LiIonInputs::temperature_K = 273 + 20
```

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

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

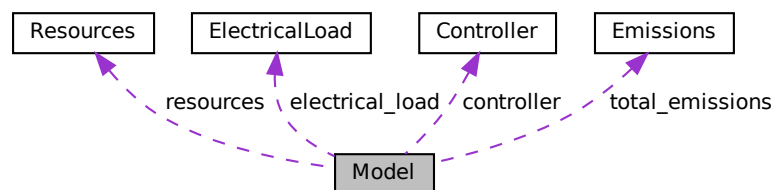
- header/Storage/[Lilon.h](#)

## 4.15 Model Class Reference

A container class which forms the centre of PGMcpp. The [Model](#) class is intended to serve as the primary user interface with the functionality of PGMcpp, and as such it contains all other classes.

```
#include <Model.h>
```

Collaboration diagram for Model:



## Public Member Functions

- [Model](#) (void)  
*Constructor (dummy) for the [Model](#) class.*
- [Model](#) ([ModelInputs](#))  
*Constructor (intended) for the [Model](#) class.*
- void [addDiesel](#) ([DieselInputs](#))  
*Method to add a [Diesel](#) asset to the [Model](#).*
- void [addResource](#) ([NoncombustionType](#), std::string, int)  
*A method to add a renewable resource time series to the [Model](#).*
- void [addResource](#) ([RenewableType](#), std::string, int)  
*A method to add a renewable resource time series to the [Model](#).*
- void [addHydro](#) ([HydroInputs](#))  
*Method to add a [Hydro](#) asset to the [Model](#).*
- void [addSolar](#) ([SolarInputs](#))  
*Method to add a [Solar](#) asset to the [Model](#).*
- void [addTidal](#) ([TidalInputs](#))  
*Method to add a [Tidal](#) asset to the [Model](#).*
- void [addWave](#) ([WaveInputs](#))  
*Method to add a [Wave](#) asset to the [Model](#).*
- void [addWind](#) ([WindInputs](#))  
*Method to add a [Wind](#) asset to the [Model](#).*
- void [addLilon](#) ([LilonInputs](#))  
*Method to add a [Lilon](#) 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](#) attributes. It leaves the [Controller](#), [ElectricalLoad](#), and [Resources](#) objects of the [Model](#) alone.*
- void [clear](#) (void)  
*Method to clear all attributes of the [Model](#) object.*
- void [writeResults](#) (std::string, int=-1)  
*Method which writes [Model](#) results to an output directory. Also calls out to [writeResults\(\)](#) for each contained asset.*
- [~Model](#) (void)  
*Destructor for the [Model](#) class.*

## Public Attributes

- double [total\\_fuel\\_consumed\\_L](#)  
*The total fuel consumed [L] over a model run.*
- [Emissions](#) [total\\_emissions](#)  
*An [Emissions](#) structure for holding total emissions [kg].*
- double [net\\_present\\_cost](#)  
*The net present cost of the [Model](#) (undefined currency).*
- double [total\\_renewable\\_dispatch\\_kWh](#)  
*The total energy dispatched [kWh] by all renewable assets over the [Model](#) run.*
- double [total\\_dispatch\\_discharge\\_kWh](#)  
*The total energy dispatched/discharged [kWh] over the [Model](#) run.*
- double [levellized\\_cost\\_of\\_energy\\_kWh](#)  
*The levellized cost of energy, per unit energy dispatched/discharged, of the [Model](#) [1/kWh] (undefined currency).*

- [Controller controller](#)  
*Controller component of Model.*
- [ElectricalLoad electrical\\_load](#)  
*ElectricalLoad component of Model.*
- [Resources resources](#)  
*Resources component of Model.*
- `std::vector< Combustion * > combustion_ptr_vec`  
*A vector of pointers to the various [Combustion](#) assets in the [Model](#).*
- `std::vector< Noncombustion * > noncombustion_ptr_vec`  
*A vector of pointers to the various [Noncombustion](#) assets in the [Model](#).*
- `std::vector< Renewable * > renewable_ptr_vec`  
*A vector of pointers to the various [Renewable](#) assets in the [Model](#).*
- `std::vector< Storage * > storage_ptr_vec`  
*A vector of pointers to the various [Storage](#) assets in the [Model](#).*

## Private Member Functions

- `void __checkInputs (ModelInputs)`  
*Helper method (private) to check inputs to the [Model](#) constructor.*
- `void __computeFuelAndEmissions (void)`  
*Helper method to compute the total fuel consumption and emissions over the [Model](#) run.*
- `void __computeNetPresentCost (void)`  
*Helper method to compute the overall net present cost, for the [Model](#) run, from the asset-wise net present costs. Also tallies up total dispatch and discharge.*
- `void __computeLevellizedCostOfEnergy (void)`  
*Helper method to compute the overall levellized cost of energy, for the [Model](#) run, from the asset-wise levellized costs of energy.*
- `void __computeEconomics (void)`  
*Helper method to compute key economic metrics for the [Model](#) run.*
- `void __writeSummary (std::string)`  
*Helper method to write summary results for [Model](#).*
- `void __writeTimeSeries (std::string, int=-1)`  
*Helper method to write time series results for [Model](#).*

### 4.15.1 Detailed Description

A container class which forms the centre of PGMcpp. The [Model](#) class is intended to serve as the primary user interface with the functionality of PGMcpp, and as such it contains all other classes.

### 4.15.2 Constructor & Destructor Documentation

#### 4.15.2.1 Model() [1/2]

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

Constructor (dummy) for the [Model](#) class.

```
573 {
574     return;
575 } /* Model() */
```

#### 4.15.2.2 Model() [2/2]

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

Constructor (intended) for the [Model](#) class.

##### Parameters

<i>model_inputs</i>	A structure of <a href="#">Model</a> constructor inputs.
---------------------	--

```
592 {
593     // 1. check inputs
594     this->__checkInputs(model_inputs);
595
596     // 2. read in electrical load data
597     this->electrical_load.readLoadData(model_inputs.path_2_electrical_load_time_series);
598
599     // 3. set control mode
600     this->controller.setControlMode(model_inputs.control_mode);
601
602     // 4. set public attributes
603     this->total_fuel_consumed_L = 0;
604     this->net_present_cost = 0;
605     this->total_dispatch_discharge_kWh = 0;
606     this->total_renewable_dispatch_kWh = 0;
607     this->levellized_cost_of_energy_kWh = 0;
608
609     return;
610 } /* Model() */
```

#### 4.15.2.3 ~Model()

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

Destructor for the [Model](#) class.

```
1123 {
1124     this->clear();
1125     return;
1126 } /* ~Model() */
```

### 4.15.3 Member Function Documentation

### 4.15.3.1 `__checkInputs()`

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

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

#### Parameters

<code>model_inputs</code>	A structure of <a href="#">Model</a> constructor inputs.
---------------------------	--

```
40 {
41     // 1. check path_2_electrical_load_time_series
42     if (model_inputs.path_2_electrical_load_time_series.empty()) {
43         std::string error_str = "ERROR: Model() path_2_electrical_load_time_series ";
44         error_str += "cannot be empty";
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() */
```

### 4.15.3.2 `__computeEconomics()`

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

Helper method to compute key economic metrics for the [Model](#) run.

```
240 {
241     this->__computeNetPresentCost();
242     this->__computeLevellingCostOfEnergy();
243
244     return;
245 } /* __computeEconomics() */
```

### 4.15.3.3 `__computeFuelAndEmissions()`

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

Helper method to compute the total fuel consumption and emissions over the [Model](#) run.

```
70 {
71     for (size_t i = 0; i < this->combustion_ptr_vec.size(); i++) {
72         this->combustion_ptr_vec[i]->computeFuelAndEmissions();
73
74         this->total_fuel_consumed_L +=
75             this->combustion_ptr_vec[i]->total_fuel_consumed_L;
76
77         this->total_emissions.CO2_kg +=
78             this->combustion_ptr_vec[i]->total_emissions.CO2_kg;
79
80         this->total_emissions.CO_kg +=
81             this->combustion_ptr_vec[i]->total_emissions.CO_kg;
82
83         this->total_emissions.NOx_kg +=
84             this->combustion_ptr_vec[i]->total_emissions.NOx_kg;
85
86         this->total_emissions.SOx_kg +=
```

```

87         this->combustion_ptr_vec[i]->total_emissions.SOx_kg;
88
89         this->total_emissions.CH4_kg +=
90             this->combustion_ptr_vec[i]->total_emissions.CH4_kg;
91
92         this->total_emissions.PM_kg +=
93             this->combustion_ptr_vec[i]->total_emissions.PM_kg;
94     }
95
96     return;
97 } /* __computeFuelAndEmissions() */

```

#### 4.15.3.4 \_\_computeLevellizedCostOfEnergy()

```

void Model::__computeLevellizedCostOfEnergy (
    void ) [private]

```

Helper method to compute the overall levellized cost of energy, for the [Model](#) run, from the asset-wise levellized costs of energy.

```

187 {
188     // 1. account for Combustion economics in levellized cost of energy
189     for (size_t i = 0; i < this->combustion_ptr_vec.size(); i++) {
190         this->levellized_cost_of_energy_kWh +=
191             (
192                 this->combustion_ptr_vec[i]->levellized_cost_of_energy_kWh *
193                 this->combustion_ptr_vec[i]->total_dispatch_kWh
194             ) / this->total_dispatch_discharge_kWh;
195     }
196
197     // 2. account for Noncombustion economics in levellized cost of energy
198     for (size_t i = 0; i < this->noncombustion_ptr_vec.size(); i++) {
199         this->levellized_cost_of_energy_kWh +=
200             (
201                 this->noncombustion_ptr_vec[i]->levellized_cost_of_energy_kWh *
202                 this->noncombustion_ptr_vec[i]->total_dispatch_kWh
203             ) / this->total_dispatch_discharge_kWh;
204     }
205
206     // 3. account for Renewable economics in levellized cost of energy
207     for (size_t i = 0; i < this->renewable_ptr_vec.size(); i++) {
208         this->levellized_cost_of_energy_kWh +=
209             (
210                 this->renewable_ptr_vec[i]->levellized_cost_of_energy_kWh *
211                 this->renewable_ptr_vec[i]->total_dispatch_kWh
212             ) / this->total_dispatch_discharge_kWh;
213     }
214
215     // 4. account for Storage economics in levellized cost of energy
216     for (size_t i = 0; i < this->storage_ptr_vec.size(); i++) {
217         this->levellized_cost_of_energy_kWh +=
218             (
219                 this->storage_ptr_vec[i]->levellized_cost_of_energy_kWh *
220                 this->storage_ptr_vec[i]->total_discharge_kWh
221             ) / this->total_dispatch_discharge_kWh;
222     }
223
224     return;
225 } /* __computeLevellizedCostOfEnergy() */

```

#### 4.15.3.5 \_\_computeNetPresentCost()

```

void Model::__computeNetPresentCost (
    void ) [private]

```

Helper method to compute the overall net present cost, for the [Model](#) run, from the asset-wise net present costs. Also tallies up total dispatch and discharge.

```

114 {
115     // 1. account for Combustion economics in net present cost

```



```

116 // increment total dispatch
117 for (size_t i = 0; i < this->combustion_ptr_vec.size(); i++) {
118     this->combustion_ptr_vec[i]->computeEconomics(
119         &(this->electrical_load.time_vec_hrs)
120     );
121
122     this->net_present_cost += this->combustion_ptr_vec[i]->net_present_cost;
123
124     this->total_dispatch_discharge_kWh +=
125         this->combustion_ptr_vec[i]->total_dispatch_kWh;
126 }
127
128 // 2. account for Noncombustion economics in net present cost
129 // increment total dispatch
130 for (size_t i = 0; i < this->noncombustion_ptr_vec.size(); i++) {
131     this->noncombustion_ptr_vec[i]->computeEconomics(
132         &(this->electrical_load.time_vec_hrs)
133     );
134
135     this->net_present_cost += this->noncombustion_ptr_vec[i]->net_present_cost;
136
137     this->total_dispatch_discharge_kWh +=
138         this->noncombustion_ptr_vec[i]->total_dispatch_kWh;
139 }
140
141 // 3. account for Renewable economics in net present cost,
142 // increment total dispatch
143 for (size_t i = 0; i < this->renewable_ptr_vec.size(); i++) {
144     this->renewable_ptr_vec[i]->computeEconomics(
145         &(this->electrical_load.time_vec_hrs)
146     );
147
148     this->net_present_cost += this->renewable_ptr_vec[i]->net_present_cost;
149
150     this->total_dispatch_discharge_kWh +=
151         this->renewable_ptr_vec[i]->total_dispatch_kWh;
152
153     this->total_renewable_dispatch_kWh +=
154         this->renewable_ptr_vec[i]->total_dispatch_kWh;
155 }
156
157 // 4. account for Storage economics in net present cost
158 // increment total dispatch
159 for (size_t i = 0; i < this->storage_ptr_vec.size(); i++) {
160     this->storage_ptr_vec[i]->computeEconomics(
161         &(this->electrical_load.time_vec_hrs)
162     );
163
164     this->net_present_cost += this->storage_ptr_vec[i]->net_present_cost;
165
166     this->total_dispatch_discharge_kWh +=
167         this->storage_ptr_vec[i]->total_discharge_kWh;
168 }
169
170 return;
171 } /* __computeNetPresentCost() */

```

#### 4.15.3.6 \_\_writeSummary()

```

void Model::__writeSummary (
    std::string write_path ) [private]

```

Helper method to write summary results for [Model](#).

##### Parameters

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

```

263 {
264     // 1. create subdirectory
265     write_path += "Model/";
266     std::filesystem::create_directory(write_path);
267 }

```

```

268 // 2. create filestream
269 write_path += "summary_results.md";
270 std::ofstream ofs;
271 ofs.open(write_path, std::ofstream::out);
272
273 // 3. write summary results (markdown)
274 ofs << "# Model Summary Results\n";
275 ofs << "\n-----\n\n";
276
277 // 3.1. ElectricalLoad
278 ofs << "## Electrical Load\n";
279 ofs << "\n";
280 ofs << "Path: " <<
281     this->electrical_load.path_2_electrical_load_time_series << " \n";
282 ofs << "Data Points: " << this->electrical_load.n_points << " \n";
283 ofs << "Years: " << this->electrical_load.n_years << " \n";
284 ofs << "Min: " << this->electrical_load.min_load_kW << " kW \n";
285 ofs << "Mean: " << this->electrical_load.mean_load_kW << " kW \n";
286 ofs << "Max: " << this->electrical_load.max_load_kW << " kW \n";
287 ofs << "\n-----\n\n";
288
289 // 3.2. Controller
290 ofs << "## Controller\n";
291 ofs << "\n";
292 ofs << "Control Mode: " << this->controller.control_string << " \n";
293 ofs << "\n-----\n\n";
294
295 // 3.3. Resources (1D)
296 ofs << "## 1D Renewable Resources\n";
297 ofs << "\n";
298
299 std::map<int, std::string>::iterator string_map_1D_iter =
300     this->resources.string_map_1D.begin();
301 std::map<int, std::string>::iterator path_map_1D_iter =
302     this->resources.path_map_1D.begin();
303
304 while (
305     string_map_1D_iter != this->resources.string_map_1D.end() and
306     path_map_1D_iter != this->resources.path_map_1D.end()
307 ) {
308     ofs << "Resource Key: " << string_map_1D_iter->first << " \n";
309     ofs << "Type: " << string_map_1D_iter->second << " \n";
310     ofs << "Path: " << path_map_1D_iter->second << " \n";
311     ofs << "\n";
312
313     string_map_1D_iter++;
314     path_map_1D_iter++;
315 }
316
317 ofs << "\n-----\n\n";
318
319 // 3.4. Resources (2D)
320 ofs << "## 2D Renewable Resources\n";
321 ofs << "\n";
322
323 std::map<int, std::string>::iterator string_map_2D_iter =
324     this->resources.string_map_2D.begin();
325 std::map<int, std::string>::iterator path_map_2D_iter =
326     this->resources.path_map_2D.begin();
327
328 while (
329     string_map_2D_iter != this->resources.string_map_2D.end() and
330     path_map_2D_iter != this->resources.path_map_2D.end()
331 ) {
332     ofs << "Resource Key: " << string_map_2D_iter->first << " \n";
333     ofs << "Type: " << string_map_2D_iter->second << " \n";
334     ofs << "Path: " << path_map_2D_iter->second << " \n";
335     ofs << "\n";
336
337     string_map_2D_iter++;
338     path_map_2D_iter++;
339 }
340
341 ofs << "\n-----\n\n";
342
343 // 3.5. Combustion
344 ofs << "## Combustion Assets\n";
345 ofs << "\n";
346
347 for (size_t i = 0; i < this->combustion_ptr_vec.size(); i++) {
348     ofs << "Asset Index: " << i << " \n";
349     ofs << "Type: " << this->combustion_ptr_vec[i]->type_str << " \n";
350     ofs << "Capacity: " << this->combustion_ptr_vec[i]->capacity_kW << " kW \n";
351     ofs << "\n";
352 }
353
354 ofs << "\n-----\n\n";

```

```

355
356 // 3.6. Noncombustion
357 ofs << "## Noncombustion Assets\n";
358 ofs << "\n";
359
360 for (size_t i = 0; i < this->noncombustion_ptr_vec.size(); i++) {
361     ofs << "Asset Index: " << i << " \n";
362     ofs << "Type: " << this->noncombustion_ptr_vec[i]->type_str << " \n";
363     ofs << "Capacity: " << this->noncombustion_ptr_vec[i]->capacity_kW << " kW \n";
364
365     if (this->noncombustion_ptr_vec[i]->type == NoncombustionType::HYDRO) {
366         ofs << "Reservoir Capacity: " <<
367             ((Hydro*) (this->noncombustion_ptr_vec[i]))->reservoir_capacity_m3 <<
368             " m3 \n";
369     }
370
371     ofs << "\n";
372 }
373
374 ofs << "\n-----\n\n";
375
376 // 3.7. Renewable
377 ofs << "## Renewable Assets\n";
378 ofs << "\n";
379
380 for (size_t i = 0; i < this->renewable_ptr_vec.size(); i++) {
381     ofs << "Asset Index: " << i << " \n";
382     ofs << "Type: " << this->renewable_ptr_vec[i]->type_str << " \n";
383     ofs << "Capacity: " << this->renewable_ptr_vec[i]->capacity_kW << " kW \n";
384     ofs << "\n";
385 }
386
387 ofs << "\n-----\n\n";
388
389 // 3.8. Storage
390 ofs << "## Storage Assets\n";
391 ofs << "\n";
392
393 for (size_t i = 0; i < this->storage_ptr_vec.size(); i++) {
394     ofs << "Asset Index: " << i << " \n";
395     ofs << "Type: " << this->storage_ptr_vec[i]->type_str << " \n";
396     ofs << "Power Capacity: " << this->storage_ptr_vec[i]->power_capacity_kW
397         << " kW \n";
398     ofs << "Energy Capacity: " << this->storage_ptr_vec[i]->energy_capacity_kWh
399         << " kWh \n";
400     ofs << "\n";
401 }
402
403 ofs << "\n-----\n\n";
404
405 // 3.9. Model Results
406 ofs << "## Results\n";
407 ofs << "\n";
408
409 ofs << "Net Present Cost: " << this->net_present_cost << " \n";
410 ofs << "\n";
411
412 ofs << "Total Dispatch + Discharge: " << this->total_dispatch_discharge_kWh
413     << " kWh \n";
414
415 ofs << "Renewable Penetration: "
416     << this->total_renewable_dispatch_kWh / this->total_dispatch_discharge_kWh
417     << " \n";
418 ofs << "\n";
419
420 ofs << "Levellized Cost of Energy: " << this->levellized_cost_of_energy_kWh
421     << " per kWh dispatched/discharged \n";
422 ofs << "\n";
423
424 ofs << "Total Fuel Consumed: " << this->total_fuel_consumed_L << " L "
425     << "(Annual Average: " <<
426         this->total_fuel_consumed_L / this->electrical_load.n_years
427         << " L/yr) \n";
428 ofs << "\n";
429
430 ofs << "Total Carbon Dioxide (CO2) Emissions: " <<
431     this->total_emissions.CO2_kg << " kg "
432     << "(Annual Average: " <<
433         this->total_emissions.CO2_kg / this->electrical_load.n_years
434         << " kg/yr) \n";
435
436 ofs << "Total Carbon Monoxide (CO) Emissions: " <<
437     this->total_emissions.CO_kg << " kg "
438     << "(Annual Average: " <<
439         this->total_emissions.CO_kg / this->electrical_load.n_years
440         << " kg/yr) \n";
441

```

```

442 ofs << "Total Nitrogen Oxides (NOx) Emissions: " <<
443     this->total_emissions.NOx_kg << " kg "
444     << "(Annual Average: " <<
445         this->total_emissions.NOx_kg / this->electrical_load.n_years
446         << " kg/yr) \n";
447
448 ofs << "Total Sulfur Oxides (SOx) Emissions: " <<
449     this->total_emissions.SOx_kg << " kg "
450     << "(Annual Average: " <<
451         this->total_emissions.SOx_kg / this->electrical_load.n_years
452         << " kg/yr) \n";
453
454 ofs << "Total Methane (CH4) Emissions: " << this->total_emissions.CH4_kg << " kg "
455     << "(Annual Average: " <<
456         this->total_emissions.CH4_kg / this->electrical_load.n_years
457         << " kg/yr) \n";
458
459 ofs << "Total Particulate Matter (PM) Emissions: " <<
460     this->total_emissions.PM_kg << " kg "
461     << "(Annual Average: " <<
462         this->total_emissions.PM_kg / this->electrical_load.n_years
463         << " kg/yr) \n";
464
465 ofs << "\n-----\n\n";
466
467 ofs.close();
468 return;
469 } /* __writeSummary() */

```

#### 4.15.3.7 \_\_writeTimeSeries()

```

void Model::__writeTimeSeries (
    std::string write_path,
    int max_lines = -1 ) [private]

```

Helper method to write time series results for [Model](#).

##### Parameters

<i>write_path</i>	A path (either relative or absolute) to the directory location where results are to be written. If already exists, will overwrite.
<i>max_lines</i>	The maximum number of lines of output to write.

```

489 {
490     // 1. create filestream
491     write_path += "Model/time_series_results.csv";
492     std::ofstream ofs;
493     ofs.open(write_path, std::ofstream::out);
494
495     // 2. write time series results header (comma separated value)
496     ofs << "Time (since start of data) [hrs],";
497     ofs << "Electrical Load [kW],";
498     ofs << "Net Load [kW],";
499     ofs << "Missed Load [kW],";
500
501     for (size_t i = 0; i < this->renewable_ptr_vec.size(); i++) {
502         ofs << this->renewable_ptr_vec[i]->capacity_kW << " kW "
503             << this->renewable_ptr_vec[i]->type_str << " Dispatch [kW],";
504     }
505
506     for (size_t i = 0; i < this->storage_ptr_vec.size(); i++) {
507         ofs << this->storage_ptr_vec[i]->power_capacity_kW << " kW "
508             << this->storage_ptr_vec[i]->energy_capacity_kWh << " kWh "
509             << this->storage_ptr_vec[i]->type_str << " Discharge [kW],";
510     }
511
512     for (size_t i = 0; i < this->noncombustion_ptr_vec.size(); i++) {
513         ofs << this->noncombustion_ptr_vec[i]->capacity_kW << " kW "
514             << this->noncombustion_ptr_vec[i]->type_str << " Dispatch [kW],";
515     }
516
517     for (size_t i = 0; i < this->combustion_ptr_vec.size(); i++) {
518         ofs << this->combustion_ptr_vec[i]->capacity_kW << " kW "

```

```

519         « this->combustion_ptr_vec[i]->type_str « " Dispatch [kW],";
520     }
521
522     ofs « "\n";
523
524     // 3. write time series results values (comma separated value)
525     for (int i = 0; i < max_lines; i++) {
526         // 3.1. load values
527         ofs « this->electrical_load.time_vec_hrs[i] « ",";
528         ofs « this->electrical_load.load_vec_kW[i] « ",";
529         ofs « this->controller.net_load_vec_kW[i] « ",";
530         ofs « this->controller.missed_load_vec_kW[i] « ",";
531
532         // 3.2. asset-wise dispatch/discharge
533         for (size_t j = 0; j < this->renewable_ptr_vec.size(); j++) {
534             ofs « this->renewable_ptr_vec[j]->dispatch_vec_kW[i] « ",";
535         }
536
537         for (size_t j = 0; j < this->storage_ptr_vec.size(); j++) {
538             ofs « this->storage_ptr_vec[j]->discharging_power_vec_kW[i] « ",";
539         }
540
541         for (size_t j = 0; j < this->noncombustion_ptr_vec.size(); j++) {
542             ofs « this->noncombustion_ptr_vec[j]->dispatch_vec_kW[i] « ",";
543         }
544
545         for (size_t j = 0; j < this->combustion_ptr_vec.size(); j++) {
546             ofs « this->combustion_ptr_vec[j]->dispatch_vec_kW[i] « ",";
547         }
548
549         ofs « "\n";
550     }
551
552     ofs.close();
553     return;
554 } /* __writeTimeSeries() */

```

#### 4.15.3.8 addDiesel()

```

void Model::addDiesel (
    DieselInputs diesel_inputs )

```

Method to add a [Diesel](#) asset to the [Model](#).

##### Parameters

<i>diesel_inputs</i>	A structure of <a href="#">Diesel</a> constructor inputs.
----------------------	---

```

627 {
628     Combustion* diesel_ptr = new Diesel(
629         this->electrical_load.n_points,
630         this->electrical_load.n_years,
631         diesel_inputs
632     );
633
634     this->combustion_ptr_vec.push_back(diesel_ptr);
635
636     return;
637 } /* addDiesel() */

```

#### 4.15.3.9 addHydro()

```

void Model::addHydro (
    HydroInputs hydro_inputs )

```

Method to add a [Hydro](#) asset to the [Model](#).

## Parameters

<i>hydro_inputs</i>	A structure of <a href="#">Hydro</a> constructor inputs.
---------------------	--

```

730 {
731     Noncombustion* hydro_ptr = new Hydro(
732         this->electrical_load.n_points,
733         this->electrical_load.n_years,
734         hydro_inputs
735     );
736
737     this->noncombustion_ptr_vec.push_back(hydro_ptr);
738
739     return;
740 } /* addHydro() */

```

## 4.15.3.10 addLilIon()

```

void Model::addLiIon (
    LiIonInputs liion_inputs )

```

Method to add a [LilIon](#) asset to the [Model](#).

## Parameters

<i>liion_inputs</i>	A structure of <a href="#">LilIon</a> constructor inputs.
---------------------	---

```

865 {
866     Storage* liion_ptr = new LiIon(
867         this->electrical_load.n_points,
868         this->electrical_load.n_years,
869         liion_inputs
870     );
871
872     this->storage_ptr_vec.push_back(liion_ptr);
873
874     return;
875 } /* addLiIon() */

```

## 4.15.3.11 addResource() [1/2]

```

void Model::addResource (
    NoncombustionType noncombustion_type,
    std::string path_2_resource_data,
    int resource_key )

```

A method to add a renewable resource time series to the [Model](#).

## Parameters

<i>noncombustion_type</i>	The type of renewable resource being added to the <a href="#">Model</a> .
<i>path_2_resource_data</i>	A string defining the path (either relative or absolute) to the given resource time series.
<i>resource_key</i>	A key used to index into the <a href="#">Resources</a> object, used to associate <a href="#">Renewable</a> assets with the corresponding resource.

```

666 {

```

```

667     resources.addResource(
668         noncombustion_type,
669         path_2_resource_data,
670         resource_key,
671         &(this->electrical_load)
672     );
673
674     return;
675 } /* addResource() */

```

#### 4.15.3.12 addResource() [2/2]

```

void Model::addResource (
    RenewableType renewable_type,
    std::string path_2_resource_data,
    int resource_key )

```

A method to add a renewable resource time series to the [Model](#).

##### Parameters

<i>renewable_type</i>	The type of renewable resource being added to the <a href="#">Model</a> .
<i>path_2_resource_data</i>	A string defining the path (either relative or absolute) to the given resource time series.
<i>resource_key</i>	A key used to index into the <a href="#">Resources</a> object, used to associate <a href="#">Renewable</a> assets with the corresponding resource.

```

704 {
705     resources.addResource(
706         renewable_type,
707         path_2_resource_data,
708         resource_key,
709         &(this->electrical_load)
710     );
711
712     return;
713 } /* addResource() */

```

#### 4.15.3.13 addSolar()

```

void Model::addSolar (
    SolarInputs solar_inputs )

```

Method to add a [Solar](#) asset to the [Model](#).

##### Parameters

<i>solar_inputs</i>	A structure of <a href="#">Solar</a> constructor inputs.
---------------------	--

```

757 {
758     Renewable* solar_ptr = new Solar(
759         this->electrical_load.n_points,
760         this->electrical_load.n_years,
761         solar_inputs
762     );
763
764     this->renewable_ptr_vec.push_back(solar_ptr);
765
766     return;

```

```
767 }    /* addSolar() */
```

#### 4.15.3.14 addTidal()

```
void Model::addTidal (
    TidalInputs tidal_inputs )
```

Method to add a [Tidal](#) asset to the [Model](#).

##### Parameters

<i>tidal_inputs</i>	A structure of <a href="#">Tidal</a> constructor inputs.
---------------------	--

```
784 {
785     Renewable* tidal_ptr = new Tidal(
786         this->electrical_load.n_points,
787         this->electrical_load.n_years,
788         tidal_inputs
789     );
790
791     this->renewable_ptr_vec.push_back(tidal_ptr);
792
793     return;
794 }    /* addTidal() */
```

#### 4.15.3.15 addWave()

```
void Model::addWave (
    WaveInputs wave_inputs )
```

Method to add a [Wave](#) asset to the [Model](#).

##### Parameters

<i>wave_inputs</i>	A structure of <a href="#">Wave</a> constructor inputs.
--------------------	---

```
811 {
812     Renewable* wave_ptr = new Wave(
813         this->electrical_load.n_points,
814         this->electrical_load.n_years,
815         wave_inputs
816     );
817
818     this->renewable_ptr_vec.push_back(wave_ptr);
819
820     return;
821 }    /* addWave() */
```

#### 4.15.3.16 addWind()

```
void Model::addWind (
    WindInputs wind_inputs )
```

Method to add a [Wind](#) asset to the [Model](#).



## Parameters

<code>wind_inputs</code>	A structure of <a href="#">Wind</a> constructor inputs.
--------------------------	---

```

838 {
839     Renewable* wind_ptr = new Wind(
840         this->electrical_load.n_points,
841         this->electrical_load.n_years,
842         wind_inputs
843     );
844
845     this->renewable_ptr_vec.push_back(wind_ptr);
846
847     return;
848 } /* addWind() */

```

## 4.15.3.17 clear()

```

void Model::clear (
    void )

```

Method to clear all attributes of the [Model](#) object.

```

992 {
993     // 1. reset
994     this->reset();
995
996     // 2. clear components
997     controller.clear();
998     electrical_load.clear();
999     resources.clear();
1000
1001     return;
1002 } /* clear() */

```

## 4.15.3.18 reset()

```

void Model::reset (
    void )

```

Method which resets the model for use in assessing a new candidate microgrid design. This method only clears the asset pointer vectors and resets select [Model](#) attributes. It leaves the [Controller](#), [ElectricalLoad](#), and [Resources](#) objects of the [Model](#) alone.

```

934 {
935     // 1. clear combustion_ptr_vec
936     for (size_t i = 0; i < this->combustion_ptr_vec.size(); i++) {
937         delete this->combustion_ptr_vec[i];
938     }
939     this->combustion_ptr_vec.clear();
940
941     // 2. clear noncombustion_ptr_vec
942     for (size_t i = 0; i < this->noncombustion_ptr_vec.size(); i++) {
943         delete this->noncombustion_ptr_vec[i];
944     }
945     this->noncombustion_ptr_vec.clear();
946
947     // 3. clear renewable_ptr_vec
948     for (size_t i = 0; i < this->renewable_ptr_vec.size(); i++) {
949         delete this->renewable_ptr_vec[i];
950     }
951     this->renewable_ptr_vec.clear();
952
953     // 4. clear storage_ptr_vec
954     for (size_t i = 0; i < this->storage_ptr_vec.size(); i++) {
955         delete this->storage_ptr_vec[i];
956     }
957     this->storage_ptr_vec.clear();

```

```

958
959 // 5. reset components and attributes
960 this->controller.clear();
961
962 this->total_fuel_consumed_L = 0;
963
964 this->total_emissions.CO2_kg = 0;
965 this->total_emissions.CO_kg = 0;
966 this->total_emissions.NOx_kg = 0;
967 this->total_emissions.SOx_kg = 0;
968 this->total_emissions.CH4_kg = 0;
969 this->total_emissions.PM_kg = 0;
970
971 this->net_present_cost = 0;
972 this->total_dispatch_discharge_kWh = 0;
973 this->total_renewable_dispatch_kWh = 0;
974 this->levellized_cost_of_energy_kWh = 0;
975
976 return;
977 } /* reset() */

```

#### 4.15.3.19 run()

```

void Model::run (
    void )

```

A method to run the [Model](#).

```

890 {
891 // 1. init Controller
892 this->controller.init (
893     &(this->electrical_load),
894     &(this->renewable_ptr_vec),
895     &(this->resources),
896     &(this->combustion_ptr_vec)
897 );
898
899 // 2. apply dispatch control
900 this->controller.applyDispatchControl (
901     &(this->electrical_load),
902     &(this->resources),
903     &(this->combustion_ptr_vec),
904     &(this->noncombustion_ptr_vec),
905     &(this->renewable_ptr_vec),
906     &(this->storage_ptr_vec)
907 );
908
909 // 3. compute total fuel consumption and emissions
910 this->__computeFuelAndEmissions();
911
912 // 4. compute key economic metrics
913 this->__computeEconomics();
914
915 return;
916 } /* run() */

```

#### 4.15.3.20 writeResults()

```

void Model::writeResults (
    std::string write_path,
    int max_lines = -1 )

```

Method which writes [Model](#) results to an output directory. Also calls out to [writeResults\(\)](#) for each contained asset.

## Parameters

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

```

1030 {
1031     // 1. handle sentinel
1032     if (max_lines < 0) {
1033         max_lines = this->electrical_load.n_points;
1034     }
1035
1036     // 2. check for pre-existing, warn (and remove), then create
1037     if (write_path.back() != '/') {
1038         write_path += '/';
1039     }
1040
1041     if (std::filesystem::is_directory(write_path)) {
1042         std::string warning_str = "WARNING: Model::writeResults(): ";
1043         warning_str += write_path;
1044         warning_str += " already exists, contents will be overwritten!";
1045
1046         std::cout << warning_str << std::endl;
1047
1048         std::filesystem::remove_all(write_path);
1049     }
1050
1051     std::filesystem::create_directory(write_path);
1052
1053     // 3. write summary
1054     this->__writeSummary(write_path);
1055
1056     // 4. write time series
1057     if (max_lines > this->electrical_load.n_points) {
1058         max_lines = this->electrical_load.n_points;
1059     }
1060
1061     if (max_lines > 0) {
1062         this->__writeTimeSeries(write_path, max_lines);
1063     }
1064
1065     // 5. call out to Combustion :: writeResults()
1066     for (size_t i = 0; i < this->combustion_ptr_vec.size(); i++) {
1067         this->combustion_ptr_vec[i]->writeResults(
1068             write_path,
1069             &(this->electrical_load.time_vec_hrs),
1070             i,
1071             max_lines
1072         );
1073     }
1074
1075     // 6. call out to Noncombustion :: writeResults()
1076     for (size_t i = 0; i < this->noncombustion_ptr_vec.size(); i++) {
1077         this->noncombustion_ptr_vec[i]->writeResults(
1078             write_path,
1079             &(this->electrical_load.time_vec_hrs),
1080             i,
1081             max_lines
1082         );
1083     }
1084
1085     // 7. call out to Renewable :: writeResults()
1086     for (size_t i = 0; i < this->renewable_ptr_vec.size(); i++) {
1087         this->renewable_ptr_vec[i]->writeResults(
1088             write_path,
1089             &(this->electrical_load.time_vec_hrs),
1090             &(this->resources.resource_map_1D),
1091             &(this->resources.resource_map_2D),
1092             i,
1093             max_lines
1094         );
1095     }
1096
1097     // 8. call out to Storage :: writeResults()
1098     for (size_t i = 0; i < this->storage_ptr_vec.size(); i++) {
1099         this->storage_ptr_vec[i]->writeResults(
1100             write_path,
1101             &(this->electrical_load.time_vec_hrs),
1102             i,
1103             max_lines
1104         );
1105     }
1106 }

```

```
1107     return;  
1108 }    /* writeResults() */
```

## 4.15.4 Member Data Documentation

### 4.15.4.1 combustion\_ptr\_vec

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

A vector of pointers to the various [Combustion](#) assets in the [Model](#).

### 4.15.4.2 controller

```
Controller Model::controller
```

[Controller](#) component of [Model](#).

### 4.15.4.3 electrical\_load

```
ElectricalLoad Model::electrical_load
```

[ElectricalLoad](#) component of [Model](#).

### 4.15.4.4 levellized\_cost\_of\_energy\_kWh

```
double Model::levellized_cost_of_energy_kWh
```

The levellized cost of energy, per unit energy dispatched/discharged, of the [Model](#) [1/kWh] (undefined currency).

### 4.15.4.5 net\_present\_cost

```
double Model::net_present_cost
```

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

#### 4.15.4.6 noncombustion\_ptr\_vec

```
std::vector<Noncombustion*> Model::noncombustion_ptr_vec
```

A vector of pointers to the various [Noncombustion](#) assets in the [Model](#).

#### 4.15.4.7 renewable\_ptr\_vec

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

A vector of pointers to the various [Renewable](#) assets in the [Model](#).

#### 4.15.4.8 resources

```
Resources Model::resources
```

[Resources](#) component of [Model](#).

#### 4.15.4.9 storage\_ptr\_vec

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

A vector of pointers to the various [Storage](#) assets in the [Model](#).

#### 4.15.4.10 total\_dispatch\_discharge\_kWh

```
double Model::total_dispatch_discharge_kWh
```

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

#### 4.15.4.11 total\_emissions

```
Emissions Model::total_emissions
```

An [Emissions](#) structure for holding total emissions [kg].

#### 4.15.4.12 total\_fuel\_consumed\_L

```
double Model::total_fuel_consumed_L
```

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

#### 4.15.4.13 total\_renewable\_dispatch\_kWh

```
double Model::total_renewable_dispatch_kWh
```

The total energy dispatched [kWh] by all renewable assets over the [Model](#) run.

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

- header/[Model.h](#)
- source/[Model.cpp](#)

## 4.16 ModelInputs Struct Reference

A structure which bundles the necessary inputs for the [Model](#) constructor. Provides default values for every necessary input (except `path_2_electrical_load_time_series`, for which a valid input must be provided).

```
#include <Model.h>
```

### Public Attributes

- `std::string path_2_electrical_load_time_series = ""`  
*A string defining the path (either relative or absolute) to the given electrical load time series.*
- `ControlMode control_mode = ControlMode :: LOAD_FOLLOWING`  
*The control mode to be applied by the [Controller](#) object.*

#### 4.16.1 Detailed Description

A structure which bundles the necessary inputs for the [Model](#) constructor. Provides default values for every necessary input (except `path_2_electrical_load_time_series`, for which a valid input must be provided).

#### 4.16.2 Member Data Documentation

#### 4.16.2.1 control\_mode

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

The control mode to be applied by the [Controller](#) object.

#### 4.16.2.2 path\_2\_electrical\_load\_time\_series

```
std::string ModelInputs::path_2_electrical_load_time_series = ""
```

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

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

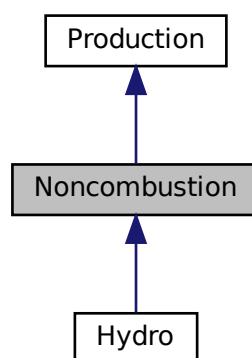
- [header/Model.h](#)

## 4.17 Noncombustion Class Reference

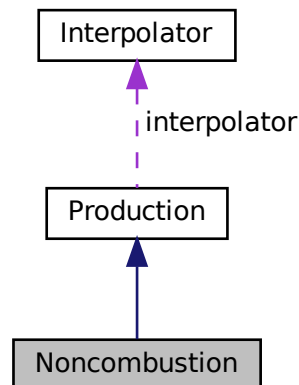
The root of the [Noncombustion](#) branch of the [Production](#) hierarchy. This branch contains derived classes which model controllable production which is not based on combustion.

```
#include <Noncombustion.h>
```

Inheritance diagram for Noncombustion:



Collaboration diagram for Noncombustion:



## Public Member Functions

- [Noncombustion](#) (void)  
*Constructor (dummy) for the [Noncombustion](#) class.*
- [Noncombustion](#) (int, double, [NoncombustionInputs](#))  
*Constructor (intended) for the [Noncombustion](#) class.*
- virtual void [handleReplacement](#) (int)  
*Method to handle asset replacement and capital cost incursion, if applicable.*
- void [computeEconomics](#) (std::vector< double > \*)  
*Helper method to compute key economic metrics for the [Model](#) run.*
- virtual double [requestProductionkW](#) (int, double, double)
- virtual double [requestProductionkW](#) (int, double, double, double)
- virtual double [commit](#) (int, double, double, double)  
*Method which takes in production and load for the current timestep, computes and records dispatch and curtailment, and then returns remaining load.*
- virtual double [commit](#) (int, double, double, double, double)
- void [writeResults](#) (std::string, std::vector< double > \*, int, int=-1)  
*Method which writes [Noncombustion](#) results to an output directory.*
- virtual [~Noncombustion](#) (void)  
*Destructor for the [Noncombustion](#) class.*

## Public Attributes

- [NoncombustionType](#) type  
*The type ([NoncombustionType](#)) of the asset.*
- int [resource\\_key](#)  
*A key used to index into the [Resources](#) object, to associate this asset with the appropriate resource time series.*



## Private Member Functions

- void `__checkInputs` ([NoncombustionInputs](#))  
*Helper method to check inputs to the [Noncombustion](#) constructor.*
- void `__handleStartStop` (int, double, double)  
*Helper method to handle the starting/stopping of the [Noncombustion](#) asset.*
- virtual void `__writeSummary` (std::string)
- virtual void `__writeTimeSeries` (std::string, std::vector< double > \*, int=-1)

### 4.17.1 Detailed Description

The root of the [Noncombustion](#) branch of the [Production](#) hierarchy. This branch contains derived classes which model controllable production which is not based on combustion.

### 4.17.2 Constructor & Destructor Documentation

#### 4.17.2.1 [Noncombustion\(\)](#) [1/2]

```
Noncombustion::Noncombustion (
    void )
```

Constructor (dummy) for the [Noncombustion](#) class.

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

#### 4.17.2.2 [Noncombustion\(\)](#) [2/2]

```
Noncombustion::Noncombustion (
    int n_points,
    double n_years,
    NoncombustionInputs noncombustion_inputs )
```

Constructor (intended) for the [Noncombustion](#) class.

##### Parameters

<code>n_points</code>	The number of points in the modelling time series.
<code>n_years</code>	The number of years being modelled.
<code>noncombustion_inputs</code>	A structure of <a href="#">Noncombustion</a> constructor inputs.

```
133 :
134 Production(
135     n_points,
136     n_years,
137     noncombustion_inputs.production_inputs
138 )
139 {
```

```

140     // 1. check inputs
141     this->__checkInputs(noncombustion_inputs);
142
143     // 2. set attributes
144     //...
145
146     // 3. construction print
147     if (this->print_flag) {
148         std::cout << "Noncombustion object constructed at " << this << std::endl;
149     }
150
151     return;
152 } /* Noncombustion() */

```

#### 4.17.2.3 ~Noncombustion()

```

Noncombustion::~~Noncombustion (
    void ) [virtual]

```

Destructor for the [Noncombustion](#) class.

```

343 {
344     // 1. destruction print
345     if (this->print_flag) {
346         std::cout << "Noncombustion object at " << this << " destroyed" << std::endl;
347     }
348
349     return;
350 } /* ~Noncombustion() */

```

### 4.17.3 Member Function Documentation

#### 4.17.3.1 \_\_checkInputs()

```

void Noncombustion::__checkInputs (
    NoncombustionInputs noncombustion_inputs ) [private]

```

Helper method to check inputs to the [Noncombustion](#) constructor.

##### Parameters

<i>noncombustion_inputs</i>	A structure of <a href="#">Noncombustion</a> constructor inputs.
-----------------------------	--

```

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

```

#### 4.17.3.2 \_\_handleStartStop()

```

void Noncombustion::__handleStartStop (
    int timestep,

```

```
double dt_hrs,
double production_kW ) [private]
```

Helper method to handle the starting/stopping of the [Noncombustion](#) asset.

```
67 {
68     if (this->is_running) {
69         // handle stopping
70         if (production_kW <= 0) {
71             this->is_running = false;
72         }
73     }
74
75     else {
76         // handle starting
77         if (production_kW > 0) {
78             this->is_running = true;
79             this->n_starts++;
80         }
81     }
82
83     return;
84 } /* __handleStartStop() */
```

#### 4.17.3.3 \_\_writeSummary()

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

Reimplemented in [Hydro](#).

```
70 {return;}
```

#### 4.17.3.4 \_\_writeTimeSeries()

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

Reimplemented in [Hydro](#).

```
75     {return;}
```

#### 4.17.3.5 commit() [1/2]

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

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

**Parameters**

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

```

238 {
239     // 1. handle start/stop
240     this->__handleStartStop(timestep, dt_hrs, production_kW);
241
242     // 2. invoke base class method
243     load_kW = Production::commit(
244         timestep,
245         dt_hrs,
246         production_kW,
247         load_kW
248     );
249
250
251     //...
252
253     return load_kW;
254 } /* commit() */

```

**4.17.3.6 commit() [2/2]**

```

virtual double Noncombustion::commit (
    int ,
    double ,
    double ,
    double ,
    double ) [inline], [virtual]

```

Reimplemented in [Hydro](#).

```

96 {return 0;}

```

**4.17.3.7 computeEconomics()**

```

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

```

Helper method to compute key economic metrics for the [Model](#) run.

Ref: [HOMER \[2023b\]](#)

## Parameters

<i>time_vec_hrs_ptr</i>	A pointer to the <i>time_vec_hrs</i> attribute of the <a href="#">ElectricalLoad</a> .
-------------------------	--

Reimplemented from [Production](#).

```

197 {
198     // 1. invoke base class method
199     Production::computeEconomics(time_vec_hrs_ptr);
200
201     return;
202 } /* computeEconomics() */

```

## 4.17.3.8 handleReplacement()

```

void Noncombustion::handleReplacement (
    int timestep ) [virtual]

```

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

## Parameters

<i>timestep</i>	The current time step of the <a href="#">Model</a> run.
-----------------	---

Reimplemented from [Production](#).

Reimplemented in [Hydro](#).

```

170 {
171     // 1. reset attributes
172     //...
173
174     // 2. invoke base class method
175     Production::handleReplacement(timestep);
176
177     return;
178 } /* __handleReplacement() */

```

## 4.17.3.9 requestProductionkW() [1/2]

```

virtual double Noncombustion::requestProductionkW (
    int ,
    double ,
    double ) [inline], [virtual]
92 {return 0;}

```

## 4.17.3.10 requestProductionkW() [2/2]

```

virtual double Noncombustion::requestProductionkW (
    int ,
    double ,
    double ,
    double ) [inline], [virtual]

```

Reimplemented in [Hydro](#).

```

93 {return 0;}

```

### 4.17.3.11 writeResults()

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

Method which writes [Noncombustion](#) results to an output directory.

#### Parameters

<i>write_path</i>	A path (either relative or absolute) to the directory location where results are to be written. If already exists, will overwrite.
<i>time_vec_hrs_ptr</i>	A pointer to the <code>time_vec_hrs</code> attribute of the <a href="#">ElectricalLoad</a> .
<i>noncombustion_index</i>	An integer which corresponds to the index of the <a href="#">Noncombustion</a> asset in the <a href="#">Model</a> .
<i>max_lines</i>	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.

```
290 {
291     // 1. handle sentinel
292     if (max_lines < 0) {
293         max_lines = this->n_points;
294     }
295
296     // 2. create subdirectories
297     write_path += "Production/";
298     if (not std::filesystem::is_directory(write_path)) {
299         std::filesystem::create_directory(write_path);
300     }
301
302     write_path += "Noncombustion/";
303     if (not std::filesystem::is_directory(write_path)) {
304         std::filesystem::create_directory(write_path);
305     }
306
307     write_path += this->type_str;
308     write_path += "_";
309     write_path += std::to_string(int(ceil(this->capacity_kW)));
310     write_path += "kW_idx";
311     write_path += std::to_string(combustion_index);
312     write_path += "/";
313     std::filesystem::create_directory(write_path);
314
315     // 3. write summary
316     this->__writeSummary(write_path);
317
318     // 4. write time series
319     if (max_lines > this->n_points) {
320         max_lines = this->n_points;
321     }
322
323     if (max_lines > 0) {
324         this->__writeTimeSeries(write_path, time_vec_hrs_ptr, max_lines);
325     }
326
327     return;
328 } /* writeResults() */
```

## 4.17.4 Member Data Documentation

### 4.17.4.1 resource\_key

```
int Noncombustion::resource_key
```

A key used to index into the [Resources](#) object, to associate this asset with the appropriate resource time series.

#### 4.17.4.2 type

`NoncombustionType` `Noncombustion::type`

The type (`NoncombustionType`) of the asset.

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

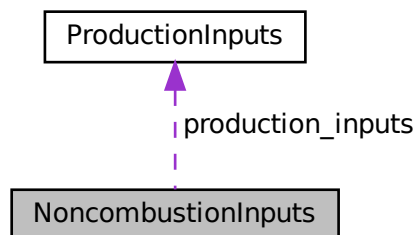
- [header/Production/Noncombustion/Noncombustion.h](#)
- [source/Production/Noncombustion/Noncombustion.cpp](#)

## 4.18 NoncombustionInputs Struct Reference

A structure which bundles the necessary inputs for the [Noncombustion](#) constructor. Provides default values for every necessary input. Note that this structure encapsulates [ProductionInputs](#).

```
#include <Noncombustion.h>
```

Collaboration diagram for `NoncombustionInputs`:



### Public Attributes

- [ProductionInputs](#) `production_inputs`  
An encapsulated [ProductionInputs](#) instance.

#### 4.18.1 Detailed Description

A structure which bundles the necessary inputs for the [Noncombustion](#) constructor. Provides default values for every necessary input. Note that this structure encapsulates [ProductionInputs](#).

#### 4.18.2 Member Data Documentation

#### 4.18.2.1 production\_inputs

`ProductionInputs` `NoncombustionInputs::production_inputs`

An encapsulated `ProductionInputs` instance.

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

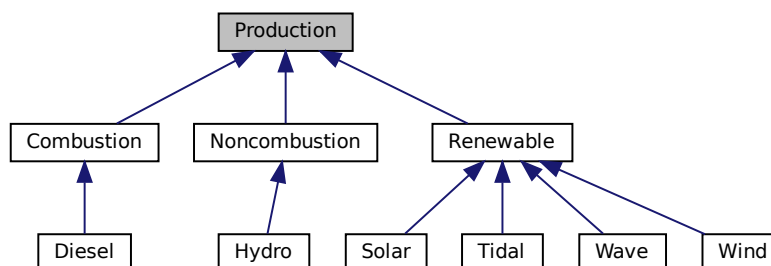
- `header/Production/Noncombustion/Noncombustion.h`

## 4.19 Production Class Reference

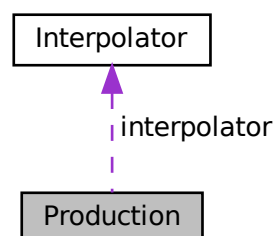
The base class of the `Production` hierarchy. This hierarchy contains derived classes which model the production of energy, be it renewable or otherwise.

```
#include <Production.h>
```

Inheritance diagram for `Production`:



Collaboration diagram for `Production`:





## Public Member Functions

- [Production](#) (void)  
*Constructor (dummy) for the [Production](#) class.*
- [Production](#) (int, double, [ProductionInputs](#))  
*Constructor (intended) for the [Production](#) class.*
- virtual void [handleReplacement](#) (int)  
*Method to handle asset replacement and capital cost incursion, if applicable.*
- double [computeRealDiscountAnnual](#) (double, double)  
*Method to compute the real, annual discount rate to be used in computing model economics. This enables application of the discount factor approach.*
- virtual void [computeEconomics](#) (std::vector< double > \*)  
*Helper method to compute key economic metrics for the [Model](#) run.*
- virtual double [commit](#) (int, double, double, double)  
*Method which takes in production and load for the current timestep, computes and records dispatch and curtailment, and then returns remaining load.*
- virtual [~Production](#) (void)  
*Destructor for the [Production](#) class.*

## Public Attributes

- [Interpolator](#) [interpolator](#)  
*[Interpolator](#) component of [Production](#).*
- bool [print\\_flag](#)  
*A flag which indicates whether or not object construct/destruction should be verbose.*
- bool [is\\_running](#)  
*A boolean which indicates whether or not the asset is running.*
- bool [is\\_sunk](#)  
*A boolean which indicates whether or not the asset should be considered a sunk cost (i.e., capital cost incurred at the start of the model, or no).*
- 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 asset has been operating.*
- double [replace\\_running\\_hrs](#)  
*The number of running hours after which the asset must be replaced.*
- double [capacity\\_kW](#)  
*The rated production capacity [kW] of the asset.*
- double [nominal\\_inflation\\_annual](#)  
*The nominal, annual inflation rate to use in computing model economics.*
- double [nominal\\_discount\\_annual](#)  
*The nominal, annual discount rate to use in computing model economics.*
- double [real\\_discount\\_annual](#)  
*The real, annual discount rate used in computing model economics. Is computed from the given nominal inflation and discount rates.*

- double [capital\\_cost](#)  
*The capital cost of the asset (undefined currency).*
- double [operation\\_maintenance\\_cost\\_kWh](#)  
*The operation and maintenance cost of the asset [1/kWh] (undefined currency). This is a cost incurred per unit of energy produced.*
- double [net\\_present\\_cost](#)  
*The net present cost of this asset.*
- double [total\\_dispatch\\_kWh](#)  
*The total energy dispatched [kWh] over the [Model](#) run.*
- double [levellized\\_cost\\_of\\_energy\\_kWh](#)  
*The levellized cost of energy [1/kWh] (undefined currency) of this asset. This metric considers only dispatch.*
- std::string [type\\_str](#)  
*A string describing the type of the asset.*
- std::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 actual costs).*
- std::vector< double > [operation\\_maintenance\\_cost\\_vec](#)  
*A vector of operation and maintenance costs (undefined currency) incurred over each modelling time step. These costs are not discounted (i.e., these are actual costs).*

## Private Member Functions

- void [\\_\\_checkInputs](#) (int, double, [ProductionInputs](#))  
*Helper method to check inputs to the [Production](#) constructor.*

### 4.19.1 Detailed Description

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

### 4.19.2 Constructor & Destructor Documentation

## 4.19.2.1 Production() [1/2]

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

Constructor (dummy) for the [Production](#) class.

```
112 {
113     return;
114 } /* Production() */
```

## 4.19.2.2 Production() [2/2]

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

Constructor (intended) for the [Production](#) class.

## Parameters

<i>n_points</i>	The number of points in the modelling time series.
<i>n_years</i>	The number of years being modelled.
<i>production_inputs</i>	A structure of <a href="#">Production</a> constructor inputs.

```
143 {
144     // 1. check inputs
145     this->__checkInputs(n_points, n_years, production_inputs);
146
147     // 2. set attributes
148     this->print_flag = production_inputs.print_flag;
149     this->is_running = false;
150     this->is_sunk = production_inputs.is_sunk;
151
152     this->n_points = n_points;
153     this->n_starts = 0;
154     this->n_replacements = 0;
155
156     this->n_years = n_years;
157
158     this->running_hours = 0;
159     this->replace_running_hrs = production_inputs.replace_running_hrs;
160
161     this->capacity_kW = production_inputs.capacity_kW;
162
163     this->nominal_inflation_annual = production_inputs.nominal_inflation_annual;
164     this->nominal_discount_annual = production_inputs.nominal_discount_annual;
165
166     this->real_discount_annual = this->computeRealDiscountAnnual (
167         production_inputs.nominal_inflation_annual,
168         production_inputs.nominal_discount_annual
169     );
170
171     this->capital_cost = 0;
172     this->operation_maintenance_cost_kWh = 0;
173     this->net_present_cost = 0;
174     this->total_dispatch_kWh = 0;
175     this->levellized_cost_of_energy_kWh = 0;
176
177     this->is_running_vec.resize(this->n_points, 0);
178
179     this->production_vec_kW.resize(this->n_points, 0);
180     this->dispatch_vec_kW.resize(this->n_points, 0);
181     this->storage_vec_kW.resize(this->n_points, 0);
182     this->curtailment_vec_kW.resize(this->n_points, 0);
183
184     this->capital_cost_vec.resize(this->n_points, 0);
185     this->operation_maintenance_cost_vec.resize(this->n_points, 0);
186 }
```

```

187     // 3. construction print
188     if (this->print_flag) {
189         std::cout << "Production object constructed at " << this << std::endl;
190     }
191
192     return;
193 } /* Production() */

```

#### 4.19.2.3 ~Production()

```

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

```

Destructor for the [Production](#) class.

```

417 {
418     // 1. destruction print
419     if (this->print_flag) {
420         std::cout << "Production object at " << this << " destroyed" << std::endl;
421     }
422
423     return;
424 } /* ~Production() */

```

### 4.19.3 Member Function Documentation

#### 4.19.3.1 \_\_checkInputs()

```

void Production::__checkInputs (
    int n_points,
    double n_years,
    ProductionInputs production_inputs ) [private]

```

Helper method to check inputs to the [Production](#) constructor.

##### Parameters

<i>n_points</i>	The number of points in the modelling time series.
<i>production_inputs</i>	A structure of <a href="#">Production</a> constructor inputs.

```

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

```

```

65         throw std::invalid_argument(error_str);
66     }
67
68     // 3. check capacity_kW
69     if (production_inputs.capacity_kW <= 0) {
70         std::string error_str = "ERROR: Production(): ";
71         error_str += "ProductionInputs::capacity_kW must be > 0";
72
73         #ifdef _WIN32
74             std::cout << error_str << std::endl;
75         #endif
76
77         throw std::invalid_argument(error_str);
78     }
79
80     // 4. check replace_running_hrs
81     if (production_inputs.replace_running_hrs <= 0) {
82         std::string error_str = "ERROR: Production(): ";
83         error_str += "ProductionInputs::replace_running_hrs must be > 0";
84
85         #ifdef _WIN32
86             std::cout << error_str << std::endl;
87         #endif
88
89         throw std::invalid_argument(error_str);
90     }
91
92     return;
93 } /* __checkInputs() */

```

#### 4.19.3.2 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

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

##### Returns

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

Reimplemented in [Wind](#), [Wave](#), [Tidal](#), [Solar](#), [Renewable](#), [Noncombustion](#), [Diesel](#), and [Combustion](#).

```

358 {
359     // 1. record production
360     this->production_vec_kW[timestep] = production_kW;
361
362     // 2. compute and record dispatch and curtailment
363     double dispatch_kW = 0;
364     double curtailment_kW = 0;
365
366     if (production_kW > load_kW) {
367         dispatch_kW = load_kW;
368         curtailment_kW = production_kW - dispatch_kW;
369     }

```

```

370
371     else {
372         dispatch_kW = production_kW;
373     }
374
375     this->dispatch_vec_kW[timestep] = dispatch_kW;
376     this->total_dispatch_kWh += dispatch_kW * dt_hrs;
377     this->curtailment_vec_kW[timestep] = curtailment_kW;
378
379     // 3. update load
380     load_kW -= dispatch_kW;
381
382     // 4. update and log running attributes
383     if (this->is_running) {
384         // 4.1. log running state, running hours
385         this->is_running_vec[timestep] = this->is_running;
386         this->running_hours += dt_hrs;
387
388         // 4.2. incur operation and maintenance costs
389         double produced_kWh = production_kW * dt_hrs;
390
391         double operation_maintenance_cost =
392             this->operation_maintenance_cost_kWh * produced_kWh;
393         this->operation_maintenance_cost_vec[timestep] = operation_maintenance_cost;
394     }
395
396     // 5. trigger replacement, if applicable
397     if (this->running_hours >= (this->n_replacements + 1) * this->replace_running_hrs) {
398         this->handleReplacement(timestep);
399     }
400
401     return load_kW;
402 } /* commit() */

```

#### 4.19.3.3 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

<i>time_vec_hrs_ptr</i>	A pointer to the <i>time_vec_hrs</i> attribute of the <a href="#">ElectricalLoad</a> .
-------------------------	--

1. compute levlized cost of energy (per unit dispatched)

Reimplemented in [Renewable](#), [Noncombustion](#), and [Combustion](#).

```

281 {
282     // 1. compute net present cost
283     double t_hrs = 0;
284     double real_discount_scalar = 0;
285
286     for (int i = 0; i < this->n_points; i++) {
287         t_hrs = time_vec_hrs_ptr->at(i);
288
289         real_discount_scalar = 1.0 / pow(
290             1 + this->real_discount_annual,
291             t_hrs / 8760
292         );

```

```

293
294         this->net_present_cost += real_discount_scalar * this->capital_cost_vec[i];
295
296         this->net_present_cost +=
297             real_discount_scalar * this->operation_maintenance_cost_vec[i];
298     }
299
300     // assuming 8,760 hours per year
301     if (this->total_dispatch_kWh <= 0) {
302         this->levellized_cost_of_energy_kWh = this->net_present_cost;
303     }
304
305     else {
306         double n_years = time_vec_hrs_ptr->at(this->n_points - 1) / 8760;
307
308         double capital_recovery_factor =
309             (this->real_discount_annual * pow(1 + this->real_discount_annual, n_years)) /
310             (pow(1 + this->real_discount_annual, n_years) - 1);
311
312         double total_annualized_cost = capital_recovery_factor *
313             this->net_present_cost;
314
315         this->levellized_cost_of_energy_kWh =
316             (n_years * total_annualized_cost) /
317             this->total_dispatch_kWh;
318     }
319
320     return;
321 } /* computeEconomics() */

```

#### 4.19.3.4 computeRealDiscountAnnual()

```

double Production::computeRealDiscountAnnual (
    double nominal_inflation_annual,
    double nominal_discount_annual )

```

Method to compute the real, annual discount rate to be used in computing model economics. This enables application of the discount factor approach.

Ref: [HOMER \[2023h\]](#)

Ref: [HOMER \[2023b\]](#)

##### Parameters

<i>nominal_inflation_annual</i>	The nominal, annual inflation rate to use in computing model economics.
<i>nominal_discount_annual</i>	The nominal, annual discount rate to use in computing model economics.

##### Returns

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

```

254 {
255     double real_discount_annual = nominal_discount_annual - nominal_inflation_annual;
256     real_discount_annual /= 1 + nominal_inflation_annual;
257
258     return real_discount_annual;
259 } /* __computeRealDiscountAnnual() */

```

#### 4.19.3.5 handleReplacement()

```

void Production::handleReplacement (
    int timestep ) [virtual]

```

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



## Parameters

<i>timestep</i>	The current time step of the <a href="#">Model</a> run.
-----------------	---

Reimplemented in [Wind](#), [Wave](#), [Tidal](#), [Solar](#), [Renewable](#), [Noncombustion](#), [Hydro](#), [Diesel](#), and [Combustion](#).

```

211 {
212     // 1. reset attributes
213     this->is_running = false;
214
215     // 2. log replacement
216     this->n_replacements++;
217
218     // 3. incur capital cost in timestep
219     this->capital_cost_vec[timestep] = this->capital_cost;
220
221     return;
222 } /* __handleReplacement() */

```

## 4.19.4 Member Data Documentation

### 4.19.4.1 capacity\_kW

```
double Production::capacity_kW
```

The rated production capacity [kW] of the asset.

### 4.19.4.2 capital\_cost

```
double Production::capital_cost
```

The capital cost of the asset (undefined currency).

### 4.19.4.3 capital\_cost\_vec

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

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

### 4.19.4.4 curtailment\_vec\_kW

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

A vector of curtailment [kW] at each point in the modelling time series. Curtailment is the amount of production that can be neither dispatched nor stored, and is hence curtailed.

#### 4.19.4.5 dispatch\_vec\_kW

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

A vector of dispatch [kW] at each point in the modelling time series. Dispatch is the amount of production that is sent to the grid to satisfy load.

#### 4.19.4.6 interpolator

```
Interpolator Production::interpolator
```

[Interpolator](#) component of [Production](#).

#### 4.19.4.7 is\_running

```
bool Production::is_running
```

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

#### 4.19.4.8 is\_running\_vec

```
std::vector<bool> Production::is_running_vec
```

A boolean vector for tracking if the asset is running at a particular point in time.

#### 4.19.4.9 is\_sunk

```
bool Production::is_sunk
```

A boolean which indicates whether or not the asset should be considered a sunk cost (i.e., capital cost incurred at the start of the model, or no).

#### 4.19.4.10 levellized\_cost\_of\_energy\_kWh

```
double Production::levellized_cost_of_energy_kWh
```

The levellized cost of energy [1/kWh] (undefined currency) of this asset. This metric considers only dispatch.

**4.19.4.11 n\_points**

```
int Production::n_points
```

The number of points in the modelling time series.

**4.19.4.12 n\_replacements**

```
int Production::n_replacements
```

The number of times the asset has been replaced.

**4.19.4.13 n\_starts**

```
int Production::n_starts
```

The number of times the asset has been started.

**4.19.4.14 n\_years**

```
double Production::n_years
```

The number of years being modelled.

**4.19.4.15 net\_present\_cost**

```
double Production::net_present_cost
```

The net present cost of this asset.

**4.19.4.16 nominal\_discount\_annual**

```
double Production::nominal_discount_annual
```

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

#### 4.19.4.17 nominal\_inflation\_annual

```
double Production::nominal_inflation_annual
```

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

#### 4.19.4.18 operation\_maintenance\_cost\_kWh

```
double Production::operation_maintenance_cost_kWh
```

The operation and maintenance cost of the asset [1/kWh] (undefined currency). This is a cost incurred per unit of energy produced.

#### 4.19.4.19 operation\_maintenance\_cost\_vec

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

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

#### 4.19.4.20 print\_flag

```
bool Production::print_flag
```

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

#### 4.19.4.21 production\_vec\_kW

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

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

#### 4.19.4.22 real\_discount\_annual

```
double Production::real_discount_annual
```

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

#### 4.19.4.23 replace\_running\_hrs

```
double Production::replace_running_hrs
```

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

#### 4.19.4.24 running\_hours

```
double Production::running_hours
```

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

#### 4.19.4.25 storage\_vec\_kW

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

A vector of storage [kW] at each point in the modelling time series. [Storage](#) is the amount of production that is sent to storage.

#### 4.19.4.26 total\_dispatch\_kWh

```
double Production::total_dispatch_kWh
```

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

#### 4.19.4.27 type\_str

```
std::string Production::type_str
```

A string describing the type of the asset.

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

- header/Production/[Production.h](#)
- source/Production/[Production.cpp](#)

## 4.20 ProductionInputs Struct Reference

A structure which bundles the necessary inputs for the [Production](#) constructor. Provides default values for every necessary input.

```
#include <Production.h>
```

## Public Attributes

- bool `print_flag` = false  
*A flag which indicates whether or not object construct/destruction should be verbose.*
- bool `is_sunk` = false  
*A boolean which indicates whether or not the asset should be considered a sunk cost (i.e., capital cost incurred at the start of the model, or no).*
- double `capacity_kW` = 100  
*The rated production capacity [kW] of the asset.*
- double `nominal_inflation_annual` = 0.02  
*The nominal, annual inflation rate to use in computing model economics.*
- double `nominal_discount_annual` = 0.04  
*The nominal, annual discount rate to use in computing model economics.*
- double `replace_running_hrs` = 90000  
*The number of running hours after which the asset must be replaced.*

### 4.20.1 Detailed Description

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

### 4.20.2 Member Data Documentation

#### 4.20.2.1 `capacity_kW`

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

The rated production capacity [kW] of the asset.

#### 4.20.2.2 `is_sunk`

```
bool ProductionInputs::is_sunk = false
```

A boolean which indicates whether or not the asset should be considered a sunk cost (i.e., capital cost incurred at the start of the model, or no).

#### 4.20.2.3 `nominal_discount_annual`

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

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

#### 4.20.2.4 nominal\_inflation\_annual

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

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

#### 4.20.2.5 print\_flag

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

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

#### 4.20.2.6 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:

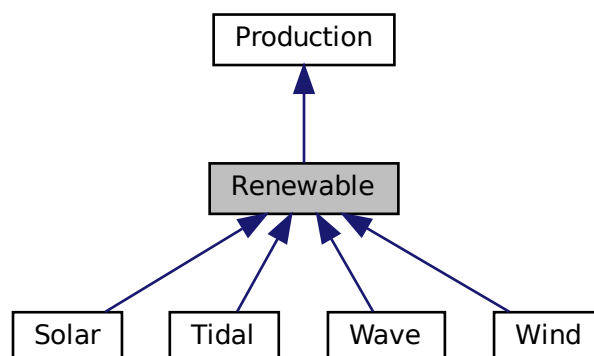
- header/Production/[Production.h](#)

## 4.21 Renewable Class Reference

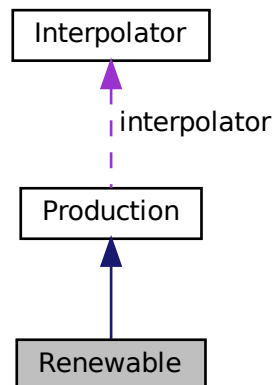
The root of the [Renewable](#) branch of the [Production](#) hierarchy. This branch contains derived classes which model the renewable production of energy.

```
#include <Renewable.h>
```

Inheritance diagram for Renewable:



Collaboration diagram for Renewable:



## Public Member Functions

- [Renewable](#) (void)  
*Constructor (dummy) for the [Renewable](#) class.*
- [Renewable](#) (int, double, [RenewableInputs](#))  
*Constructor (intended) for the [Renewable](#) class.*
- virtual void [handleReplacement](#) (int)  
*Method to handle asset replacement and capital cost incursion, if applicable.*
- void [computeEconomics](#) (std::vector< double > \*)  
*Helper method to compute key economic metrics for the [Model](#) run.*
- virtual double [computeProductionkW](#) (int, double, double)
- virtual double [computeProductionkW](#) (int, double, double, double)
- virtual double [commit](#) (int, double, double, double)  
*Method which takes in production and load for the current timestep, computes and records dispatch and curtailment, and then returns remaining load.*
- void [writeResults](#) (std::string, std::vector< double > \*, std::map< int, std::vector< double >> \*, std::map< int, std::vector< std::vector< double >>> \*, int, int=-1)  
*Method which writes [Renewable](#) results to an output directory.*
- virtual [~Renewable](#) (void)  
*Destructor for the [Renewable](#) class.*

## Public Attributes

- [RenewableType](#) type  
*The type ([RenewableType](#)) of the asset.*
- int [resource\\_key](#)  
*A key used to index into the [Resources](#) object, to associate this asset with the appropriate resource time series.*



## Private Member Functions

- void `__checkInputs` ([RenewableInputs](#))  
*Helper method to check inputs to the [Renewable](#) constructor.*
- void `__handleStartStop` (int, double, double)  
*Helper method to handle the starting/stopping of the renewable asset.*
- virtual void `__writeSummary` (std::string)
- virtual void `__writeTimeSeries` (std::string, std::vector< double > \*, std::map< int, std::vector< double >> \*, std::map< int, std::vector< std::vector< double >>> \*, int=-1)

### 4.21.1 Detailed Description

The root of the [Renewable](#) branch of the [Production](#) hierarchy. This branch contains derived classes which model the renewable production of energy.

### 4.21.2 Constructor & Destructor Documentation

#### 4.21.2.1 [Renewable\(\)](#) [1/2]

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

Constructor (dummy) for the [Renewable](#) class.

```
100 {
101     //...
102
103     return;
104 } /* Renewable() */
```

#### 4.21.2.2 [Renewable\(\)](#) [2/2]

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

Constructor (intended) for the [Renewable](#) class.

##### Parameters

<code>n_points</code>	The number of points in the modelling time series.
<code>n_years</code>	The number of years being modelled.
<code>renewable_inputs</code>	A structure of <a href="#">Renewable</a> constructor inputs.

```
132 :
133 Production(
134     n_points,
```

```

135     n_years,
136     renewable_inputs.production_inputs
137 )
138 {
139     // 1. check inputs
140     this->__checkInputs(renewable_inputs);
141
142     // 2. set attributes
143     //...
144
145     // 3. construction print
146     if (this->print_flag) {
147         std::cout << "Renewable object constructed at " << this << std::endl;
148     }
149
150     return;
151 } /* Renewable() */

```

#### 4.21.2.3 ~Renewable()

```

Renewable::~Renewable (
    void ) [virtual]

```

Destructor for the [Renewable](#) class.

```

354 {
355     // 1. destruction print
356     if (this->print_flag) {
357         std::cout << "Renewable object at " << this << " destroyed" << std::endl;
358     }
359
360     return;
361 } /* ~Renewable() */

```

### 4.21.3 Member Function Documentation

#### 4.21.3.1 \_\_checkInputs()

```

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

```

Helper method to check inputs to the [Renewable](#) constructor.

```

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

```

#### 4.21.3.2 `__handleStartStop()`

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

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

```
64 {
65     if (this->is_running) {
66         // handle stopping
67         if (production_kW <= 0) {
68             this->is_running = false;
69         }
70     }
71
72     else {
73         // handle starting
74         if (production_kW > 0) {
75             this->is_running = true;
76             this->n_starts++;
77         }
78     }
79
80     return;
81 } /* __handleStartStop() */
```

#### 4.21.3.3 `__writeSummary()`

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

Reimplemented in [Wind](#), [Wave](#), [Tidal](#), and [Solar](#).

```
72 {return;}
```

#### 4.21.3.4 `__writeTimeSeries()`

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

Reimplemented in [Wind](#), [Wave](#), [Tidal](#), and [Solar](#).

```
79     {return;}
```

#### 4.21.3.5 `commit()`

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

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

**Parameters**

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

```

235 {
236     // 1. handle start/stop
237     this->__handleStartStop(timestep, dt_hrs, production_kW);
238
239     // 2. invoke base class method
240     load_kW = Production::commit(
241         timestep,
242         dt_hrs,
243         production_kW,
244         load_kW
245     );
246
247
248     //...
249
250     return load_kW;
251 } /* commit() */

```

**4.21.3.6 computeEconomics()**

```

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

```

Helper method to compute key economic metrics for the [Model](#) run.

**Parameters**

<i>time_vec_hrs_ptr</i>	A pointer to the <i>time_vec_hrs</i> attribute of the <a href="#">ElectricalLoad</a> .
-------------------------	--

Reimplemented from [Production](#).

```

194 {
195     // 1. invoke base class method
196     Production::computeEconomics(time_vec_hrs_ptr);
197
198     return;
199 } /* computeEconomics() */

```

**4.21.3.7 computeProductionkW() [1/2]**

```

virtual double Renewable::computeProductionkW (
    int ,

```

```
double ,
double ) [inline], [virtual]
```

Reimplemented in [Wind](#), [Tidal](#), and [Solar](#).

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

#### 4.21.3.8 computeProductionkW() [2/2]

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

Reimplemented in [Wave](#).

```
97 {return 0;}
```

#### 4.21.3.9 handleReplacement()

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

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

##### Parameters

<i>timestep</i>	The current time step of the <a href="#">Model</a> run.
-----------------	---

Reimplemented from [Production](#).

Reimplemented in [Wind](#), [Wave](#), [Tidal](#), and [Solar](#).

```
169 {
170     // 1. reset attributes
171     //...
172
173     // 2. invoke base class method
174     Production::handleReplacement(timestep);
175
176     return;
177 } /* __handleReplacement() */
```

#### 4.21.3.10 writeResults()

```
void Renewable::writeResults (
    std::string write_path,
    std::vector< double > * time_vec_hrs_ptr,
    std::map< int, std::vector< double >> * resource_map_1D_ptr,
    std::map< int, std::vector< std::vector< double >>> * resource_map_2D_ptr,
    int renewable_index,
    int max_lines = -1 )
```

Method which writes [Renewable](#) results to an output directory.

## Parameters

<i>write_path</i>	A path (either relative or absolute) to the directory location where results are to be written. If already exists, will overwrite.
<i>time_vec_hrs_ptr</i>	A pointer to the <code>time_vec_hrs</code> attribute of the <a href="#">ElectricalLoad</a> .
<i>resource_map_1D_ptr</i>	A pointer to the 1D map of <a href="#">Resources</a> .
<i>resource_map_2D_ptr</i>	A pointer to the 2D map of <a href="#">Resources</a> .
<i>renewable_index</i>	An integer which corresponds to the index of the <a href="#">Renewable</a> asset in the <a href="#">Model</a> .
<i>max_lines</i>	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.

```

295 {
296     // 1. handle sentinel
297     if (max_lines < 0) {
298         max_lines = this->n_points;
299     }
300
301     // 2. create subdirectories
302     write_path += "Production/";
303     if (not std::filesystem::is_directory(write_path)) {
304         std::filesystem::create_directory(write_path);
305     }
306
307     write_path += "Renewable/";
308     if (not std::filesystem::is_directory(write_path)) {
309         std::filesystem::create_directory(write_path);
310     }
311
312     write_path += this->type_str;
313     write_path += "_";
314     write_path += std::to_string(int(ceil(this->capacity_kw)));
315     write_path += "kW_idx";
316     write_path += std::to_string(renewable_index);
317     write_path += "/";
318     std::filesystem::create_directory(write_path);
319
320     // 3. write summary
321     this->__writeSummary(write_path);
322
323     // 4. write time series
324     if (max_lines > this->n_points) {
325         max_lines = this->n_points;
326     }
327
328     if (max_lines > 0) {
329         this->__writeTimeSeries(
330             write_path,
331             time_vec_hrs_ptr,
332             resource_map_1D_ptr,
333             resource_map_2D_ptr,
334             max_lines
335         );
336     }
337
338     return;
339 } /* writeResults() */

```

## 4.21.4 Member Data Documentation

### 4.21.4.1 resource\_key

```
int Renewable::resource_key
```

A key used to index into the [Resources](#) object, to associate this asset with the appropriate resource time series.

#### 4.21.4.2 type

`RenewableType` `Renewable::type`

The type (`RenewableType`) of the asset.

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

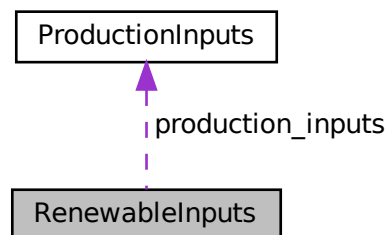
- `header/Production/Renewable/Renewable.h`
- `source/Production/Renewable/Renewable.cpp`

## 4.22 RenewableInputs Struct Reference

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

```
#include <Renewable.h>
```

Collaboration diagram for `RenewableInputs`:



### Public Attributes

- `ProductionInputs production_inputs`  
*An encapsulated `ProductionInputs` instance.*

#### 4.22.1 Detailed Description

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

#### 4.22.2 Member Data Documentation

#### 4.22.2.1 production\_inputs

`ProductionInputs RenewableInputs::production_inputs`

An encapsulated `ProductionInputs` instance.

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

- header/Production/Renewable/[Renewable.h](#)

### 4.23 Resources Class Reference

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

```
#include <Resources.h>
```

#### Public Member Functions

- [Resources](#) (void)  
*Constructor for the [Resources](#) class.*
- void [addResource](#) ([NoncombustionType](#), std::string, int, [ElectricalLoad](#) \*)  
*A method to add a renewable resource time series to [Resources](#). Checks if given resource key is already in use. The associated helper methods also check against [ElectricalLoad](#) to ensure that all added time series align with the electrical load time series (both in terms of length and which points in time are included).*
- void [addResource](#) ([RenewableType](#), std::string, int, [ElectricalLoad](#) \*)  
*A method to add a renewable resource time series to [Resources](#). Checks if given resource key is already in use. The associated helper methods also check against [ElectricalLoad](#) to ensure that all added time series align with the electrical load time series (both in terms of length and which points in time are included).*
- void [clear](#) (void)  
*Method to clear all attributes of the [Resources](#) object.*
- [~Resources](#) (void)  
*Destructor for the [Resources](#) class.*

#### Public Attributes

- std::map< int, std::vector< double > > [resource\\_map\\_1D](#)  
*A map <int, vector<double>> of given 1D renewable resource time series.*
- std::map< int, std::string > [string\\_map\\_1D](#)  
*A map <int, string> of descriptors for the type of the given 1D renewable resource time series.*
- std::map< int, std::string > [path\\_map\\_1D](#)  
*A map <int, string> of the paths (either relative or absolute) to given 1D renewable resource time series.*
- std::map< int, std::vector< std::vector< double > > > [resource\\_map\\_2D](#)  
*A map <int, vector<vector<double>>> of given 2D renewable resource time series.*
- std::map< int, std::string > [string\\_map\\_2D](#)  
*A map <int, string> of descriptors for the type of the given 2D renewable resource time series.*
- std::map< int, std::string > [path\\_map\\_2D](#)  
*A map <int, string> of the paths (either relative or absolute) to given 2D renewable resource time series.*



## Private Member Functions

- void `__checkResourceKey1D` (int, [RenewableType](#))  
*Helper method to check if given resource key (1D) is already in use.*
- void `__checkResourceKey2D` (int, [RenewableType](#))  
*Helper method to check if given resource key (2D) is already in use.*
- void `__checkResourceKey1D` (int, [NoncombustionType](#))  
*Helper method to check if given resource key (1D) is already in use.*
- void `__checkTimePoint` (double, double, std::string, [ElectricalLoad](#) \*)  
*Helper method to check received time point against expected time point.*
- void `__throwLengthError` (std::string, [ElectricalLoad](#) \*)  
*Helper method to throw data length error.*
- void `__readHydroResource` (std::string, int, [ElectricalLoad](#) \*)  
*Helper method to handle reading a hydro resource time series into [Resources](#).*
- void `__readSolarResource` (std::string, int, [ElectricalLoad](#) \*)  
*Helper method to handle reading a solar resource time series into [Resources](#).*
- void `__readTidalResource` (std::string, int, [ElectricalLoad](#) \*)  
*Helper method to handle reading a tidal resource time series into [Resources](#).*
- void `__readWaveResource` (std::string, int, [ElectricalLoad](#) \*)  
*Helper method to handle reading a wave resource time series into [Resources](#).*
- void `__readWindResource` (std::string, int, [ElectricalLoad](#) \*)  
*Helper method to handle reading a wind resource time series into [Resources](#).*

### 4.23.1 Detailed Description

A class which contains renewable resource data. Intended to serve as a component class of [Model](#).

### 4.23.2 Constructor & Destructor Documentation

#### 4.23.2.1 Resources()

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

Constructor for the [Resources](#) class.

```
727 {
728     return;
729 } /* Resources() */
```

#### 4.23.2.2 ~Resources()

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

Destructor for the [Resources](#) class.

```
939 {
940     this->clear();
941     return;
942 } /* ~Resources() */
```

### 4.23.3 Member Function Documentation

#### 4.23.3.1 `__checkResourceKey1D()` [1/2]

```
void Resources::__checkResourceKey1D (
    int resource_key,
    NoncombustionType noncombustion_type ) [private]
```

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

##### Parameters

<i>resource_key</i>	The key associated with the given renewable resource.
<i>noncombustion_type</i>	The type of renewable resource being added to <a href="#">Resources</a> .

```
114 {
115     if (this->resource_map_1D.count(resource_key) > 0) {
116         std::string error_str = "ERROR: Resources::addResource(";
117
118         switch (noncombustion_type) {
119             case (NoncombustionType :: HYDRO): {
120                 error_str += "HYDRO): ";
121
122                 break;
123             }
124
125             default: {
126                 error_str += "UNDEFINED_TYPE): ";
127
128                 break;
129             }
130         }
131
132         error_str += "resource key (1D) ";
133         error_str += std::to_string(resource_key);
134         error_str += " is already in use";
135
136         #ifdef _WIN32
137             std::cout << error_str << std::endl;
138         #endif
139
140         throw std::invalid_argument(error_str);
141     }
142
143     return;
144 } /* __checkResourceKey1D() */
```

#### 4.23.3.2 `__checkResourceKey1D()` [2/2]

```
void Resources::__checkResourceKey1D (
    int resource_key,
    RenewableType renewable_type ) [private]
```

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

##### Parameters

<i>resource_key</i>	The key associated with the given renewable resource.
<i>renewable_type</i>	The type of renewable resource being added to <a href="#">Resources</a> .

```

47 {
48     if (this->resource_map_1D.count(resource_key) > 0) {
49         std::string error_str = "ERROR: Resources::addResource(";
50
51         switch (renewable_type) {
52             case (RenewableType :: SOLAR): {
53                 error_str += "SOLAR): ";
54
55                 break;
56             }
57
58             case (RenewableType :: TIDAL): {
59                 error_str += "TIDAL): ";
60
61                 break;
62             }
63
64             case (RenewableType :: WIND): {
65                 error_str += "WIND): ";
66
67                 break;
68             }
69
70             default: {
71                 error_str += "UNDEFINED_TYPE): ";
72
73                 break;
74             }
75         }
76
77         error_str += "resource key (1D) ";
78         error_str += std::to_string(resource_key);
79         error_str += " is already in use";
80
81         #ifdef WIN32
82             std::cout << error_str << std::endl;
83         #endif
84
85         throw std::invalid_argument(error_str);
86     }
87
88     return;
89 } /* __checkResourceKey1D() */

```

#### 4.23.3.3 \_\_checkResourceKey2D()

```

void Resources::__checkResourceKey2D (
    int resource_key,
    RenewableType renewable_type ) [private]

```

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

##### Parameters

<i>resource_key</i>	The key associated with the given renewable resource.
---------------------	---

```

167 {
168     if (this->resource_map_2D.count(resource_key) > 0) {
169         std::string error_str = "ERROR: Resources::addResource(";
170
171         switch (renewable_type) {
172             case (RenewableType :: WAVE): {
173                 error_str += "WAVE): ";
174
175                 break;
176             }
177
178             default: {
179                 error_str += "UNDEFINED_TYPE): ";
180
181                 break;
182             }
183         }
184     }

```

```

185         error_str += "resource key (2D) ";
186         error_str += std::to_string(resource_key);
187         error_str += " is already in use";
188
189         #ifdef _WIN32
190             std::cout << error_str << std::endl;
191         #endif
192
193         throw std::invalid_argument(error_str);
194     }
195
196     return;
197 } /* __checkResourceKey2D() */

```

#### 4.23.3.4 \_\_checkTimePoint()

```

void Resources::__checkTimePoint (
    double time_received_hrs,
    double time_expected_hrs,
    std::string path_2_resource_data,
    ElectricalLoad * electrical_load_ptr ) [private]

```

Helper method to check received time point against expected time point.

##### Parameters

<i>time_received_hrs</i>	The point in time received from the given data.
<i>time_expected_hrs</i>	The point in time expected (this comes from the electrical load time series).
<i>path_2_resource_data</i>	The path (either relative or absolute) to the given resource time series.
<i>electrical_load_ptr</i>	A pointer to the <a href="#">Model's ElectricalLoad</a> object.

```

232 {
233     if (time_received_hrs != time_expected_hrs) {
234         std::string error_str = "ERROR: Resources::addResource(): ";
235         error_str += "the given resource time series at ";
236         error_str += path_2_resource_data;
237         error_str += " does not align with the ";
238         error_str += "previously given electrical load time series at ";
239         error_str += electrical_load_ptr->path_2_electrical_load_time_series;
240
241         #ifdef _WIN32
242             std::cout << error_str << std::endl;
243         #endif
244
245         throw std::runtime_error(error_str);
246     }
247
248     return;
249 } /* __checkTimePoint() */

```

#### 4.23.3.5 \_\_readHydroResource()

```

void Resources::__readHydroResource (
    std::string path_2_resource_data,
    int resource_key,
    ElectricalLoad * electrical_load_ptr ) [private]

```

Helper method to handle reading a hydro resource time series into [Resources](#).

## Parameters

<i>path_2_resource_data</i>	The path (either relative or absolute) to the given resource time series.
<i>resource_key</i>	The key associated with the given renewable resource.
<i>electrical_load_ptr</i>	A pointer to the <a href="#">Model's ElectricalLoad</a> object.

```

320 {
321     // 1. init CSV reader, record path and type
322     io::CSVReader<2> CSV(path_2_resource_data);
323
324     CSV.read_header(
325         io::ignore_extra_column,
326         "Time (since start of data) [hrs]",
327         "Hydro Inflow [m3/hr]"
328     );
329
330     this->path_map_1D.insert(
331         std::pair<int, std::string>(resource_key, path_2_resource_data)
332     );
333
334     this->string_map_1D.insert(std::pair<int, std::string>(resource_key, "HYDRO"));
335
336     // 2. init map element
337     this->resource_map_1D.insert(
338         std::pair<int, std::vector<double>>(resource_key, {})
339     );
340     this->resource_map_1D[resource_key].resize(electrical_load_ptr->n_points, 0);
341
342
343     // 3. read in resource data, check against time series (point-wise and length)
344     int n_points = 0;
345     double time_hrs = 0;
346     double time_expected_hrs = 0;
347     double hydro_resource_m3hr = 0;
348
349     while (CSV.read_row(time_hrs, hydro_resource_m3hr)) {
350         if (n_points > electrical_load_ptr->n_points) {
351             this->__throwLengthError(path_2_resource_data, electrical_load_ptr);
352         }
353
354         time_expected_hrs = electrical_load_ptr->time_vec_hrs[n_points];
355         this->__checkTimePoint(
356             time_hrs,
357             time_expected_hrs,
358             path_2_resource_data,
359             electrical_load_ptr
360         );
361
362         this->resource_map_1D[resource_key][n_points] = hydro_resource_m3hr;
363
364         n_points++;
365     }
366
367     // 4. check data length
368     if (n_points != electrical_load_ptr->n_points) {
369         this->__throwLengthError(path_2_resource_data, electrical_load_ptr);
370     }
371
372     return;
373 } /* __readHydroResource() */

```

## 4.23.3.6 \_\_readSolarResource()

```

void Resources::__readSolarResource (
    std::string path_2_resource_data,
    int resource_key,
    ElectricalLoad * electrical_load_ptr ) [private]

```

Helper method to handle reading a solar resource time series into [Resources](#).

## Parameters

<i>path_2_resource_data</i>	The path (either relative or absolute) to the given resource time series.
<i>resource_key</i>	The key associated with the given renewable resource.
<i>electrical_load_ptr</i>	A pointer to the <a href="#">Model's ElectricalLoad</a> object.

```

403 {
404     // 1. init CSV reader, record path and type
405     io::CSVReader<2> CSV(path_2_resource_data);
406
407     CSV.read_header(
408         io::ignore_extra_column,
409         "Time (since start of data) [hrs]",
410         "Solar GHI [kW/m2]"
411     );
412
413     this->path_map_1D.insert(
414         std::pair<int, std::string>(resource_key, path_2_resource_data)
415     );
416
417     this->string_map_1D.insert(std::pair<int, std::string>(resource_key, "SOLAR"));
418
419     // 2. init map element
420     this->resource_map_1D.insert(
421         std::pair<int, std::vector<double>>(resource_key, {})
422     );
423     this->resource_map_1D[resource_key].resize(electrical_load_ptr->n_points, 0);
424
425     // 3. read in resource data, check against time series (point-wise and length)
426     int n_points = 0;
427     double time_hrs = 0;
428     double time_expected_hrs = 0;
429     double solar_resource_kWm2 = 0;
430
431     while (CSV.read_row(time_hrs, solar_resource_kWm2)) {
432         if (n_points > electrical_load_ptr->n_points) {
433             this->__throwLengthError(path_2_resource_data, electrical_load_ptr);
434         }
435
436         time_expected_hrs = electrical_load_ptr->time_vec_hrs[n_points];
437         this->__checkTimePoint(
438             time_hrs,
439             time_expected_hrs,
440             path_2_resource_data,
441             electrical_load_ptr
442         );
443
444         this->resource_map_1D[resource_key][n_points] = solar_resource_kWm2;
445         n_points++;
446     }
447
448     // 4. check data length
449     if (n_points != electrical_load_ptr->n_points) {
450         this->__throwLengthError(path_2_resource_data, electrical_load_ptr);
451     }
452
453     return;
454 }
455 /* __readSolarResource() */
456 }

```

## 4.23.3.7 \_\_readTidalResource()

```

void Resources::__readTidalResource (
    std::string path_2_resource_data,
    int resource_key,
    ElectricalLoad * electrical_load_ptr ) [private]

```

Helper method to handle reading a tidal resource time series into [Resources](#).

## Parameters

<i>path_2_resource_data</i>	The path (either relative or absolute) to the given resource time series.
<i>resource_key</i>	The key associated with the given renewable resource.
<i>electrical_load_ptr</i>	A pointer to the <a href="#">Model's ElectricalLoad</a> object.

```

486 {
487     // 1. init CSV reader, record path and type
488     io::CSVReader<2> CSV(path_2_resource_data);
489
490     CSV.read_header(
491         io::ignore_extra_column,
492         "Time (since start of data) [hrs]",
493         "Tidal Speed (hub depth) [m/s]"
494     );
495
496     this->path_map_1D.insert(
497         std::pair<int, std::string>(resource_key, path_2_resource_data)
498     );
499
500     this->string_map_1D.insert(std::pair<int, std::string>(resource_key, "TIDAL"));
501
502     // 2. init map element
503     this->resource_map_1D.insert(
504         std::pair<int, std::vector<double>>(resource_key, {})
505     );
506     this->resource_map_1D[resource_key].resize(electrical_load_ptr->n_points, 0);
507
508
509     // 3. read in resource data, check against time series (point-wise and length)
510     int n_points = 0;
511     double time_hrs = 0;
512     double time_expected_hrs = 0;
513     double tidal_resource_ms = 0;
514
515     while (CSV.read_row(time_hrs, tidal_resource_ms)) {
516         if (n_points > electrical_load_ptr->n_points) {
517             this->__throwLengthError(path_2_resource_data, electrical_load_ptr);
518         }
519
520         time_expected_hrs = electrical_load_ptr->time_vec_hrs[n_points];
521         this->__checkTimePoint(
522             time_hrs,
523             time_expected_hrs,
524             path_2_resource_data,
525             electrical_load_ptr
526         );
527
528         this->resource_map_1D[resource_key][n_points] = tidal_resource_ms;
529
530         n_points++;
531     }
532
533     // 4. check data length
534     if (n_points != electrical_load_ptr->n_points) {
535         this->__throwLengthError(path_2_resource_data, electrical_load_ptr);
536     }
537
538     return;
539 } /* __readTidalResource() */

```

## 4.23.3.8 \_\_readWaveResource()

```

void Resources::__readWaveResource (
    std::string path_2_resource_data,
    int resource_key,
    ElectricalLoad * electrical_load_ptr ) [private]

```

Helper method to handle reading a wave resource time series into [Resources](#).

## Parameters

<i>path_2_resource_data</i>	The path (either relative or absolute) to the given resource time series.
<i>resource_key</i>	The key associated with the given renewable resource.
<i>electrical_load_ptr</i>	A pointer to the <a href="#">Model's ElectricalLoad</a> object.

```

569 {
570     // 1. init CSV reader, record path and type
571     io::CSVReader<3> CSV(path_2_resource_data);
572
573     CSV.read_header(
574         io::ignore_extra_column,
575         "Time (since start of data) [hrs]",
576         "Significant Wave Height [m]",
577         "Energy Period [s]"
578     );
579
580     this->path_map_2D.insert(
581         std::pair<int, std::string>(resource_key, path_2_resource_data)
582     );
583
584     this->string_map_2D.insert(std::pair<int, std::string>(resource_key, "WAVE"));
585
586     // 2. init map element
587     this->resource_map_2D.insert(
588         std::pair<int, std::vector<std::vector<double>>>(resource_key, {})
589     );
590     this->resource_map_2D[resource_key].resize(electrical_load_ptr->n_points, {0, 0});
591
592
593     // 3. read in resource data, check against time series (point-wise and length)
594     int n_points = 0;
595     double time_hrs = 0;
596     double time_expected_hrs = 0;
597     double significant_wave_height_m = 0;
598     double energy_period_s = 0;
599
600     while (CSV.read_row(time_hrs, significant_wave_height_m, energy_period_s)) {
601         if (n_points > electrical_load_ptr->n_points) {
602             this->__throwLengthError(path_2_resource_data, electrical_load_ptr);
603         }
604
605         time_expected_hrs = electrical_load_ptr->time_vec_hrs[n_points];
606         this->__checkTimePoint(
607             time_hrs,
608             time_expected_hrs,
609             path_2_resource_data,
610             electrical_load_ptr
611         );
612
613         this->resource_map_2D[resource_key][n_points][0] = significant_wave_height_m;
614         this->resource_map_2D[resource_key][n_points][1] = energy_period_s;
615
616         n_points++;
617     }
618
619     // 4. check data length
620     if (n_points != electrical_load_ptr->n_points) {
621         this->__throwLengthError(path_2_resource_data, electrical_load_ptr);
622     }
623
624     return;
625 } /* __readWaveResource() */

```

## 4.23.3.9 \_\_readWindResource()

```

void Resources::__readWindResource (
    std::string path_2_resource_data,
    int resource_key,
    ElectricalLoad * electrical_load_ptr ) [private]

```

Helper method to handle reading a wind resource time series into [Resources](#).



## Parameters

<i>path_2_resource_data</i>	The path (either relative or absolute) to the given resource time series.
<i>resource_key</i>	The key associated with the given renewable resource.
<i>electrical_load_ptr</i>	A pointer to the <a href="#">Model's ElectricalLoad</a> object.

```

655 {
656     // 1. init CSV reader, record path and type
657     io::CSVReader<2> CSV(path_2_resource_data);
658
659     CSV.read_header(
660         io::ignore_extra_column,
661         "Time (since start of data) [hrs]",
662         "Wind Speed (hub height) [m/s]"
663     );
664
665     this->path_map_1D.insert(
666         std::pair<int, std::string>(resource_key, path_2_resource_data)
667     );
668
669     this->string_map_1D.insert(std::pair<int, std::string>(resource_key, "WIND"));
670
671     // 2. init map element
672     this->resource_map_1D.insert(
673         std::pair<int, std::vector<double>>(resource_key, {})
674     );
675     this->resource_map_1D[resource_key].resize(electrical_load_ptr->n_points, 0);
676
677
678     // 3. read in resource data, check against time series (point-wise and length)
679     int n_points = 0;
680     double time_hrs = 0;
681     double time_expected_hrs = 0;
682     double wind_resource_ms = 0;
683
684     while (CSV.read_row(time_hrs, wind_resource_ms)) {
685         if (n_points > electrical_load_ptr->n_points) {
686             this->__throwLengthError(path_2_resource_data, electrical_load_ptr);
687         }
688
689         time_expected_hrs = electrical_load_ptr->time_vec_hrs[n_points];
690         this->__checkTimePoint(
691             time_hrs,
692             time_expected_hrs,
693             path_2_resource_data,
694             electrical_load_ptr
695         );
696
697         this->resource_map_1D[resource_key][n_points] = wind_resource_ms;
698
699         n_points++;
700     }
701
702     // 4. check data length
703     if (n_points != electrical_load_ptr->n_points) {
704         this->__throwLengthError(path_2_resource_data, electrical_load_ptr);
705     }
706
707     return;
708 } /* __readWindResource() */

```

## 4.23.3.10 \_\_throwLengthError()

```

void Resources::__throwLengthError (
    std::string path_2_resource_data,
    ElectricalLoad * electrical_load_ptr ) [private]

```

Helper method to throw data length error.

## Parameters

<i>path_2_resource_data</i>	The path (either relative or absolute) to the given resource time series.
<i>electrical_load_ptr</i>	A pointer to the <a href="#">Model's ElectricalLoad</a> object.

```

275 {
276     std::string error_str = "ERROR: Resources::addResource(): ";
277     error_str += "the given resource time series at ";
278     error_str += path_2_resource_data;
279     error_str += " is not the same length as the previously given electrical";
280     error_str += " load time series at ";
281     error_str += electrical_load_ptr->path_2_electrical_load_time_series;
282
283     #ifdef _WIN32
284         std::cout << error_str << std::endl;
285     #endif
286
287     throw std::runtime_error(error_str);
288
289     return;
290 } /* __throwLengthError() */

```

#### 4.23.3.11 addResource() [1/2]

```

void Resources::addResource (
    NoncombustionType noncombustion_type,
    std::string path_2_resource_data,
    int resource_key,
    ElectricalLoad * electrical_load_ptr )

```

A method to add a renewable resource time series to [Resources](#). Checks if given resource key is already in use. The associated helper methods also check against [ElectricalLoad](#) to ensure that all added time series align with the electrical load time series (both in terms of length and which points in time are included).

##### Parameters

<i>noncombustion_type</i>	The type of renewable resource being added to <a href="#">Resources</a> .
<i>path_2_resource_data</i>	A string defining the path (either relative or absolute) to the given resource time series.
<i>resource_key</i>	A key used to index into the <a href="#">Resources</a> object, used to associate <a href="#">Renewable</a> assets with the corresponding resource.
<i>electrical_load_ptr</i>	A pointer to the <a href="#">Model's ElectricalLoad</a> object.

```

766 {
767     switch (noncombustion_type) {
768         case (NoncombustionType :: HYDRO): {
769             this->__checkResourceKey1D(resource_key, noncombustion_type);
770
771             this->__readHydroResource (
772                 path_2_resource_data,
773                 resource_key,
774                 electrical_load_ptr
775             );
776
777             break;
778         }
779
780         default: {
781             std::string error_str = "ERROR: Resources :: addResource(): ";
782             error_str += "noncombustion type ";
783             error_str += std::to_string(noncombustion_type);
784             error_str += " has no associated resource";
785
786             #ifdef _WIN32
787                 std::cout << error_str << std::endl;
788             #endif
789
790             throw std::runtime_error(error_str);
791
792             break;
793         }
794     }
795
796     return;

```

```
797 } /* addResource() */
```

#### 4.23.3.12 addResource() [2/2]

```
void Resources::addResource (
    RenewableType renewable_type,
    std::string path_2_resource_data,
    int resource_key,
    ElectricalLoad * electrical_load_ptr )
```

A method to add a renewable resource time series to [Resources](#). Checks if given resource key is already in use. The associated helper methods also check against [ElectricalLoad](#) to ensure that all added time series align with the electrical load time series (both in terms of length and which points in time are included).

##### Parameters

<i>renewable_type</i>	The type of renewable resource being added to <a href="#">Resources</a> .
<i>path_2_resource_data</i>	A string defining the path (either relative or absolute) to the given resource time series.
<i>resource_key</i>	A key used to index into the <a href="#">Resources</a> object, used to associate <a href="#">Renewable</a> assets with the corresponding resource.
<i>electrical_load_ptr</i>	A pointer to the <a href="#">Model's ElectricalLoad</a> object.

```
834 {
835     switch (renewable_type) {
836         case (RenewableType :: SOLAR): {
837             this->__checkResourceKey1D(resource_key, renewable_type);
838
839             this->__readSolarResource(
840                 path_2_resource_data,
841                 resource_key,
842                 electrical_load_ptr
843             );
844
845             break;
846         }
847
848         case (RenewableType :: TIDAL): {
849             this->__checkResourceKey1D(resource_key, renewable_type);
850
851             this->__readTidalResource(
852                 path_2_resource_data,
853                 resource_key,
854                 electrical_load_ptr
855             );
856
857             break;
858         }
859
860         case (RenewableType :: WAVE): {
861             this->__checkResourceKey2D(resource_key, renewable_type);
862
863             this->__readWaveResource(
864                 path_2_resource_data,
865                 resource_key,
866                 electrical_load_ptr
867             );
868
869             break;
870         }
871
872         case (RenewableType :: WIND): {
873             this->__checkResourceKey1D(resource_key, renewable_type);
874
875             this->__readWindResource(
876                 path_2_resource_data,
877                 resource_key,
878                 electrical_load_ptr
879             );
```

```

880
881         break;
882     }
883
884     default: {
885         std::string error_str = "ERROR: Resources :: addResource(: ";
886         error_str += "renewable type ";
887         error_str += std::to_string(renewable_type);
888         error_str += " not recognized";
889
890         #ifdef _WIN32
891             std::cout << error_str << std::endl;
892         #endif
893
894         throw std::runtime_error(error_str);
895
896         break;
897     }
898 }
899
900 return;
901 } /* addResource() */

```

#### 4.23.3.13 clear()

```

void Resources::clear (
    void )

```

Method to clear all attributes of the [Resources](#) object.

```

915 {
916     this->resource_map_1D.clear();
917     this->string_map_1D.clear();
918     this->path_map_1D.clear();
919
920     this->resource_map_2D.clear();
921     this->string_map_2D.clear();
922     this->path_map_2D.clear();
923
924     return;
925 } /* clear() */

```

### 4.23.4 Member Data Documentation

#### 4.23.4.1 path\_map\_1D

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

A map <int, string> of the paths (either relative or absolute) to given 1D renewable resource time series.

#### 4.23.4.2 path\_map\_2D

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

A map <int, string> of the paths (either relative or absolute) to given 2D renewable resource time series.

#### 4.23.4.3 resource\_map\_1D

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

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

#### 4.23.4.4 resource\_map\_2D

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

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

#### 4.23.4.5 string\_map\_1D

```
std::map<int, std::string> Resources::string_map_1D
```

A map <int, string> of descriptors for the type of the given 1D renewable resource time series.

#### 4.23.4.6 string\_map\_2D

```
std::map<int, std::string> Resources::string_map_2D
```

A map <int, string> of descriptors for the type of the given 2D renewable resource time series.

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

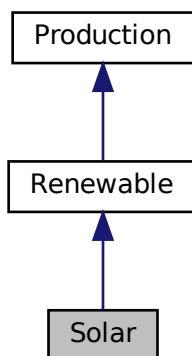
- header/[Resources.h](#)
- source/[Resources.cpp](#)

## 4.24 Solar Class Reference

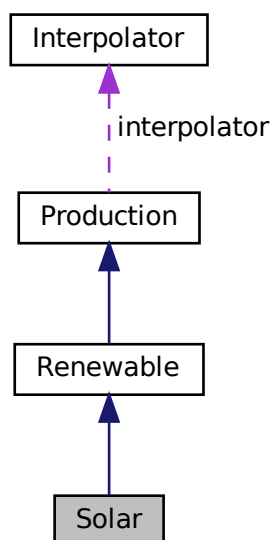
A derived class of the [Renewable](#) branch of [Production](#) which models solar production.

```
#include <Solar.h>
```

Inheritance diagram for Solar:



Collaboration diagram for Solar:



## Public Member Functions

- [Solar](#) (void)  
*Constructor (dummy) for the [Solar](#) class.*
- [Solar](#) (int, double, [SolarInputs](#))  
*Constructor (intended) for the [Solar](#) class.*
- void [handleReplacement](#) (int)  
*Method to handle asset replacement and capital cost incursion, if applicable.*
- double [computeProductionkW](#) (int, double, double)  
*Method which takes in the solar resource at a particular point in time, and then returns the solar PV production at that point in time.*
- double [commit](#) (int, double, double, double)  
*Method which takes in production and load for the current timestep, computes and records dispatch and curtailment, and then returns remaining load.*
- [~Solar](#) (void)  
*Destructor for the [Solar](#) class.*

## Public Attributes

- double [derating](#)  
*The derating of the solar PV array (i.e., shadowing, soiling, etc.).*

## 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](#).*

### 4.24.1 Detailed Description

A derived class of the [Renewable](#) branch of [Production](#) which models solar production.

### 4.24.2 Constructor & Destructor Documentation

**4.24.2.1 Solar()** [1/2]

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

Constructor (dummy) for the [Solar](#) class.

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

**4.24.2.2 Solar()** [2/2]

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

Constructor (intended) for the [Solar](#) class.

**Parameters**

<i>n_points</i>	The number of points in the modelling time series.
<i>n_years</i>	The number of years being modelled.
<i>solar_inputs</i>	A structure of <a href="#">Solar</a> 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() */
```



### 4.24.2.3 ~Solar()

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

Destructor for the [Solar](#) class.

```
488 {
489     // 1. destruction print
490     if (this->print_flag) {
491         std::cout << "Solar object at " << this << " destroyed" << std::endl;
492     }
493
494     return;
495 } /* ~Solar() */
```

## 4.24.3 Member Function Documentation

### 4.24.3.1 \_\_checkInputs()

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

Helper method to check inputs to the [Solar](#) constructor.

```
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() */
```

### 4.24.3.2 \_\_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() */
```

#### 4.24.3.3 `__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() */
```

#### 4.24.3.4 `__writeSummary()`

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

Helper method to write summary results for [Solar](#).

##### Parameters

<i>write_path</i>	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() */

```

#### 4.24.3.5 \_\_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

<i>write_path</i>	A path (either relative or absolute) to the directory location where results are to be written. If already exists, will overwrite.
<i>time_vec_hrs_ptr</i>	A pointer to the <code>time_vec_hrs</code> attribute of the <a href="#">ElectricalLoad</a> .
<i>resource_map_1D_ptr</i>	A pointer to the 1D map of <a href="#">Resources</a> .
<i>resource_map_2D_ptr</i>	A pointer to the 2D map of <a href="#">Resources</a> .
<i>max_lines</i>	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() */

```

#### 4.24.3.6 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

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

```

460 {
461     // 1. invoke base class method
462     load_kW = Renewable::commit(
463         timestep,
464         dt_hrs,
465         production_kW,
466         load_kW
467     );
468
469     //...
470
471     return load_kW;
472 } /* commit() */

```

#### 4.24.3.7 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

<i>timestep</i>	The timestep (i.e., time series index) for the request.
<i>dt_hrs</i>	The interval of time [hrs] associated with the timestep.
<i>solar_resource_kWm2</i>	<a href="#">Solar</a> resource (i.e. irradiance) [kW/m2].

##### Returns

The production [kW] of the solar PV array.

Reimplemented from [Renewable](#).

```
409 {
410     // check if no resource
411     if (solar_resource_kWm2 <= 0) {
412         return 0;
413     }
414
415     // compute production
416     double production_kW = this->derating * solar_resource_kWm2 * this->capacity_kW;
417
418     // cap production at capacity
419     if (production_kW > this->capacity_kW) {
420         production_kW = this->capacity_kW;
421     }
422
423     return production_kW;
424 } /* computeProductionkW() */
```

#### 4.24.3.8 handleReplacement()

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

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

##### Parameters

<i>timestep</i>	The current time step of the <a href="#">Model</a> run.
-----------------	---

Reimplemented from [Renewable](#).

```
367 {
368     // 1. reset attributes
369     //...
```

```

370
371 // 2. invoke base class method
372 Renewable :: handleReplacement(timestep);
373
374 return;
375 } /* __handleReplacement() */

```

## 4.24.4 Member Data Documentation

### 4.24.4.1 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:

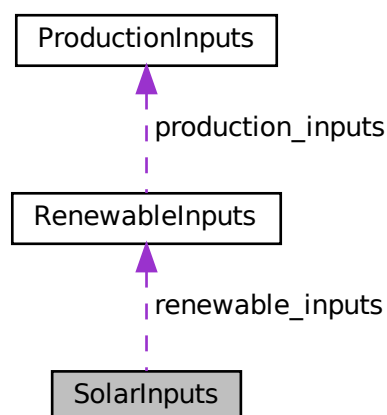
- header/Production/Renewable/[Solar.h](#)
- source/Production/Renewable/[Solar.cpp](#)

## 4.25 SolarInputs Struct Reference

A structure which bundles the necessary inputs for the [Solar](#) constructor. Provides default values for every necessary input. Note that this structure encapsulates [RenewableInputs](#).

```
#include <Solar.h>
```

Collaboration diagram for SolarInputs:



## Public Attributes

- [RenewableInputs renewable\\_inputs](#)  
*An encapsulated [RenewableInputs](#) instance.*
- int [resource\\_key](#) = 0  
*A key used to index into the [Resources](#) object, to associate this asset with the appropriate resource time series.*
- double [capital\\_cost](#) = -1  
*The capital cost of the asset (undefined currency). -1 is a sentinel value, which triggers a generic cost model on construction (in fact, any negative value here will trigger). Note that the generic cost model is in terms of Canadian dollars [CAD].*
- double [operation\\_maintenance\\_cost\\_kWh](#) = -1  
*The operation and maintenance cost of the asset [1/kWh] (undefined currency). This is a cost incurred per unit of energy produced. -1 is a sentinel value, which triggers a generic cost model on construction (in fact, any negative value here will trigger). Note that the generic cost model is in terms of Canadian dollars [CAD/kWh].*
- double [derating](#) = 0.8  
*The derating of the solar PV array (i.e., shadowing, soiling, etc.).*

### 4.25.1 Detailed Description

A structure which bundles the necessary inputs for the [Solar](#) constructor. Provides default values for every necessary input. Note that this structure encapsulates [RenewableInputs](#).

### 4.25.2 Member Data Documentation

#### 4.25.2.1 capital\_cost

```
double SolarInputs::capital_cost = -1
```

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

#### 4.25.2.2 derating

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

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

#### 4.25.2.3 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].

#### 4.25.2.4 renewable\_inputs

```
RenewableInputs SolarInputs::renewable_inputs
```

An encapsulated [RenewableInputs](#) instance.

#### 4.25.2.5 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:

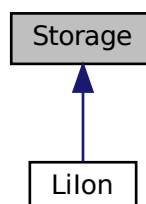
- [header/Production/Renewable/Solar.h](#)

## 4.26 Storage Class Reference

The base class of the [Storage](#) hierarchy. This hierarchy contains derived classes which model the storage of energy.

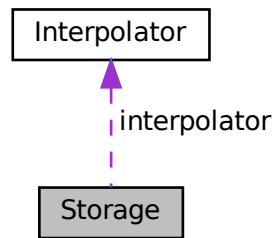
```
#include <Storage.h>
```

Inheritance diagram for Storage:





Collaboration diagram for Storage:



## Public Member Functions

- **Storage** (void)  
*Constructor (dummy) for the **Storage** class.*
- **Storage** (int, double, **StorageInputs**)  
*Constructor (intended) for the **Storage** class.*
- virtual void **handleReplacement** (int)  
*Method to handle asset replacement and capital cost incursion, if applicable.*
- void **computeEconomics** (std::vector< double > \*)  
*Helper method to compute key economic metrics for the **Model** run.*
- virtual double **getAvailablekW** (double)
- virtual double **getAcceptablekW** (double)
- virtual void **commitCharge** (int, double, double)
- virtual double **commitDischarge** (int, double, double, double)
- void **writeResults** (std::string, std::vector< double > \*, int, int=-1)  
*Method which writes **Storage** results to an output directory.*
- virtual **~Storage** (void)  
*Destructor for the **Storage** class.*

## Public Attributes

- **StorageType** type  
*The type (**StorageType**) of the asset.*
- **Interpolator** interpolator  
***Interpolator** component of **Storage**.*
- bool **print\_flag**  
*A flag which indicates whether or not object construct/destruction should be verbose.*
- bool **is\_depleted**  
*A boolean which indicates whether or not the asset is currently considered depleted.*
- bool **is\_sunk**  
*A boolean which indicates whether or not the asset should be considered a sunk cost (i.e., capital cost incurred at the start of the model, or no).*
- int **n\_points**  
*The number of points in the modelling time series.*

- int [n\\_replacements](#)  
*The number of times the asset has been replaced.*
- double [n\\_years](#)  
*The number of years being modelled.*
- double [power\\_capacity\\_kW](#)  
*The rated power capacity [kW] of the asset.*
- double [energy\\_capacity\\_kWh](#)  
*The rated energy capacity [kWh] of the asset.*
- double [charge\\_kWh](#)  
*The energy [kWh] stored in the asset.*
- double [power\\_kW](#)  
*The power [kW] currently being charged/discharged by the asset.*
- double [nominal\\_inflation\\_annual](#)  
*The nominal, annual inflation rate to use in computing model economics.*
- double [nominal\\_discount\\_annual](#)  
*The nominal, annual discount rate to use in computing model economics.*
- double [real\\_discount\\_annual](#)  
*The real, annual discount rate used in computing model economics. Is computed from the given nominal inflation and discount rates.*
- double [capital\\_cost](#)  
*The capital cost of the asset (undefined currency).*
- double [operation\\_maintenance\\_cost\\_kWh](#)  
*The operation and maintenance cost of the asset [1/kWh] (undefined currency). This is a cost incurred per unit of energy charged/discharged.*
- double [net\\_present\\_cost](#)  
*The net present cost of this asset.*
- double [total\\_discharge\\_kWh](#)  
*The total energy discharged [kWh] over the [Model](#) run.*
- double [levellized\\_cost\\_of\\_energy\\_kWh](#)  
*The levellized cost of energy [1/kWh] (undefined currency) of this asset. This metric considers only discharge.*
- std::string [type\\_str](#)  
*A string describing the type of the asset.*
- std::vector< double > [charge\\_vec\\_kWh](#)  
*A vector of the charge state [kWh] at each point in the modelling time series.*
- std::vector< double > [charging\\_power\\_vec\\_kW](#)  
*A vector of the charging power [kW] at each point in the modelling time series.*
- std::vector< double > [discharging\\_power\\_vec\\_kW](#)  
*A vector of the discharging power [kW] at each point in the modelling time series.*
- std::vector< double > [capital\\_cost\\_vec](#)  
*A vector of capital costs (undefined currency) incurred over each modelling time step. These costs are not discounted (i.e., these are actual costs).*
- std::vector< double > [operation\\_maintenance\\_cost\\_vec](#)  
*A vector of operation and maintenance costs (undefined currency) incurred over each modelling time step. These costs are not discounted (i.e., these are actual costs).*

## Private Member Functions

- void [\\_\\_checkInputs](#) (int, double, [StorageInputs](#))  
*Helper method to check inputs to the [Storage](#) constructor.*
- double [\\_\\_computeRealDiscountAnnual](#) (double, double)  
*Helper method to compute the real, annual discount rate to be used in computing model economics. This enables application of the discount factor approach.*
- virtual void [\\_\\_writeSummary](#) (std::string)
- virtual void [\\_\\_writeTimeSeries](#) (std::string, std::vector< double > \*, int=-1)

### 4.26.1 Detailed Description

The base class of the [Storage](#) hierarchy. This hierarchy contains derived classes which model the storage of energy.

### 4.26.2 Constructor & Destructor Documentation

#### 4.26.2.1 Storage() [1/2]

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

Constructor (dummy) for the [Storage](#) class.

```
151 {
152     return;
153 } /* Storage() */
```

#### 4.26.2.2 Storage() [2/2]

```
Storage::Storage (
    int n_points,
    double n_years,
    StorageInputs storage_inputs )
```

Constructor (intended) for the [Storage](#) class.

##### Parameters

<i>n_points</i>	The number of points in the modelling time series.
<i>n_years</i>	The number of years being modelled.
<i>storage_inputs</i>	A structure of <a href="#">Storage</a> constructor inputs.

```
182 {
183     // 1. check inputs
184     this->__checkInputs(n_points, n_years, storage_inputs);
185
186     // 2. set attributes
187     this->print_flag = storage_inputs.print_flag;
188     this->is_depleted = false;
189     this->is_sunk = storage_inputs.is_sunk;
190
191     this->n_points = n_points;
192     this->n_replacements = 0;
193
194     this->n_years = n_years;
195
196     this->power_capacity_kW = storage_inputs.power_capacity_kW;
197     this->energy_capacity_kWh = storage_inputs.energy_capacity_kWh;
198
199     this->charge_kWh = 0;
200     this->power_kW = 0;
201
202     this->nominal_inflation_annual = storage_inputs.nominal_inflation_annual;
203     this->nominal_discount_annual = storage_inputs.nominal_discount_annual;
204
205     this->real_discount_annual = this->__computeRealDiscountAnnual(
206         storage_inputs.nominal_inflation_annual,
```

```

207     storage_inputs.nominal_discount_annual
208 );
209
210 this->capital_cost = 0;
211 this->operation_maintenance_cost_kWh = 0;
212 this->net_present_cost = 0;
213 this->total_discharge_kWh = 0;
214 this->levellized_cost_of_energy_kWh = 0;
215
216 this->charge_vec_kWh.resize(this->n_points, 0);
217 this->charging_power_vec_kW.resize(this->n_points, 0);
218 this->discharging_power_vec_kW.resize(this->n_points, 0);
219
220 this->capital_cost_vec.resize(this->n_points, 0);
221 this->operation_maintenance_cost_vec.resize(this->n_points, 0);
222
223 // 3. construction print
224 if (this->print_flag) {
225     std::cout << "Storage object constructed at " << this << std::endl;
226 }
227
228 return;
229 } /* Storage() */

```

#### 4.26.2.3 ~Storage()

```

Storage::~Storage (
    void ) [virtual]

```

Destructor for the [Storage](#) class.

```

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

```

### 4.26.3 Member Function Documentation

#### 4.26.3.1 \_\_checkInputs()

```

void Storage::__checkInputs (
    int n_points,
    double n_years,
    StorageInputs storage_inputs ) [private]

```

Helper method to check inputs to the [Storage](#) constructor.

##### Parameters

<i>n_points</i>	The number of points in the modelling time series.
<i>storage_inputs</i>	A structure of <a href="#">Storage</a> constructor inputs.

```

45 {
46     // 1. check n_points
47     if (n_points <= 0) {
48         std::string error_str = "ERROR: Storage(): n_points must be > 0";

```

```

49
50     #ifdef _WIN32
51         std::cout << error_str << std::endl;
52     #endif
53
54     throw std::invalid_argument(error_str);
55 }
56
57 // 2. check n_years
58 if (n_years <= 0) {
59     std::string error_str = "ERROR: Storage(): n_years must be > 0";
60
61     #ifdef _WIN32
62         std::cout << error_str << std::endl;
63     #endif
64
65     throw std::invalid_argument(error_str);
66 }
67
68 // 3. check power_capacity_kW
69 if (storage_inputs.power_capacity_kW <= 0) {
70     std::string error_str = "ERROR: Storage(): ";
71     error_str += "StorageInputs::power_capacity_kW must be > 0";
72
73     #ifdef _WIN32
74         std::cout << error_str << std::endl;
75     #endif
76
77     throw std::invalid_argument(error_str);
78 }
79
80 // 4. check energy_capacity_kWh
81 if (storage_inputs.energy_capacity_kWh <= 0) {
82     std::string error_str = "ERROR: Storage(): ";
83     error_str += "StorageInputs::energy_capacity_kWh must be > 0";
84
85     #ifdef _WIN32
86         std::cout << error_str << std::endl;
87     #endif
88
89     throw std::invalid_argument(error_str);
90 }
91
92 return;
93 } /* __checkInputs() */

```

#### 4.26.3.2 \_\_computeRealDiscountAnnual()

```

double Storage::__computeRealDiscountAnnual (
    double nominal_inflation_annual,
    double nominal_discount_annual ) [private]

```

Helper method to compute the real, annual discount rate to be used in computing model economics. This enables application of the discount factor approach.

Ref: [HOMER \[2023h\]](#)

Ref: [HOMER \[2023b\]](#)

##### Parameters

<i>nominal_inflation_annual</i>	The nominal, annual inflation rate to use in computing model economics.
<i>nominal_discount_annual</i>	The nominal, annual discount rate to use in computing model economics.

##### Returns

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

```
127 {  
128     double real_discount_annual = nominal_discount_annual - nominal_inflation_annual;  
129     real_discount_annual /= 1 + nominal_inflation_annual;  
130  
131     return real_discount_annual;  
132 } /* __computeRealDiscountAnnual() */
```

#### 4.26.3.3 \_\_writeSummary()

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

Reimplemented in [Lilon](#).

```
79 {return;}
```

#### 4.26.3.4 \_\_writeTimeSeries()

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

Reimplemented in [Lilon](#).

```
80 {return;}
```

#### 4.26.3.5 commitCharge()

```
virtual void Storage::commitCharge (  
    int ,  
    double ,  
    double ) [inline], [virtual]
```

Reimplemented in [Lilon](#).

```
134 {return;}
```

#### 4.26.3.6 commitDischarge()

```
virtual double Storage::commitDischarge (  
    int ,  
    double ,  
    double ,  
    double ) [inline], [virtual]
```

Reimplemented in [Lilon](#).

```
135 {return 0;}
```

## 4.26.3.7 computeEconomics()

```
void Storage::computeEconomics (
    std::vector< double > * time_vec_hrs_ptr )
```

Helper method to compute key economic metrics for the [Model](#) run.

Ref: [HOMER \[2023b\]](#)

Ref: [HOMER \[2023g\]](#)

Ref: [HOMER \[2023i\]](#)

Ref: [HOMER \[2023a\]](#)

## Parameters

<i>time_vec_hrs_ptr</i>	A pointer to the <code>time_vec_hrs</code> attribute of the <a href="#">ElectricalLoad</a> .
-------------------------	--

## 1. compute levellized cost of energy (per unit discharged)

```
282 {
283     // 1. compute net present cost
284     double t_hrs = 0;
285     double real_discount_scalar = 0;
286
287     for (int i = 0; i < this->n_points; i++) {
288         t_hrs = time_vec_hrs_ptr->at(i);
289
290         real_discount_scalar = 1.0 / pow(
291             1 + this->real_discount_annual,
292             t_hrs / 8760
293         );
294
295         this->net_present_cost += real_discount_scalar * this->capital_cost_vec[i];
296
297         this->net_present_cost +=
298             real_discount_scalar * this->operation_maintenance_cost_vec[i];
299     }
300
301     // assuming 8,760 hours per year
302     if (this->total_discharge_kWh <= 0) {
303         this->levellized_cost_of_energy_kWh = this->net_present_cost;
304     }
305
306     else {
307         double n_years = time_vec_hrs_ptr->at(this->n_points - 1) / 8760;
308
309         double capital_recovery_factor =
310             (this->real_discount_annual * pow(1 + this->real_discount_annual, n_years)) /
311             (pow(1 + this->real_discount_annual, n_years) - 1);
312
313         double total_annualized_cost = capital_recovery_factor *
314             this->net_present_cost;
315
316         this->levellized_cost_of_energy_kWh =
317             (n_years * total_annualized_cost) /
318             this->total_discharge_kWh;
319     }
320
321     return;
322 }
323 } /* computeEconomics() */
```

## 4.26.3.8 getAcceptablekW()

```
virtual double Storage::getAcceptablekW (
    double ) [inline], [virtual]
```

Reimplemented in [Lilon](#).

```
132 {return 0;}
```

#### 4.26.3.9 getAvailablekW()

```
virtual double Storage::getAvailablekW (
    double ) [inline], [virtual]
```

Reimplemented in [Lilon](#).

```
131 {return 0;}
```

#### 4.26.3.10 handleReplacement()

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

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

##### Parameters

<i>timestep</i>	The current time step of the <a href="#">Model</a> run.
-----------------	---

Reimplemented in [Lilon](#).

```
247 {
248     // 1. reset attributes
249     this->charge_kWh = 0;
250     this->power_kW = 0;
251
252     // 2. log replacement
253     this->n_replacements++;
254
255     // 3. incur capital cost in timestep
256     this->capital_cost_vec[timestep] = this->capital_cost;
257
258     return;
259 } /* __handleReplacement() */
```

#### 4.26.3.11 writeResults()

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

Method which writes [Storage](#) results to an output directory.

##### Parameters

<i>write_path</i>	A path (either relative or absolute) to the directory location where results are to be written. If already exists, will overwrite.
<i>time_vec_hrs_ptr</i>	A pointer to the <code>time_vec_hrs</code> attribute of the <a href="#">ElectricalLoad</a> .
<i>storage_index</i>	An integer which corresponds to the index of the <a href="#">Storage</a> asset in the <a href="#">Model</a> .
<i>max_lines</i>	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 += "Storage/";
368     if (not std::filesystem::is_directory(write_path)) {
369         std::filesystem::create_directory(write_path);
370     }
371
372     write_path += this->type_str;
373     write_path += "_";
374     write_path += std::to_string(int(ceil(this->power_capacity_kW)));
375     write_path += "kW";
376     write_path += std::to_string(int(ceil(this->energy_capacity_kWh)));
377     write_path += "kWh_idx";
378     write_path += std::to_string(storage_index);
379     write_path += "/";
380     std::filesystem::create_directory(write_path);
381
382     // 3. write summary
383     this->__writeSummary(write_path);
384
385     // 4. write time series
386     if (max_lines > this->n_points) {
387         max_lines = this->n_points;
388     }
389
390     if (max_lines > 0) {
391         this->__writeTimeSeries(
392             write_path,
393             time_vec_hrs_ptr,
394             max_lines
395         );
396     }
397
398     return;
399 } /* writeResults() */

```

## 4.26.4 Member Data Documentation

### 4.26.4.1 capital\_cost

double Storage::capital\_cost

The capital cost of the asset (undefined currency).

### 4.26.4.2 capital\_cost\_vec

std::vector<double> Storage::capital\_cost\_vec

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

#### 4.26.4.3 charge\_kWh

```
double Storage::charge_kWh
```

The energy [kWh] stored in the asset.

#### 4.26.4.4 charge\_vec\_kWh

```
std::vector<double> Storage::charge_vec_kWh
```

A vector of the charge state [kWh] at each point in the modelling time series.

#### 4.26.4.5 charging\_power\_vec\_kW

```
std::vector<double> Storage::charging_power_vec_kW
```

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

#### 4.26.4.6 discharging\_power\_vec\_kW

```
std::vector<double> Storage::discharging_power_vec_kW
```

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

#### 4.26.4.7 energy\_capacity\_kWh

```
double Storage::energy_capacity_kWh
```

The rated energy capacity [kWh] of the asset.

#### 4.26.4.8 interpolator

```
Interpolator Storage::interpolator
```

[Interpolator](#) component of [Storage](#).

**4.26.4.9 is\_depleted**

```
bool Storage::is_depleted
```

A boolean which indicates whether or not the asset is currently considered depleted.

**4.26.4.10 is\_sunk**

```
bool Storage::is_sunk
```

A boolean which indicates whether or not the asset should be considered a sunk cost (i.e., capital cost incurred at the start of the model, or no).

**4.26.4.11 levlized\_cost\_of\_energy\_kWh**

```
double Storage::levellized_cost_of_energy_kWh
```

The levlized cost of energy [1/kWh] (undefined currency) of this asset. This metric considers only discharge.

**4.26.4.12 n\_points**

```
int Storage::n_points
```

The number of points in the modelling time series.

**4.26.4.13 n\_replacements**

```
int Storage::n_replacements
```

The number of times the asset has been replaced.

**4.26.4.14 n\_years**

```
double Storage::n_years
```

The number of years being modelled.

#### 4.26.4.15 net\_present\_cost

```
double Storage::net_present_cost
```

The net present cost of this asset.

#### 4.26.4.16 nominal\_discount\_annual

```
double Storage::nominal_discount_annual
```

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

#### 4.26.4.17 nominal\_inflation\_annual

```
double Storage::nominal_inflation_annual
```

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

#### 4.26.4.18 operation\_maintenance\_cost\_kWh

```
double Storage::operation_maintenance_cost_kWh
```

The operation and maintenance cost of the asset [1/kWh] (undefined currency). This is a cost incurred per unit of energy charged/discharged.

#### 4.26.4.19 operation\_maintenance\_cost\_vec

```
std::vector<double> Storage::operation_maintenance_cost_vec
```

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

#### 4.26.4.20 power\_capacity\_kW

```
double Storage::power_capacity_kW
```

The rated power capacity [kW] of the asset.

#### 4.26.4.21 power\_kW

```
double Storage::power_kW
```

The power [kW] currently being charged/discharged by the asset.

#### 4.26.4.22 print\_flag

```
bool Storage::print_flag
```

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

#### 4.26.4.23 real\_discount\_annual

```
double Storage::real_discount_annual
```

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

#### 4.26.4.24 total\_discharge\_kWh

```
double Storage::total_discharge_kWh
```

The total energy discharged [kWh] over the [Model](#) run.

#### 4.26.4.25 type

```
StorageType Storage::type
```

The type (StorageType) of the asset.

#### 4.26.4.26 type\_str

```
std::string Storage::type_str
```

A string describing the type of the asset.

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

- [header/Storage/Storage.h](#)
- [source/Storage/Storage.cpp](#)

## 4.27 StorageInputs Struct Reference

A structure which bundles the necessary inputs for the [Storage](#) constructor. Provides default values for every necessary input.

```
#include <Storage.h>
```

### Public Attributes

- bool [print\\_flag](#) = false  
*A flag which indicates whether or not object construct/destruction should be verbose.*
- bool [is\\_sunk](#) = false  
*A boolean which indicates whether or not the asset should be considered a sunk cost (i.e., capital cost incurred at the start of the model, or no).*
- double [power\\_capacity\\_kW](#) = 100  
*The rated power capacity [kW] of the asset.*
- double [energy\\_capacity\\_kWh](#) = 1000  
*The rated energy capacity [kWh] of the asset.*
- double [nominal\\_inflation\\_annual](#) = 0.02  
*The nominal, annual inflation rate to use in computing model economics.*
- double [nominal\\_discount\\_annual](#) = 0.04  
*The nominal, annual discount rate to use in computing model economics.*

### 4.27.1 Detailed Description

A structure which bundles the necessary inputs for the [Storage](#) constructor. Provides default values for every necessary input.

### 4.27.2 Member Data Documentation

#### 4.27.2.1 [energy\\_capacity\\_kWh](#)

```
double StorageInputs::energy_capacity_kWh = 1000
```

The rated energy capacity [kWh] of the asset.

#### 4.27.2.2 [is\\_sunk](#)

```
bool StorageInputs::is_sunk = false
```

A boolean which indicates whether or not the asset should be considered a sunk cost (i.e., capital cost incurred at the start of the model, or no).

#### 4.27.2.3 nominal\_discount\_annual

```
double StorageInputs::nominal_discount_annual = 0.04
```

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

#### 4.27.2.4 nominal\_inflation\_annual

```
double StorageInputs::nominal_inflation_annual = 0.02
```

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

#### 4.27.2.5 power\_capacity\_kW

```
double StorageInputs::power_capacity_kW = 100
```

The rated power capacity [kW] of the asset.

#### 4.27.2.6 print\_flag

```
bool StorageInputs::print_flag = false
```

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

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

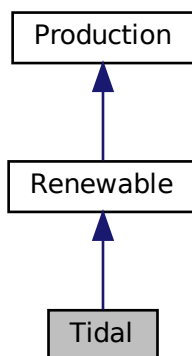
- header/Storage/[Storage.h](#)

## 4.28 Tidal Class Reference

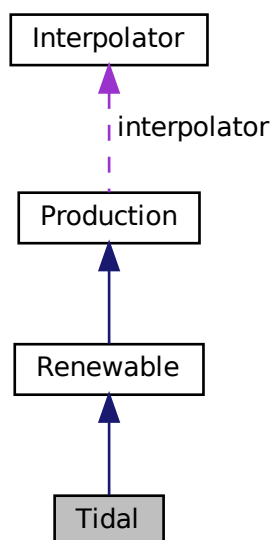
A derived class of the [Renewable](#) branch of [Production](#) which models tidal production.

```
#include <Tidal.h>
```

Inheritance diagram for Tidal:



Collaboration diagram for Tidal:





## Public Member Functions

- [Tidal](#) (void)  
*Constructor (dummy) for the [Tidal](#) class.*
- [Tidal](#) (int, double, [TidalInputs](#))  
*Constructor (intended) for the [Tidal](#) class.*
- void [handleReplacement](#) (int)  
*Method to handle asset replacement and capital cost incursion, if applicable.*
- double [computeProductionkW](#) (int, double, double)  
*Method which takes in the tidal resource at a particular point in time, and then returns the tidal turbine production at that point in time.*
- double [commit](#) (int, double, double, double)  
*Method which takes in production and load for the current timestep, computes and records dispatch and curtailment, and then returns remaining load.*
- [~Tidal](#) (void)  
*Destructor for the [Tidal](#) class.*

## Public Attributes

- double [design\\_speed\\_ms](#)  
*The tidal stream speed [m/s] at which the tidal turbine achieves its rated capacity.*
- [TidalPowerProductionModel](#) [power\\_model](#)  
*The tidal power production model to be applied.*
- std::string [power\\_model\\_string](#)  
*A string describing the active power production model.*

## Private Member Functions

- void [\\_\\_checkInputs](#) ([TidalInputs](#))  
*Helper method to check inputs to the [Tidal](#) constructor.*
- double [\\_\\_getGenericCapitalCost](#) (void)  
*Helper method to generate a generic tidal turbine capital cost.*
- double [\\_\\_getGenericOpMaintCost](#) (void)  
*Helper method to generate a generic tidal turbine operation and maintenance cost. This is a cost incurred per unit energy produced.*
- double [\\_\\_computeCubicProductionkW](#) (int, double, double)  
*Helper method to compute tidal turbine production under a cubic production model.*
- double [\\_\\_computeExponentialProductionkW](#) (int, double, double)  
*Helper method to compute tidal turbine production under an exponential production model.*
- double [\\_\\_computeLookupProductionkW](#) (int, double, double)  
*Helper method to compute tidal turbine production by way of looking up using given power curve data.*
- void [\\_\\_writeSummary](#) (std::string)  
*Helper method to write summary results for [Tidal](#).*
- void [\\_\\_writeTimeSeries](#) (std::string, std::vector< double > \*, std::map< int, std::vector< double >> \*, std::map< int, std::vector< std::vector< double >>> \*, int=-1)  
*Helper method to write time series results for [Tidal](#).*

### 4.28.1 Detailed Description

A derived class of the [Renewable](#) branch of [Production](#) which models tidal production.

## 4.28.2 Constructor & Destructor Documentation

### 4.28.2.1 Tidal() [1/2]

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

Constructor (dummy) for the [Tidal](#) class.

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

### 4.28.2.2 Tidal() [2/2]

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

Constructor (intended) for the [Tidal](#) class.

#### Parameters

<i>n_points</i>	The number of points in the modelling time series.
<i>n_years</i>	The number of years being modelled.
<i>tidal_inputs</i>	A structure of <a href="#">Tidal</a> 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             break;
481         }
482
483         case (TidalPowerProductionModel :: TIDAL_POWER_EXPONENTIAL): {
484             this->power_model_string = "EXPONENTIAL";
485             break;
486         }
487
488         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() */

```

#### 4.28.2.3 ~Tidal()

```

Tidal::~Tidal (
    void )

```

Destructor for the [Tidal](#) class.

```

710 {
711     // 1. destruction print
712     if (this->print_flag) {
713         std::cout << "Tidal object at " << this << " destroyed" << std::endl;
714     }
715
716     return;
717 } /* ~Tidal() */

```

### 4.28.3 Member Function Documentation

#### 4.28.3.1 \_\_checkInputs()

```

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

```

Helper method to check inputs to the [Tidal](#) constructor.

```

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() */

```

#### 4.28.3.2 \_\_computeCubicProductionkW()

```

double Tidal::__computeCubicProductionkW (
    int timestep,
    double dt_hrs,
    double tidal_resource_ms ) [private]

```

Helper method to compute tidal turbine production under a cubic production model.

Ref: [Buckham et al. \[2023\]](#)

##### Parameters

<i>timestep</i>	The current time step of the <a href="#">Model</a> run.
<i>dt_hrs</i>	The interval of time [hrs] associated with the action.
<i>tidal_resource_ms</i>	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() */

```

### 4.28.3.3 `__computeExponentialProductionkW()`

```
double Tidal::__computeExponentialProductionkW (
    int timestep,
    double dt_hrs,
    double tidal_resource_ms ) [private]
```

Helper method to compute tidal turbine production under an exponential production model.

Ref: [Truelove et al. \[2019\]](#)

#### Parameters

<i>timestep</i>	The current time step of the <a href="#">Model</a> run.
<i>dt_hrs</i>	The interval of time [hrs] associated with the action.
<i>tidal_resource_ms</i>	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() */
```

### 4.28.3.4 `__computeLookupProductionkW()`

```
double Tidal::__computeLookupProductionkW (
    int timestep,
    double dt_hrs,
    double tidal_resource_ms ) [private]
```

Helper method to compute tidal turbine production by way of looking up using given power curve data.

#### Parameters

<i>timestep</i>	The current time step of the <a href="#">Model</a> run.
<i>dt_hrs</i>	The interval of time [hrs] associated with the action.
<i>tidal_resource_ms</i>	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() */

```

**4.28.3.5 \_\_getGenericCapitalCost()**

```

double Tidal::__getGenericCapitalCost (
    void ) [private]

```

Helper method to generate a generic tidal turbine capital cost.

Note that this model expresses cost in terms of Canadian dollars [CAD].

Ref: [MacDougall \[2019\]](#)

**Returns**

A generic capital cost for the tidal turbine [CAD].

```

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() */

```

**4.28.3.6 \_\_getGenericOpMaintCost()**

```

double Tidal::__getGenericOpMaintCost (
    void ) [private]

```

Helper method to generate a generic tidal turbine operation and maintenance cost. This is a cost incurred per unit energy produced.

Note that this model expresses cost in terms of Canadian dollars [CAD/kWh].

Ref: [MacDougall \[2019\]](#)

**Returns**

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

```

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() */

```

**4.28.3.7 \_\_writeSummary()**

```

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

```

Helper method to write summary results for [Tidal](#).

## Parameters

<code>write_path</code>	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 (ID): " << 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() */

```

#### 4.28.3.8 \_\_writeTimeSeries()

```
void Tidal::__writeTimeSeries (
    std::string write_path,
    std::vector< double > * time_vec_hrs_ptr,
    std::map< int, std::vector< double >> * resource_map_1D_ptr,
    std::map< int, std::vector< std::vector< double >>> * resource_map_2D_ptr,
    int max_lines = -1 ) [private], [virtual]
```

Helper method to write time series results for [Tidal](#).

##### Parameters

<i>write_path</i>	A path (either relative or absolute) to the directory location where results are to be written. If already exists, will overwrite.
<i>time_vec_hrs_ptr</i>	A pointer to the <code>time_vec_hrs</code> attribute of the <a href="#">ElectricalLoad</a> .
<i>resource_map_1D_ptr</i>	A pointer to the 1D map of <a href="#">Resources</a> .
<i>resource_map_2D_ptr</i>	A pointer to the 2D map of <a href="#">Resources</a> .
<i>max_lines</i>	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() */
```

#### 4.28.3.9 commit()

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

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



## Parameters

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

```

682 {
683     // 1. invoke base class method
684     load_kW = Renewable :: commit(
685         timestep,
686         dt_hrs,
687         production_kW,
688         load_kW
689     );
690
691
692     //...
693
694     return load_kW;
695 } /* commit() */

```

## 4.28.3.10 computeProductionkW()

```

double Tidal::computeProductionkW (
    int timestep,
    double dt_hrs,
    double tidal_resource_ms ) [virtual]

```

Method which takes in the tidal resource at a particular point in time, and then returns the tidal turbine production at that point in time.

## Parameters

<i>timestep</i>	The timestep (i.e., time series index) for the request.
<i>dt_hrs</i>	The interval of time [hrs] associated with the timestep.
<i>tidal_resource_ms</i>	<a href="#">Tidal</a> resource (i.e. tidal stream speed) [m/s].

## Returns

The production [kW] of the tidal turbine.

Reimplemented from [Renewable](#).

```

588 {
589     // check if no resource
590     if (tidal_resource_ms <= 0) {
591         return 0;
592     }
593
594     // compute production
595     double production_kW = 0;

```

```

596
597     switch (this->power_model) {
598         case (TidalPowerProductionModel :: TIDAL_POWER_CUBIC): {
599             production_kW = this->__computeCubicProductionkW(
600                 timestep,
601                 dt_hrs,
602                 tidal_resource_ms
603             );
604
605             break;
606         }
607
608         case (TidalPowerProductionModel :: TIDAL_POWER_EXPONENTIAL): {
609             production_kW = this->__computeExponentialProductionkW(
610                 timestep,
611                 dt_hrs,
612                 tidal_resource_ms
613             );
614
615             break;
616         }
617
618         case (TidalPowerProductionModel :: TIDAL_POWER_LOOKUP): {
619             production_kW = this->__computeLookupProductionkW(
620                 timestep,
621                 dt_hrs,
622                 tidal_resource_ms
623             );
624
625             break;
626         }
627
628         default: {
629             std::string error_str = "ERROR: Tidal::computeProductionkW(): ";
630             error_str += "power model ";
631             error_str += std::to_string(this->power_model);
632             error_str += " not recognized";
633
634             #ifdef _WIN32
635                 std::cout << error_str << std::endl;
636             #endif
637
638             throw std::runtime_error(error_str);
639
640             break;
641         }
642     }
643
644     return production_kW;
645 } /* computeProductionkW() */

```

#### 4.28.3.11 handleReplacement()

```

void Tidal::handleReplacement (
    int timestep ) [virtual]

```

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

##### Parameters

<i>timestep</i>	The current time step of the <a href="#">Model</a> run.
-----------------	---

Reimplemented from [Renewable](#).

```

548 {
549     // 1. reset attributes
550     //...
551
552     // 2. invoke base class method
553     Renewable :: handleReplacement(timestep);
554
555     return;
556 } /* __handleReplacement() */

```

## 4.28.4 Member Data Documentation

### 4.28.4.1 design\_speed\_ms

```
double Tidal::design_speed_ms
```

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

### 4.28.4.2 power\_model

```
TidalPowerProductionModel Tidal::power_model
```

The tidal power production model to be applied.

### 4.28.4.3 power\_model\_string

```
std::string Tidal::power_model_string
```

A string describing the active power production model.

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

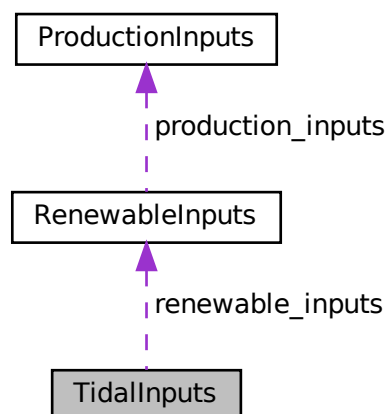
- header/Production/Renewable/[Tidal.h](#)
- source/Production/Renewable/[Tidal.cpp](#)

## 4.29 TidalInputs Struct Reference

A structure which bundles the necessary inputs for the [Tidal](#) constructor. Provides default values for every necessary input. Note that this structure encapsulates [RenewableInputs](#).

```
#include <Tidal.h>
```

Collaboration diagram for TidalInputs:



## Public Attributes

- [RenewableInputs](#) `renewable_inputs`  
An encapsulated [RenewableInputs](#) instance.
- `int resource_key = 0`  
A key used to index into the [Resources](#) object, to associate this asset with the appropriate resource time series.
- `double capital_cost = -1`  
The capital cost of the asset (undefined currency). -1 is a sentinel value, which triggers a generic cost model on construction (in fact, any negative value here will trigger). Note that the generic cost model is in terms of Canadian dollars [CAD].
- `double operation_maintenance_cost_kWh = -1`  
The operation and maintenance cost of the asset [1/kWh] (undefined currency). This is a cost incurred per unit of energy produced. -1 is a sentinel value, which triggers a generic cost model on construction (in fact, any negative value here will trigger). Note that the generic cost model is in terms of Canadian dollars [CAD/kWh].
- `double design_speed_ms = 3`  
The tidal stream speed [m/s] at which the tidal turbine achieves its rated capacity.
- `TidalPowerProductionModel power_model = TidalPowerProductionModel :: TIDAL_POWER_CUBIC`  
The tidal power production model to be applied.

### 4.29.1 Detailed Description

A structure which bundles the necessary inputs for the [Tidal](#) constructor. Provides default values for every necessary input. Note that this structure encapsulates [RenewableInputs](#).

### 4.29.2 Member Data Documentation

#### 4.29.2.1 capital\_cost

```
double TidalInputs::capital_cost = -1
```

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

#### 4.29.2.2 design\_speed\_ms

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

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

#### 4.29.2.3 operation\_maintenance\_cost\_kWh

```
double TidalInputs::operation_maintenance_cost_kWh = -1
```

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

#### 4.29.2.4 power\_model

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

The tidal power production model to be applied.

#### 4.29.2.5 renewable\_inputs

```
RenewableInputs TidalInputs::renewable_inputs
```

An encapsulated [RenewableInputs](#) instance.

#### 4.29.2.6 resource\_key

```
int TidalInputs::resource_key = 0
```

A key used to index into the [Resources](#) object, to associate this asset with the appropriate resource time series.

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

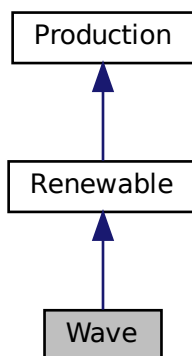
- [header/Production/Renewable/Tidal.h](#)

## 4.30 Wave Class Reference

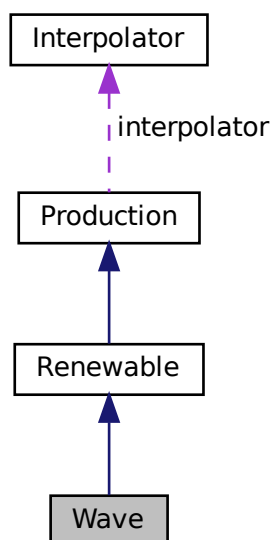
A derived class of the [Renewable](#) branch of [Production](#) which models wave production.

```
#include <Wave.h>
```

Inheritance diagram for Wave:



Collaboration diagram for Wave:



## Public Member Functions

- [Wave](#) (void)  
*Constructor (dummy) for the [Wave](#) class.*
- [Wave](#) (int, double, [WaveInputs](#))  
*Constructor (intended) for the [Wave](#) class.*
- void [handleReplacement](#) (int)  
*Method to handle asset replacement and capital cost incursion, if applicable.*
- double [computeProductionkW](#) (int, double, double, double)  
*Method which takes in the wave resource at a particular point in time, and then returns the wave turbine production at that point in time.*
- double [commit](#) (int, double, double, double)  
*Method which takes in production and load for the current timestep, computes and records dispatch and curtailment, and then returns remaining load.*
- [~Wave](#) (void)  
*Destructor for the [Wave](#) class.*

## Public Attributes

- double [design\\_significant\\_wave\\_height\\_m](#)  
*The significant wave height [m] at which the wave energy converter achieves its rated capacity.*
- double [design\\_energy\\_period\\_s](#)  
*The energy period [s] at which the wave energy converter achieves its rated capacity.*
- [WavePowerProductionModel](#) [power\\_model](#)  
*The wave power production model to be applied.*
- std::string [power\\_model\\_string](#)  
*A string describing the active power production model.*

## Private Member Functions

- void [\\_\\_checkInputs](#) ([WaveInputs](#))  
*Helper method to check inputs to the [Wave](#) constructor.*
- double [\\_\\_getGenericCapitalCost](#) (void)  
*Helper method to generate a generic wave energy converter capital cost.*
- double [\\_\\_getGenericOpMaintCost](#) (void)  
*Helper method to generate a generic wave energy converter operation and maintenance cost. This is a cost incurred per unit energy produced.*
- double [\\_\\_computeGaussianProductionkW](#) (int, double, double, double)  
*Helper method to compute wave energy converter production under a Gaussian production model.*
- double [\\_\\_computeParaboloidProductionkW](#) (int, double, double, double)  
*Helper method to compute wave energy converter production under a paraboloid production model.*
- double [\\_\\_computeLookupProductionkW](#) (int, double, double, double)  
*Helper method to compute wave energy converter production by way of looking up using given performance matrix.*
- void [\\_\\_writeSummary](#) (std::string)  
*Helper method to write summary results for [Wave](#).*
- void [\\_\\_writeTimeSeries](#) (std::string, std::vector< double > \*, std::map< int, std::vector< double >> \*, std::map< int, std::vector< std::vector< double >>> \*, int=-1)  
*Helper method to write time series results for [Wave](#).*

### 4.30.1 Detailed Description

A derived class of the [Renewable](#) branch of [Production](#) which models wave production.

### 4.30.2 Constructor & Destructor Documentation

#### 4.30.2.1 Wave() [1/2]

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

Constructor (dummy) for the [Wave](#) class.

```
501 {
502     return;
503 } /* Wave() */
```

#### 4.30.2.2 Wave() [2/2]

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

Constructor (intended) for the [Wave](#) class.

##### Parameters

<i>n_points</i>	The number of points in the modelling time series.
<i>n_years</i>	The number of years being modelled.
<i>wave_inputs</i>	A structure of <a href="#">Wave</a> constructor inputs.

```
531 :
532 Renewable(
533     n_points,
534     n_years,
535     wave_inputs.renewable_inputs
536 )
537 {
538     // 1. check inputs
539     this->__checkInputs(wave_inputs);
540
541     // 2. set attributes
542     this->type = RenewableType :: WAVE;
543     this->type_str = "WAVE";
544
545     this->resource_key = wave_inputs.resource_key;
546
547     this->design_significant_wave_height_m =
548         wave_inputs.design_significant_wave_height_m;
549     this->design_energy_period_s = wave_inputs.design_energy_period_s;
550
551     this->power_model = wave_inputs.power_model;
552
553     switch (this->power_model) {
554         case (WavePowerProductionModel :: WAVE_POWER_GAUSSIAN): {
555             this->power_model_string = "GAUSSIAN";
```



```

556
557     break;
558 }
559
560 case (WavePowerProductionModel :: WAVE_POWER_PARABOLOID): {
561     this->power_model_string = "PARABOLOID";
562
563     break;
564 }
565
566 case (WavePowerProductionModel :: WAVE_POWER_LOOKUP): {
567     this->power_model_string = "LOOKUP";
568
569     this->interpolator.addData2D(
570         0,
571         wave_inputs.path_2_normalized_performance_matrix
572     );
573
574     break;
575 }
576
577 default: {
578     std::string error_str = "ERROR: Wave(): ";
579     error_str += "power production model ";
580     error_str += std::to_string(this->power_model);
581     error_str += " not recognized";
582
583     #ifdef _WIN32
584         std::cout << error_str << std::endl;
585     #endif
586
587     throw std::runtime_error(error_str);
588
589     break;
590 }
591 }
592
593 if (wave_inputs.capital_cost < 0) {
594     this->capital_cost = this->__getGenericCapitalCost();
595 }
596
597 if (wave_inputs.operation_maintenance_cost_kWh < 0) {
598     this->operation_maintenance_cost_kWh = this->__getGenericOpMaintCost();
599 }
600
601 if (not this->is_sunk) {
602     this->capital_cost_vec[0] = this->capital_cost;
603 }
604
605 // 3. construction print
606 if (this->print_flag) {
607     std::cout << "Wave object constructed at " << this << std::endl;
608 }
609
610 return;
611 } /* Renewable() */

```

#### 4.30.2.3 ~Wave()

```

Wave::~~Wave (
    void )

```

Destructor for the [Wave](#) class.

```

797 {
798     // 1. destruction print
799     if (this->print_flag) {
800         std::cout << "Wave object at " << this << " destroyed" << std::endl;
801     }
802
803     return;
804 } /* ~Wave() */

```

### 4.30.3 Member Function Documentation

#### 4.30.3.1 `__checkInputs()`

```
void Wave::__checkInputs (
    WaveInputs wave_inputs ) [private]
```

Helper method to check inputs to the [Wave](#) constructor.

##### Parameters

<i>wave_inputs</i>	A structure of <a href="#">Wave</a> 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     // 3. if WAVE_POWER_LOOKUP, check that path is given
65     if (
66         wave_inputs.power_model == WavePowerProductionModel::WAVE_POWER_LOOKUP and
67         wave_inputs.path_2_normalized_performance_matrix.empty()
68     ) {
69         std::string error_str = "ERROR: Wave() power model was set to ";
70         error_str += "WavePowerProductionModel::WAVE_POWER_LOOKUP, but no path to a ";
71         error_str += "normalized performance matrix was given";
72
73         #ifdef _WIN32
74             std::cout << error_str << std::endl;
75         #endif
76
77         throw std::invalid_argument(error_str);
78     }
79
80     return;
81 } /* __checkInputs() */
```

#### 4.30.3.2 `__computeGaussianProductionkW()`

```
double Wave::__computeGaussianProductionkW (
    int timestep,
    double dt_hrs,
    double significant_wave_height_m,
    double energy_period_s ) [private]
```

Helper method to compute wave energy converter production under a Gaussian production model.

Ref: [Truelove et al. \[2019\]](#)

## Parameters

<i>timestep</i>	The current time step of the <a href="#">Model</a> run.
<i>dt_hrs</i>	The interval of time [hrs] associated with the action.
<i>significant_wave_height_m</i>	The significant wave height [m] in the vicinity of the wave energy converter.
<i>energy_period_s</i>	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.

```

176 {
177     double H_s_nondim =
178         (significant_wave_height_m - this->design_significant_wave_height_m) /
179         this->design_significant_wave_height_m;
180
181     double T_e_nondim =
182         (energy_period_s - this->design_energy_period_s) /
183         this->design_energy_period_s;
184
185     double production = exp(
186         -2.25119 * pow(T_e_nondim, 2) +
187         3.44570 * T_e_nondim * H_s_nondim -
188         4.01508 * pow(H_s_nondim, 2)
189     );
190
191     return production * this->capacity_kW;
192 } /* __computeGaussianProductionkW() */

```

## 4.30.3.3 \_\_computeLookupProductionkW()

```

double Wave::__computeLookupProductionkW (
    int timestep,
    double dt_hrs,
    double significant_wave_height_m,
    double energy_period_s ) [private]

```

Helper method to compute wave energy converter production by way of looking up using given performance matrix.

## Parameters

<i>timestep</i>	The current time step of the <a href="#">Model</a> run.
<i>dt_hrs</i>	The interval of time [hrs] associated with the action.
<i>significant_wave_height_m</i>	The significant wave height [m] in the vicinity of the wave energy converter.
<i>energy_period_s</i>	The energy period [s] in the vicinity of the wave energy converter

## Returns

The interpolated production [kW] of the wave energy converter.

```

293 {
294     double prod = this->interpolator.interp2D(
295         0,
296         significant_wave_height_m,
297         energy_period_s
298     );
299

```

```

300     return prod * this->capacity_kW;
301 } /* __computeLookupProductionkW() */

```

#### 4.30.3.4 \_\_computeParaboloidProductionkW()

```

double Wave::__computeParaboloidProductionkW (
    int timestep,
    double dt_hrs,
    double significant_wave_height_m,
    double energy_period_s ) [private]

```

Helper method to compute wave energy converter production under a paraboloid production model.

Ref: [Robertson et al. \[2021\]](#)

##### Parameters

<i>timestep</i>	The current time step of the <a href="#">Model</a> run.
<i>dt_hrs</i>	The interval of time [hrs] associated with the action.
<i>significant_wave_height_m</i>	The significant wave height [m] in the vicinity of the wave energy converter.
<i>energy_period_s</i>	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.

```

233 {
234     // first, check for idealized wave breaking (deep water)
235     if (significant_wave_height_m >= 0.2184 * pow(energy_period_s, 2)) {
236         return 0;
237     }
238
239     // otherwise, apply generic quadratic performance model
240     // (with outputs bounded to [0, 1])
241     double production =
242         0.289 * significant_wave_height_m -
243         0.00111 * pow(significant_wave_height_m, 2) * energy_period_s -
244         0.0169 * energy_period_s;
245
246     if (production < 0) {
247         production = 0;
248     }
249
250     else if (production > 1) {
251         production = 1;
252     }
253
254     return production * this->capacity_kW;
255 } /* __computeParaboloidProductionkW() */

```

#### 4.30.3.5 \_\_getGenericCapitalCost()

```

double Wave::__getGenericCapitalCost (
    void ) [private]

```

Helper method to generate a generic wave energy converter capital cost.

Note that this model expresses cost in terms of Canadian dollars [CAD].

Ref: [MacDougall \[2019\]](#)

#### Returns

A generic capital cost for the wave energy converter [CAD].

```
103 {
104     double capital_cost_per_kW = 7000 * pow(this->capacity_kW, -0.15) + 5000;
105
106     return capital_cost_per_kW * this->capacity_kW;
107 } /* __getGenericCapitalCost() */
```

#### 4.30.3.6 \_\_getGenericOpMaintCost()

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

Helper method to generate a generic wave energy converter operation and maintenance cost. This is a cost incurred per unit energy produced.

Note that this model expresses cost in terms of Canadian dollars [CAD/kWh].

Ref: [MacDougall \[2019\]](#)

#### Returns

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

```
131 {
132     double operation_maintenance_cost_kWh = 0.05 * pow(this->capacity_kW, -0.2) + 0.05;
133
134     return operation_maintenance_cost_kWh;
135 } /* __getGenericOpMaintCost() */
```

#### 4.30.3.7 \_\_writeSummary()

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

Helper method to write summary results for [Wave](#).

#### Parameters

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

Reimplemented from [Renewable](#).

```

319 {
320     // 1. create filestream
321     write_path += "summary_results.md";
322     std::ofstream ofs;
323     ofs.open(write_path, std::ofstream::out);
324
325     // 2. write summary results (markdown)
326     ofs << "# ";
327     ofs << std::to_string(int(ceil(this->capacity_kW)));
328     ofs << " kW WAVE Summary Results\n";
329     ofs << "\n-----\n\n";
330
331     // 2.1. Production attributes
332     ofs << "## Production Attributes\n";
333     ofs << "\n";
334
335     ofs << "Capacity: " << this->capacity_kW << "kW \n";
336     ofs << "\n";
337
338     ofs << "Sunk Cost (N = 0 / Y = 1): " << this->is_sunk << " \n";
339     ofs << "Capital Cost: " << this->capital_cost << " \n";
340     ofs << "Operation and Maintenance Cost: " << this->operation_maintenance_cost_kWh
341         << " per kWh produced \n";
342     ofs << "Nominal Inflation Rate (annual): " << this->nominal_inflation_annual
343         << " \n";
344     ofs << "Nominal Discount Rate (annual): " << this->nominal_discount_annual
345         << " \n";
346     ofs << "Real Discount Rate (annual): " << this->real_discount_annual << " \n";
347     ofs << "\n";
348
349     ofs << "Replacement Running Hours: " << this->replace_running_hrs << " \n";
350     ofs << "\n-----\n\n";
351
352     // 2.2. Renewable attributes
353     ofs << "## Renewable Attributes\n";
354     ofs << "\n";
355
356     ofs << "Resource Key (2D): " << this->resource_key << " \n";
357
358     ofs << "\n-----\n\n";
359
360     // 2.3. Wave attributes
361     ofs << "## Wave Attributes\n";
362     ofs << "\n";
363
364     ofs << "Power Production Model: " << this->power_model_string << " \n";
365     switch (this->power_model) {
366     case (WavePowerProductionModel :: WAVE_POWER_GAUSSIAN): {
367         ofs << "Design Significant Wave Height: "
368             << this->design_significant_wave_height_m << " m \n";
369
370         ofs << "Design Energy Period: " << this->design_energy_period_s << " s \n";
371
372         break;
373     }
374
375     case (WavePowerProductionModel :: WAVE_POWER_LOOKUP): {
376         ofs << "Normalized Performance Matrix: "
377             << this->interpolator.path_map_2D[0] << " \n";
378
379         break;
380     }
381
382     default: {
383         // write nothing!
384
385         break;
386     }
387     }
388
389     ofs << "\n-----\n\n";
390
391     // 2.4. Wave Results
392     ofs << "## Results\n";
393     ofs << "\n";
394
395     ofs << "Net Present Cost: " << this->net_present_cost << " \n";
396     ofs << "\n";
397
398     ofs << "Total Dispatch: " << this->total_dispatch_kWh
399         << " kWh \n";
400
401     ofs << "Levellized Cost of Energy: " << this->levellized_cost_of_energy_kWh
402         << " per kWh dispatched \n";
403     ofs << "\n";
404

```

```

405     ofs << "Running Hours: " << this->running_hours << " \n";
406     ofs << "Replacements: " << this->n_replacements << " \n";
407
408     ofs << "\n-----\n\n";
409
410     ofs.close();
411
412     return;
413 } /* __writeSummary() */

```

#### 4.30.3.8 \_\_writeTimeSeries()

```

void Wave::__writeTimeSeries (
    std::string write_path,
    std::vector< double > * time_vec_hrs_ptr,
    std::map< int, std::vector< double >> * resource_map_1D_ptr,
    std::map< int, std::vector< std::vector< double >>> * resource_map_2D_ptr,
    int max_lines = -1 ) [private], [virtual]

```

Helper method to write time series results for [Wave](#).

##### Parameters

<i>write_path</i>	A path (either relative or absolute) to the directory location where results are to be written. If already exists, will overwrite.
<i>time_vec_hrs_ptr</i>	A pointer to the <code>time_vec_hrs</code> attribute of the <a href="#">ElectricalLoad</a> .
<i>resource_map_1D_ptr</i>	A pointer to the 1D map of <a href="#">Resources</a> .
<i>resource_map_2D_ptr</i>	A pointer to the 2D map of <a href="#">Resources</a> .
<i>max_lines</i>	The maximum number of lines of output to write.

Reimplemented from [Renewable](#).

```

451 {
452     // 1. create filestream
453     write_path += "time_series_results.csv";
454     std::ofstream ofs;
455     ofs.open(write_path, std::ofstream::out);
456
457     // 2. write time series results (comma separated value)
458     ofs << "Time (since start of data) [hrs],";
459     ofs << "Significant Wave Height [m],";
460     ofs << "Energy Period [s],";
461     ofs << "Production [kW],";
462     ofs << "Dispatch [kW],";
463     ofs << "Storage [kW],";
464     ofs << "Curtailement [kW],";
465     ofs << "Capital Cost (actual),";
466     ofs << "Operation and Maintenance Cost (actual),";
467     ofs << "\n";
468
469     for (int i = 0; i < max_lines; i++) {
470         ofs << time_vec_hrs_ptr->at(i) << ",";
471         ofs << resource_map_2D_ptr->at(this->resource_key)[i][0] << ",";
472         ofs << resource_map_2D_ptr->at(this->resource_key)[i][1] << ",";
473         ofs << this->production_vec_kW[i] << ",";
474         ofs << this->dispatch_vec_kW[i] << ",";
475         ofs << this->storage_vec_kW[i] << ",";
476         ofs << this->curtailement_vec_kW[i] << ",";
477         ofs << this->capital_cost_vec[i] << ",";
478         ofs << this->operation_maintenance_cost_vec[i] << ",";
479         ofs << "\n";
480     }
481
482     return;
483 } /* __writeTimeSeries() */

```

#### 4.30.3.9 commit()

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

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

##### Parameters

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

```
769 {
770     // 1. invoke base class method
771     load_kW = Renewable::commit(
772         timestep,
773         dt_hrs,
774         production_kW,
775         load_kW
776     );
777
778
779     //...
780
781     return load_kW;
782 } /* commit() */
```

#### 4.30.3.10 computeProductionkW()

```
double Wave::computeProductionkW (
    int timestep,
    double dt_hrs,
    double significant_wave_height_m,
    double energy_period_s ) [virtual]
```

Method which takes in the wave resource at a particular point in time, and then returns the wave turbine production at that point in time.

##### Parameters

<i>timestep</i>	The timestep (i.e., time series index) for the request.
<i>dt_hrs</i>	The interval of time [hrs] associated with the timestep.
<i>signficiant_wave_height_m</i>	The significant wave height (wave statistic) [m].
<i>energy_period_s</i>	The energy period (wave statistic) [s].



## Returns

The production [kW] of the wave turbine.

Reimplemented from [Renewable](#).

```

673 {
674     // check if no resource
675     if (significant_wave_height_m <= 0 or energy_period_s <= 0) {
676         return 0;
677     }
678
679     // compute production
680     double production_kW = 0;
681
682     switch (this->power_model) {
683         case (WavePowerProductionModel :: WAVE_POWER_PARABOLOID): {
684             production_kW = this->__computeParaboloidProductionkW(
685                 timestep,
686                 dt_hrs,
687                 significant_wave_height_m,
688                 energy_period_s
689             );
690
691             break;
692         }
693
694         case (WavePowerProductionModel :: WAVE_POWER_GAUSSIAN): {
695             production_kW = this->__computeGaussianProductionkW(
696                 timestep,
697                 dt_hrs,
698                 significant_wave_height_m,
699                 energy_period_s
700             );
701
702             break;
703         }
704
705         case (WavePowerProductionModel :: WAVE_POWER_LOOKUP): {
706             production_kW = this->__computeLookupProductionkW(
707                 timestep,
708                 dt_hrs,
709                 significant_wave_height_m,
710                 energy_period_s
711             );
712
713             break;
714         }
715
716         default: {
717             std::string error_str = "ERROR: Wave::computeProductionkW(): ";
718             error_str += "power model ";
719             error_str += std::to_string(this->power_model);
720             error_str += " not recognized";
721
722             #ifdef _WIN32
723                 std::cout << error_str << std::endl;
724             #endif
725
726             throw std::runtime_error(error_str);
727
728             break;
729         }
730     }
731
732     return production_kW;
733 } /* computeProductionkW() */

```

#### 4.30.3.11 handleReplacement()

```

void Wave::handleReplacement (
    int timestep ) [virtual]

```

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

**Parameters**

<i>timestep</i>	The current time step of the <a href="#">Model</a> run.
-----------------	---

Reimplemented from [Renewable](#).

```

629 {
630     // 1. reset attributes
631     //...
632
633     // 2. invoke base class method
634     Renewable::handleReplacement(timestep);
635
636     return;
637 } /* __handleReplacement() */

```

**4.30.4 Member Data Documentation****4.30.4.1 design\_energy\_period\_s**

```
double Wave::design_energy_period_s
```

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

**4.30.4.2 design\_significant\_wave\_height\_m**

```
double Wave::design_significant_wave_height_m
```

The significant wave height [m] at which the wave energy converter achieves its rated capacity.

**4.30.4.3 power\_model**

```
WavePowerProductionModel Wave::power_model
```

The wave power production model to be applied.

**4.30.4.4 power\_model\_string**

```
std::string Wave::power_model_string
```

A string describing the active power production model.

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

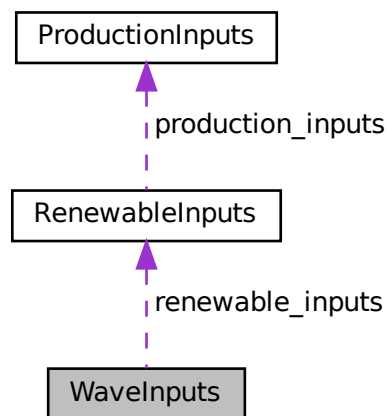
- header/Production/Renewable/[Wave.h](#)
- source/Production/Renewable/[Wave.cpp](#)

## 4.31 WaveInputs Struct Reference

A structure which bundles the necessary inputs for the [Wave](#) constructor. Provides default values for every necessary input. Note that this structure encapsulates [RenewableInputs](#).

```
#include <Wave.h>
```

Collaboration diagram for WaveInputs:



### Public Attributes

- [RenewableInputs](#) `renewable_inputs`  
An encapsulated [RenewableInputs](#) instance.
- int `resource_key` = 0  
A key used to index into the [Resources](#) object, to associate this asset with the appropriate resource time series.
- double `capital_cost` = -1  
The capital cost of the asset (undefined currency). -1 is a sentinel value, which triggers a generic cost model on construction (in fact, any negative value here will trigger). Note that the generic cost model is in terms of Canadian dollars [CAD].
- double `operation_maintenance_cost_kWh` = -1  
The operation and maintenance cost of the asset [1/kWh] (undefined currency). This is a cost incurred per unit of energy produced. -1 is a sentinel value, which triggers a generic cost model on construction (in fact, any negative value here will trigger). Note that the generic cost model is in terms of Canadian dollars [CAD/kWh].
- double `design_significant_wave_height_m` = 3  
The significant wave height [m] at which the wave energy converter achieves its rated capacity.
- double `design_energy_period_s` = 10  
The energy period [s] at which the wave energy converter achieves its rated capacity.
- [WavePowerProductionModel](#) `power_model` = [WavePowerProductionModel](#) :: [WAVE\\_POWER\\_PARABOLOID](#)  
The wave power production model to be applied.
- std::string `path_2_normalized_performance_matrix` = ""  
A path (either relative or absolute) to a normalized performance matrix for the wave energy converter.

### 4.31.1 Detailed Description

A structure which bundles the necessary inputs for the [Wave](#) constructor. Provides default values for every necessary input. Note that this structure encapsulates [RenewableInputs](#).

### 4.31.2 Member Data Documentation

#### 4.31.2.1 capital\_cost

```
double WaveInputs::capital_cost = -1
```

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

#### 4.31.2.2 design\_energy\_period\_s

```
double WaveInputs::design_energy_period_s = 10
```

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

#### 4.31.2.3 design\_significant\_wave\_height\_m

```
double WaveInputs::design_significant_wave_height_m = 3
```

The significant wave height [m] at which the wave energy converter achieves its rated capacity.

#### 4.31.2.4 operation\_maintenance\_cost\_kWh

```
double WaveInputs::operation_maintenance_cost_kWh = -1
```

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

#### 4.31.2.5 path\_2\_normalized\_performance\_matrix

```
std::string WaveInputs::path_2_normalized_performance_matrix = ""
```

A path (either relative or absolute) to a normalized performance matrix for the wave energy converter.

#### 4.31.2.6 power\_model

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

The wave power production model to be applied.

#### 4.31.2.7 renewable\_inputs

```
RenewableInputs WaveInputs::renewable_inputs
```

An encapsulated [RenewableInputs](#) instance.

#### 4.31.2.8 resource\_key

```
int WaveInputs::resource_key = 0
```

A key used to index into the [Resources](#) object, to associate this asset with the appropriate resource time series.

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

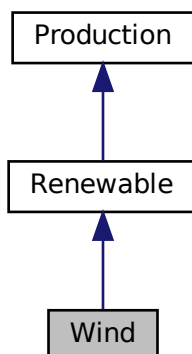
- [header/Production/Renewable/Wave.h](#)

## 4.32 Wind Class Reference

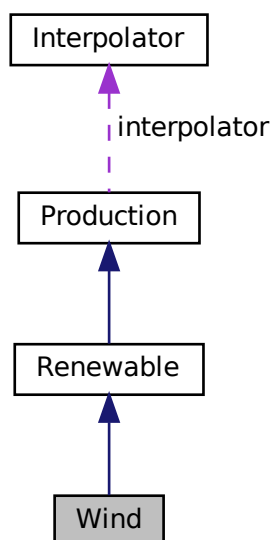
A derived class of the [Renewable](#) branch of [Production](#) which models wind production.

```
#include <Wind.h>
```

Inheritance diagram for Wind:



Collaboration diagram for Wind:



## Public Member Functions

- [Wind](#) (void)  
*Constructor (dummy) for the [Wind](#) class.*
- [Wind](#) (int, double, [WindInputs](#))  
*Constructor (intended) for the [Wind](#) class.*
- void [handleReplacement](#) (int)  
*Method to handle asset replacement and capital cost incursion, if applicable.*
- double [computeProductionkW](#) (int, double, double)  
*Method which takes in the wind resource at a particular point in time, and then returns the wind turbine production at that point in time.*
- double [commit](#) (int, double, double, double)  
*Method which takes in production and load for the current timestep, computes and records dispatch and curtailment, and then returns remaining load.*
- [~Wind](#) (void)  
*Destructor for the [Wind](#) class.*

## Public Attributes

- double [design\\_speed\\_ms](#)  
*The wind speed [m/s] at which the wind turbine achieves its rated capacity.*
- [WindPowerProductionModel](#) [power\\_model](#)  
*The wind power production model to be applied.*
- std::string [power\\_model\\_string](#)  
*A string describing the active power production model.*

## Private Member Functions

- void [\\_\\_checkInputs](#) ([WindInputs](#))  
*Helper method to check inputs to the [Wind](#) constructor.*
- double [\\_\\_getGenericCapitalCost](#) (void)  
*Helper method to generate a generic wind turbine capital cost.*
- double [\\_\\_getGenericOpMaintCost](#) (void)  
*Helper method to generate a generic wind turbine operation and maintenance cost. This is a cost incurred per unit energy produced.*
- double [\\_\\_computeExponentialProductionkW](#) (int, double, double)  
*Helper method to compute wind turbine production under an exponential production model.*
- double [\\_\\_computeLookupProductionkW](#) (int, double, double)  
*Helper method to compute wind turbine production by way of looking up using given power curve data.*
- void [\\_\\_writeSummary](#) (std::string)  
*Helper method to write summary results for [Wind](#).*
- void [\\_\\_writeTimeSeries](#) (std::string, std::vector< double > \*, std::map< int, std::vector< double > > \*, std::map< int, std::vector< std::vector< double > > > \*, int=-1)  
*Helper method to write time series results for [Wind](#).*

### 4.32.1 Detailed Description

A derived class of the [Renewable](#) branch of [Production](#) which models wind production.

## 4.32.2 Constructor & Destructor Documentation

### 4.32.2.1 Wind() [1/2]

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

Constructor (dummy) for the [Wind](#) class.

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

### 4.32.2.2 Wind() [2/2]

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

Constructor (intended) for the [Wind](#) class.

#### Parameters

<i>n_points</i>	The number of points in the modelling time series.
<i>n_years</i>	The number of years being modelled.
<i>wind_inputs</i>	A structure of <a href="#">Wind</a> 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() */

```

#### 4.32.2.3 ~Wind()

```

Wind::~Wind (
    void )

```

Destructor for the [Wind](#) class.

```

656 {
657     // 1. destruction print
658     if (this->print_flag) {
659         std::cout << "Wind object at " << this << " destroyed" << std::endl;
660     }
661
662     return;
663 } /* ~Wind() */

```

### 4.32.3 Member Function Documentation

#### 4.32.3.1 \_\_checkInputs()

```

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

```

Helper method to check inputs to the [Wind](#) constructor.

##### Parameters

<i>wind_inputs</i>	A structure of <a href="#">Wind</a> 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() */

```

#### 4.32.3.2 \_\_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

<i>timestep</i>	The current time step of the <a href="#">Model</a> run.
<i>dt_hrs</i>	The interval of time [hrs] associated with the action.
<i>wind_resource_ms</i>	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() */

```

#### 4.32.3.3 \_\_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

<i>timestep</i>	The current time step of the <a href="#">Model</a> run.
<i>dt_hrs</i>	The interval of time [hrs] associated with the action.
<i>wind_resource_ms</i>	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() */
```

#### 4.32.3.4 \_\_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() */
```

#### 4.32.3.5 \_\_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() */
```

### 4.32.3.6 \_\_writeSummary()

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

Helper method to write summary results for [Wind](#).

#### Parameters

<i>write_path</i>	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 }
```

```

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() */

```

#### 4.32.3.7 \_\_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

<i>write_path</i>	A path (either relative or absolute) to the directory location where results are to be written. If already exists, will overwrite.
<i>time_vec_hrs_ptr</i>	A pointer to the <code>time_vec_hrs</code> attribute of the <a href="#">ElectricalLoad</a> .
<i>resource_map_1D_ptr</i>	A pointer to the 1D map of <a href="#">Resources</a> .
<i>resource_map_2D_ptr</i>	A pointer to the 2D map of <a href="#">Resources</a> .
<i>max_lines</i>	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 << "Curtailement [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_ID_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() */

```

#### 4.32.3.8 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

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

```

628 {
629     // 1. invoke base class method
630     load_kW = Renewable::commit(
631         timestep,
632         dt_hrs,
633         production_kW,
634         load_kW
635     );
636
637     //...
638
639     return load_kW;
640 } /* commit() */

```

#### 4.32.3.9 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

<i>timestep</i>	The timestep (i.e., time series index) for the request.
<i>dt_hrs</i>	The interval of time [hrs] associated with the timestep.
<i>wind_resource_ms</i>	<a href="#">Wind</a> resource (i.e. wind speed) [m/s].

## Returns

The production [kW] of the wind turbine.

Reimplemented from [Renewable](#).

```

545 {
546     // check if no resource
547     if (wind_resource_ms <= 0) {
548         return 0;
549     }
550
551     // compute production
552     double production_kW = 0;
553
554     switch (this->power_model) {
555         case (WindPowerProductionModel :: WIND_POWER_EXPONENTIAL): {
556             production_kW = this->__computeExponentialProductionkW(
557                 timestep,
558                 dt_hrs,
559                 wind_resource_ms
560             );
561
562             break;
563         }
564
565         case (WindPowerProductionModel :: WIND_POWER_LOOKUP): {
566             production_kW = this->__computeLookupProductionkW(
567                 timestep,
568                 dt_hrs,
569                 wind_resource_ms
570             );
571
572             break;
573         }
574
575         default: {
576             std::string error_str = "ERROR: Wind::computeProductionkW(): ";
577             error_str += "power model ";
578             error_str += std::to_string(this->power_model);
579             error_str += " not recognized";
580
581             #ifdef _WIN32
582                 std::cout << error_str << std::endl;
583             #endif
584
585             throw std::runtime_error(error_str);
586
587             break;
588         }
589     }
590
591     return production_kW;
592 } /* computeProductionkW() */

```

#### 4.32.3.10 handleReplacement()

```

void Wind::handleReplacement (
    int timestep ) [virtual]

```

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



## Parameters

<i>timestep</i>	The current time step of the <a href="#">Model</a> run.
-----------------	---

Reimplemented from [Renewable](#).

```
505 {  
506     // 1. reset attributes  
507     //...  
508  
509     // 2. invoke base class method  
510     Renewable :: handleReplacement(timestep);  
511  
512     return;  
513 } /* __handleReplacement() */
```

## 4.32.4 Member Data Documentation

### 4.32.4.1 design\_speed\_ms

```
double Wind::design_speed_ms
```

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

### 4.32.4.2 power\_model

```
WindPowerProductionModel Wind::power_model
```

The wind power production model to be applied.

### 4.32.4.3 power\_model\_string

```
std::string Wind::power_model_string
```

A string describing the active power production model.

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

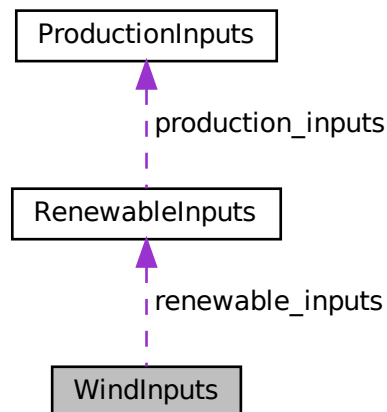
- header/Production/Renewable/[Wind.h](#)
- source/Production/Renewable/[Wind.cpp](#)

## 4.33 WindInputs Struct Reference

A structure which bundles the necessary inputs for the [Wind](#) constructor. Provides default values for every necessary input. Note that this structure encapsulates [RenewableInputs](#).

```
#include <Wind.h>
```

Collaboration diagram for WindInputs:



### Public Attributes

- [RenewableInputs](#) `renewable_inputs`  
An encapsulated [RenewableInputs](#) instance.
- int `resource_key` = 0  
A key used to index into the [Resources](#) object, to associate this asset with the appropriate resource time series.
- double `capital_cost` = -1  
The capital cost of the asset (undefined currency). -1 is a sentinel value, which triggers a generic cost model on construction (in fact, any negative value here will trigger). Note that the generic cost model is in terms of Canadian dollars [CAD].
- double `operation_maintenance_cost_kWh` = -1  
The operation and maintenance cost of the asset [1/kWh] (undefined currency). This is a cost incurred per unit of energy produced. -1 is a sentinel value, which triggers a generic cost model on construction (in fact, any negative value here will trigger). Note that the generic cost model is in terms of Canadian dollars [CAD/kWh].
- double `design_speed_ms` = 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.

### 4.33.1 Detailed Description

A structure which bundles the necessary inputs for the [Wind](#) constructor. Provides default values for every necessary input. Note that this structure encapsulates [RenewableInputs](#).

## 4.33.2 Member Data Documentation

### 4.33.2.1 capital\_cost

```
double WindInputs::capital_cost = -1
```

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

### 4.33.2.2 design\_speed\_ms

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

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

### 4.33.2.3 operation\_maintenance\_cost\_kWh

```
double WindInputs::operation_maintenance_cost_kWh = -1
```

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

### 4.33.2.4 power\_model

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

The wind power production model to be applied.

### 4.33.2.5 renewable\_inputs

```
RenewableInputs WindInputs::renewable_inputs
```

An encapsulated [RenewableInputs](#) instance.

### 4.33.2.6 resource\_key

```
int WindInputs::resource_key = 0
```

A key used to index into the [Resources](#) object, to associate this asset with the appropriate resource time series.

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

- [header/Production/Renewable/Wind.h](#)



## Chapter 5

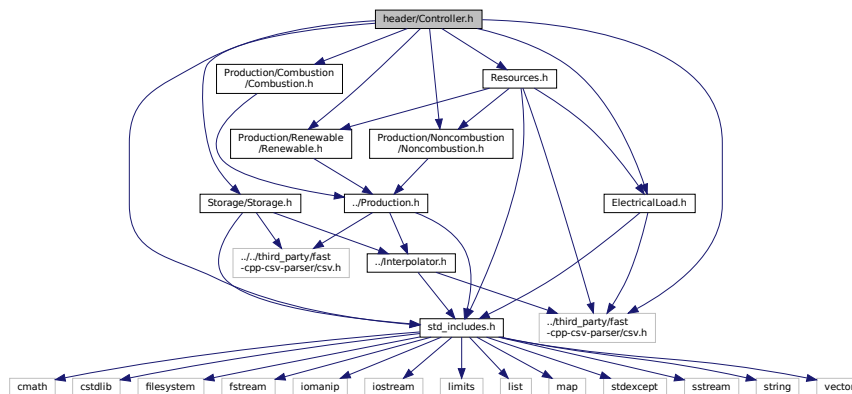
# File Documentation

### 5.1 header/Controller.h File Reference

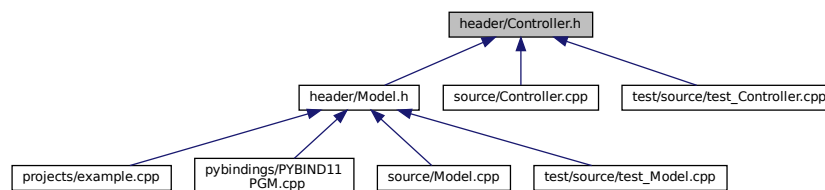
Header file for the [Controller](#) class.

```
#include "std_includes.h"
#include "../third_party/fast-cpp-csv-parser/csv.h"
#include "ElectricalLoad.h"
#include "Resources.h"
#include "Production/Combustion/Combustion.h"
#include "Production/Noncombustion/Noncombustion.h"
#include "Production/Renewable/Renewable.h"
#include "Storage/Storage.h"
```

Include dependency graph for Controller.h:



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



## Classes

- class [Controller](#)

*A class which contains a various dispatch control logic. Intended to serve as a component class of [Model](#).*

## Enumerations

- enum [ControlMode](#) { [LOAD\\_FOLLOWING](#) , [CYCLE\\_CHARGING](#) , [N\\_CONTROL\\_MODES](#) }

*An enumeration of the types of control modes supported by PGMcpp.*

### 5.1.1 Detailed Description

Header file for the [Controller](#) class.

### 5.1.2 Enumeration Type Documentation

#### 5.1.2.1 ControlMode

enum [ControlMode](#)

An enumeration of the types of control modes supported by PGMcpp.

##### Enumerator

<a href="#">LOAD_FOLLOWING</a>	Load following control, with in-order dispatch of non-Combustion assets and optimal dispatch of <a href="#">Combustion</a> assets.
<a href="#">CYCLE_CHARGING</a>	Cycle charging control, with in-order dispatch of non-Combustion assets and optimal dispatch of <a href="#">Combustion</a> assets.
<a href="#">N_CONTROL_MODES</a>	A simple hack to get the number of elements in ControlMode.

```

44         {
45     LOAD\_FOLLOWING,
46     CYCLE\_CHARGING,
47     N\_CONTROL\_MODES
48 };

```

## 5.2 header/doxygen\_cite.h File Reference

Header file which simply cites the doxygen tool.

### 5.2.1 Detailed Description

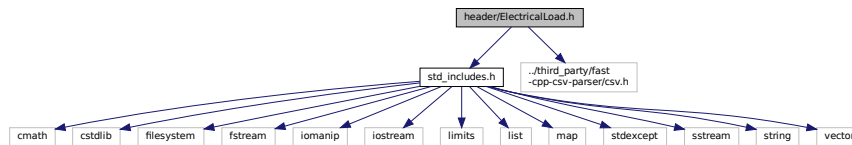
Header file which simply cites the doxygen tool.

Ref: [van Heesch](#). [2023]

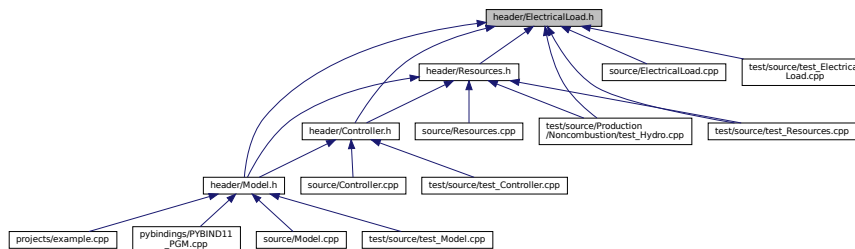
## 5.3 header/ElectricalLoad.h File Reference

Header file for the [ElectricalLoad](#) class.

```
#include "std_includes.h"
#include "../third_party/fast-cpp-csv-parser/csv.h"
Include dependency graph for ElectricalLoad.h:
```



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



## Classes

- class [ElectricalLoad](#)

*A class which contains time and electrical load data. Intended to serve as a component class of [Model](#).*

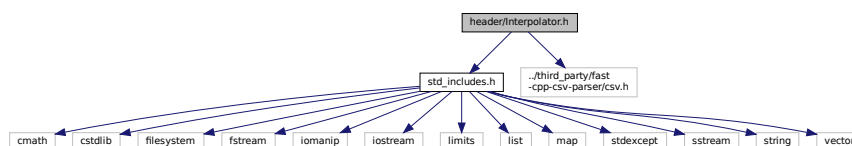
### 5.3.1 Detailed Description

Header file for the [ElectricalLoad](#) class.

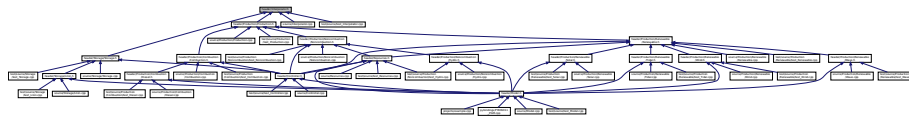
## 5.4 header/Interpolator.h File Reference

Header file for the [Interpolator](#) class.

```
#include "std_includes.h"
#include "../third_party/fast-cpp-csv-parser/csv.h"
Include dependency graph for Interpolator.h:
```



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



## Classes

- struct [InterpolatorStruct1D](#)  
A struct which holds two parallel vectors for use in 1D interpolation.
- struct [InterpolatorStruct2D](#)  
A struct which holds two parallel vectors and a matrix for use in 2D interpolation.
- class [Interpolator](#)  
A class which contains interpolation data and functionality. Intended to serve as a component of the [Production](#) and [Storage](#) hierarchies.

### 5.4.1 Detailed Description

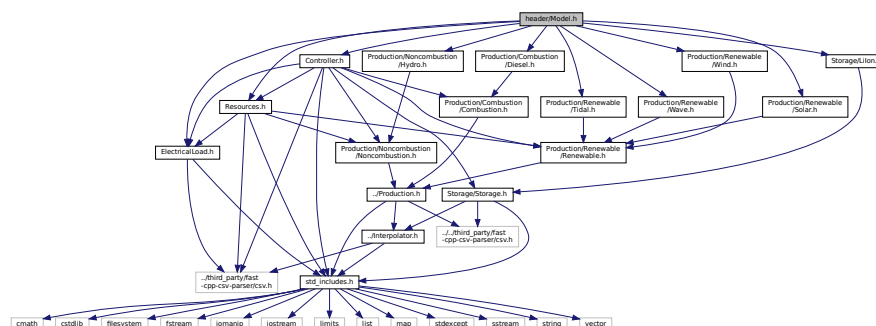
Header file for the [Interpolator](#) class.

## 5.5 header/Model.h File Reference

Header file for the [Model](#) class.

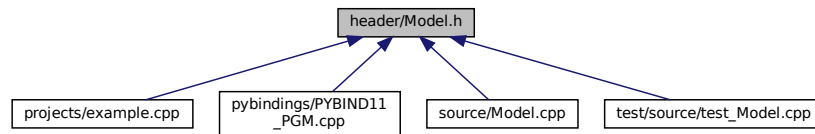
```
#include "Controller.h"
#include "ElectricalLoad.h"
#include "Resources.h"
#include "Production/Combustion/Diesel.h"
#include "Production/Noncombustion/Hydro.h"
#include "Production/Renewable/Solar.h"
#include "Production/Renewable/Tidal.h"
#include "Production/Renewable/Wave.h"
#include "Production/Renewable/Wind.h"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

Include dependency graph for Model.h:





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



## Classes

- struct [ModellInputs](#)

A structure which bundles the necessary inputs for the [Model](#) constructor. Provides default values for every necessary input (except `path_2_electrical_load_time_series`, for which a valid input must be provided).

- class [Model](#)

A container class which forms the centre of PGMcpp. The [Model](#) class is intended to serve as the primary user interface with the functionality of PGMcpp, and as such it contains all other classes.

### 5.5.1 Detailed Description

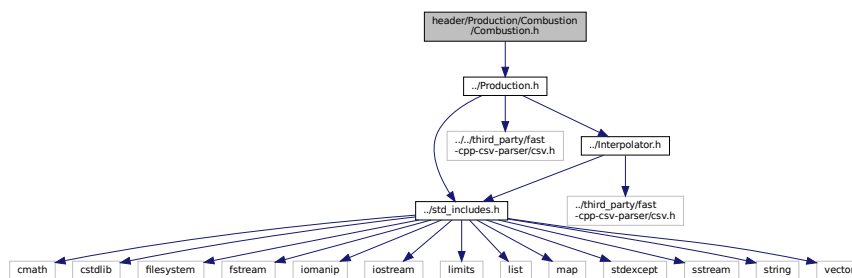
Header file for the [Model](#) class.

## 5.6 header/Production/Combustion/Combustion.h File Reference

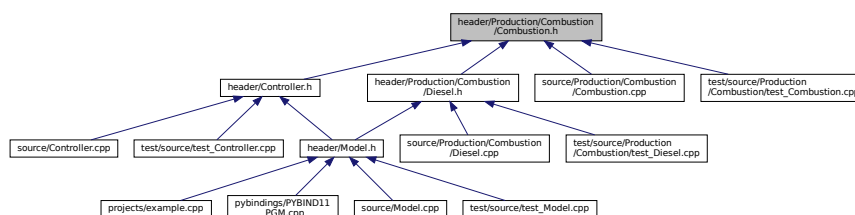
Header file for the [Combustion](#) class.

```
#include "../Production.h"
```

Include dependency graph for Combustion.h:



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



## Classes

- struct [CombustionInputs](#)  
A structure which bundles the necessary inputs for the [Combustion](#) constructor. Provides default values for every necessary input. Note that this structure encapsulates [ProductionInputs](#).
- struct [Emissions](#)  
A structure which bundles the emitted masses of various emissions chemistries.
- class [Combustion](#)  
The root of the [Combustion](#) branch of the [Production](#) hierarchy. This branch contains derived classes which model the production of energy by way of combustibles.

## Enumerations

- enum [CombustionType](#) { [DIESEL](#) , [N\\_COMBUSTION\\_TYPES](#) }  
An enumeration of the types of [Combustion](#) asset supported by PGMcpp.
- enum [FuelMode](#) { [FUEL\\_MODE\\_LINEAR](#) , [FUEL\\_MODE\\_LOOKUP](#) , [N\\_FUEL\\_MODES](#) }  
An enumeration of the fuel modes for the [Combustion](#) asset which are supported by PGMcpp.

### 5.6.1 Detailed Description

Header file for the [Combustion](#) class.

Header file for the [Noncombustion](#) class.

### 5.6.2 Enumeration Type Documentation

#### 5.6.2.1 CombustionType

```
enum CombustionType
```

An enumeration of the types of [Combustion](#) asset supported by PGMcpp.

Enumerator

<a href="#">DIESEL</a>	A diesel generator.
<a href="#">N_COMBUSTION_TYPES</a>	A simple hack to get the number of elements in <a href="#">CombustionType</a> .

```
33         {
34     DIESEL,
35     N\_COMBUSTION\_TYPES
36 };
```

#### 5.6.2.2 FuelMode

```
enum FuelMode
```

An enumeration of the fuel modes for the [Combustion](#) asset which are supported by PGMcpp.

## Enumerator

FUEL_MODE_LINEAR	A linearized fuel curve model (i.e., HOMER-like model)
FUEL_MODE_LOOKUP	Interpolating over a given fuel lookup table.
N_FUEL_MODES	A simple hack to get the number of elements in FuelMode.

```

46     {
47         FUEL_MODE_LINEAR,
48         FUEL_MODE_LOOKUP,
49         N_FUEL_MODES
50     };

```

## 5.7 header/Production/Combustion/Diesel.h File Reference

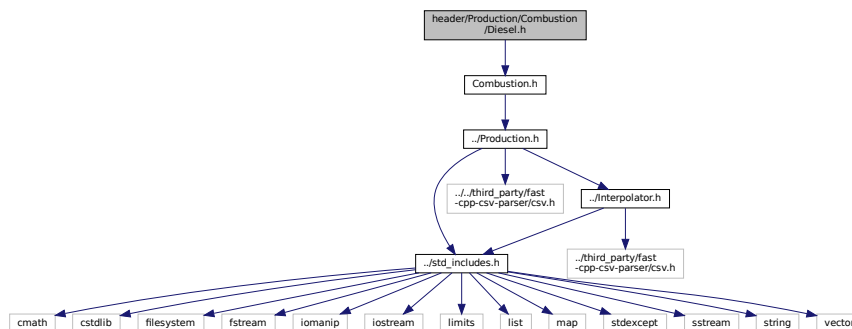
Header file for the [Diesel](#) class.

```

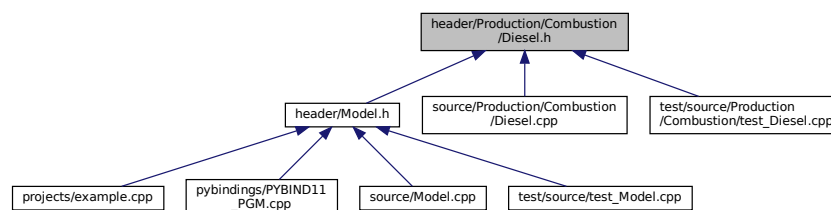
#include "Combustion.h"

```

Include dependency graph for Diesel.h:



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



## Classes

- struct [DieselInputs](#)  
A structure which bundles the necessary inputs for the [Diesel](#) constructor. Provides default values for every necessary input. Note that this structure encapsulates [CombustionInputs](#).
- class [Diesel](#)  
A derived class of the [Combustion](#) branch of [Production](#) which models production using a diesel generator.

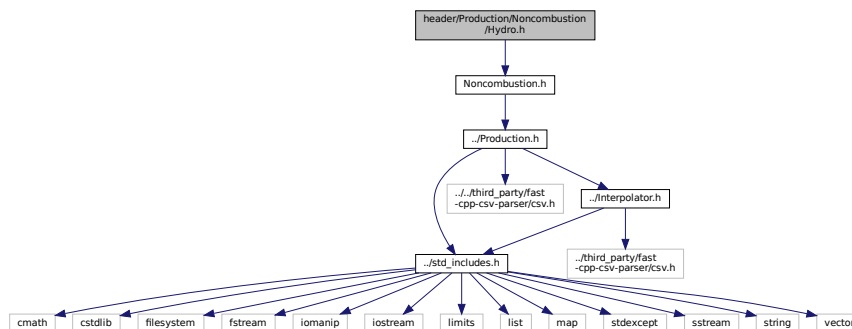
### 5.7.1 Detailed Description

Header file for the [Diesel](#) class.

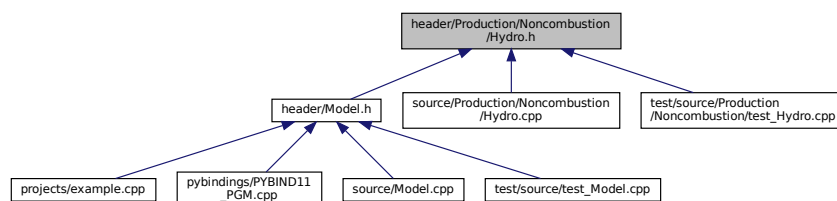
## 5.8 header/Production/Noncombustion/Hydro.h File Reference

Header file for the [Hydro](#) class.

```
#include "Noncombustion.h"
Include dependency graph for Hydro.h:
```



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



## Classes

- struct [HydroInputs](#)

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

- class [Hydro](#)

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

## Enumerations

- enum [HydroTurbineType](#) { [HYDRO\\_TURBINE\\_PELTON](#) , [HYDRO\\_TURBINE\\_FRANCIS](#) , [HYDRO\\_TURBINE\\_KAPLAN](#) , [N\\_HYDRO\\_TURBINES](#) }

An enumeration of the types of hydroelectric turbine supported by PGMcpp.

- enum [HydroInterpKeys](#) { [GENERATOR\\_EFFICIENCY\\_INTERP\\_KEY](#) , [TURBINE\\_EFFICIENCY\\_INTERP\\_KEY](#) , [FLOW\\_TO\\_POWER\\_INTERP\\_KEY](#) , [N\\_HYDRO\\_INTERP\\_KEYS](#) }

An enumeration of the [Interpolator](#) keys used by the [Hydro](#) asset.

### 5.8.1 Detailed Description

Header file for the [Hydro](#) class.

### 5.8.2 Enumeration Type Documentation

#### 5.8.2.1 HydroInterpKeys

```
enum HydroInterpKeys
```

An enumeration of the [Interpolator](#) keys used by the [Hydro](#) asset.

##### Enumerator

<a href="#">GENERATOR_EFFICIENCY_INTERP_KEY</a>	The key for generator efficiency interpolation.
<a href="#">TURBINE_EFFICIENCY_INTERP_KEY</a>	The key for turbine efficiency interpolation.
<a href="#">FLOW_TO_POWER_INTERP_KEY</a>	The key for flow to power interpolation.
<a href="#">N_HYDRO_INTERP_KEYS</a>	A simple hack to get the number of elements in <a href="#">HydroInterpKeys</a> .

```
47     {
48     GENERATOR\_EFFICIENCY\_INTERP\_KEY,
49     TURBINE\_EFFICIENCY\_INTERP\_KEY,
50     FLOW\_TO\_POWER\_INTERP\_KEY,
51     N\_HYDRO\_INTERP\_KEYS
52 };
```

#### 5.8.2.2 HydroTurbineType

```
enum HydroTurbineType
```

An enumeration of the types of hydroelectric turbine supported by PGMcpp.

##### Enumerator

<a href="#">HYDRO_TURBINE_PELTON</a>	A Pelton turbine (impluse)
<a href="#">HYDRO_TURBINE_FRANCIS</a>	A Francis turbine (reaction)
<a href="#">HYDRO_TURBINE_KAPLAN</a>	A Kaplan turbine (reaction)
<a href="#">N_HYDRO_TURBINES</a>	A simple hack to get the number of elements in <a href="#">HydroTurbineType</a> .

```

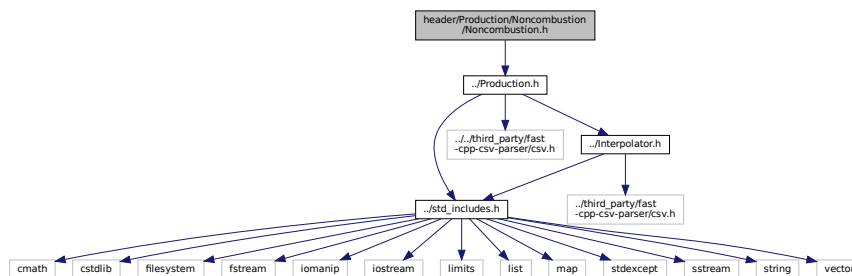
33     {
34     HYDRO_TURBINE_PELTON,
35     HYDRO_TURBINE_FRANCIS,
36     HYDRO_TURBINE_KAPLAN,
37     N_HYDRO_TURBINES
38 };

```

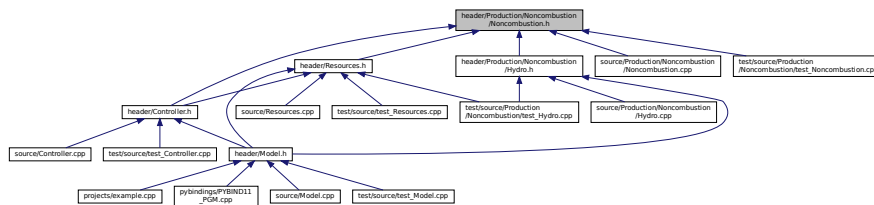
## 5.9 header/Production/Noncombustion/Noncombustion.h File Reference

```
#include "../Production.h"
```

Include dependency graph for Noncombustion.h:



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



## Classes

- struct [NoncombustionInputs](#)

A structure which bundles the necessary inputs for the [Noncombustion](#) constructor. Provides default values for every necessary input. Note that this structure encapsulates [ProductionInputs](#).

- class [Noncombustion](#)

The root of the [Noncombustion](#) branch of the [Production](#) hierarchy. This branch contains derived classes which model controllable production which is not based on combustion.

## Enumerations

- enum [NoncombustionType](#) { [HYDRO](#) , [N\\_NONCOMBUSTION\\_TYPES](#) }

An enumeration of the types of [Noncombustion](#) asset supported by PGMcpp.

## 5.9.1 Enumeration Type Documentation

### 5.9.1.1 NoncombustionType

enum `NoncombustionType`

An enumeration of the types of `Noncombustion` asset supported by PGMcpp.

#### Enumerator

HYDRO	A hydroelectric generator (either with reservoir or not)
N_NONCOMBUSTION_TYPES	A simple hack to get the number of elements in <code>NoncombustionType</code> .

```

33         {
34     HYDRO,
35     N_NONCOMBUSTION_TYPES
36 };

```

## 5.10 header/Production/Production.h File Reference

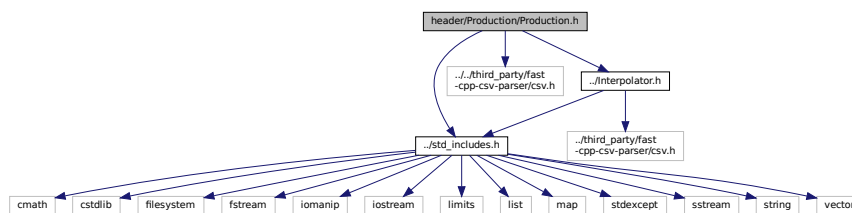
Header file for the `Production` class.

```

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

```

Include dependency graph for `Production.h`:



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





## Classes

- struct [ProductionInputs](#)

A structure which bundles the necessary inputs for the [Production](#) constructor. Provides default values for every necessary input.

- class [Production](#)

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

### 5.10.1 Detailed Description

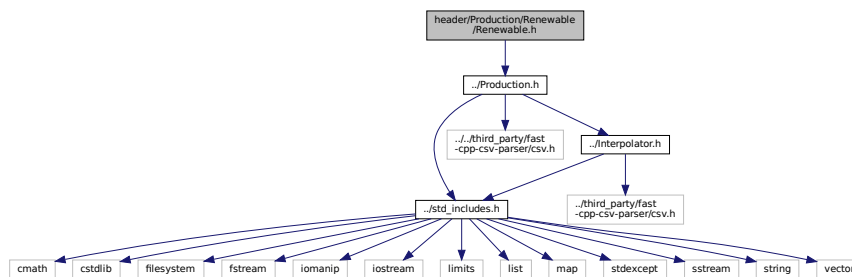
Header file for the [Production](#) class.

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

Header file for the [Renewable](#) class.

```
#include "../Production.h"
```

Include dependency graph for Renewable.h:



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



## Classes

- struct [RenewableInputs](#)

A structure which bundles the necessary inputs for the [Renewable](#) constructor. Provides default values for every necessary input. Note that this structure encapsulates [ProductionInputs](#).

- class [Renewable](#)

The root of the [Renewable](#) branch of the [Production](#) hierarchy. This branch contains derived classes which model the renewable production of energy.

## Enumerations

- enum `RenewableType` {  
`SOLAR` , `TIDAL` , `WAVE` , `WIND` ,  
`N_RENEWABLE_TYPES` }

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

### 5.11.1 Detailed Description

Header file for the `Renewable` class.

### 5.11.2 Enumeration Type Documentation

#### 5.11.2.1 RenewableType

enum `RenewableType`

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

##### Enumerator

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

```

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

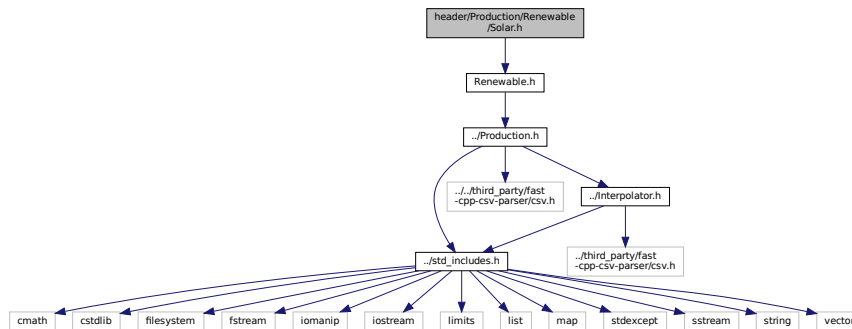
```

## 5.12 header/Production/Renewable/Solar.h File Reference

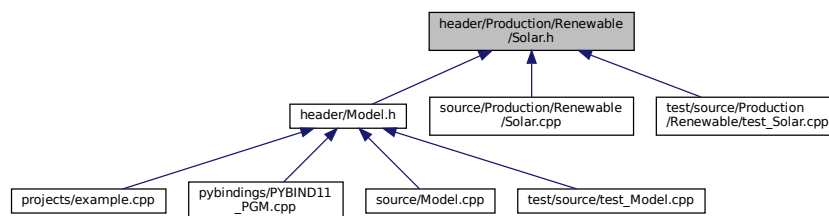
Header file for the `Solar` class.

```
#include "Renewable.h"
```

Include dependency graph for Solar.h:



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



## Classes

- struct [SolarInputs](#)  
A structure which bundles the necessary inputs for the [Solar](#) constructor. Provides default values for every necessary input. Note that this structure encapsulates [RenewableInputs](#).
- class [Solar](#)  
A derived class of the [Renewable](#) branch of [Production](#) which models solar production.

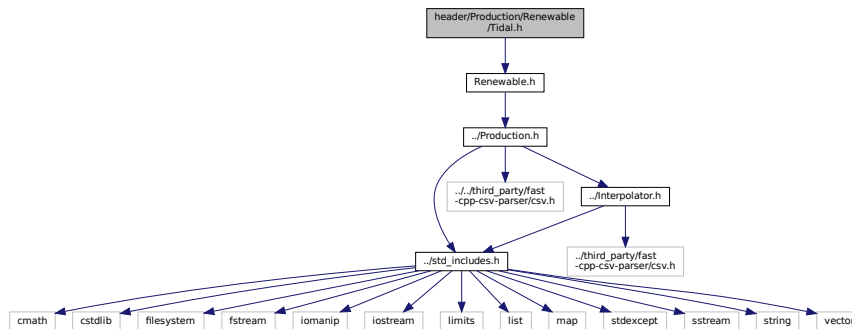
### 5.12.1 Detailed Description

Header file for the [Solar](#) class.

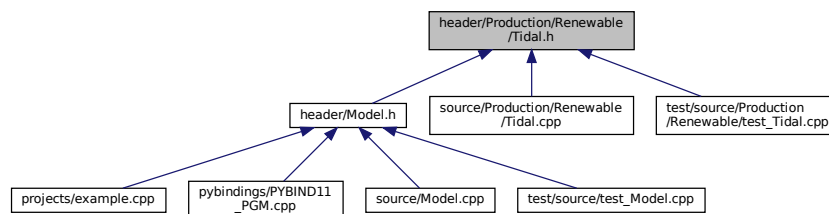
## 5.13 header/Production/Renewable/Tidal.h File Reference

Header file for the [Tidal](#) class.

```
#include "Renewable.h"
Include dependency graph for Tidal.h:
```



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



## Classes

- struct [TidalInputs](#)  
A structure which bundles the necessary inputs for the [Tidal](#) constructor. Provides default values for every necessary input. Note that this structure encapsulates [RenewableInputs](#).
- class [Tidal](#)  
A derived class of the [Renewable](#) branch of [Production](#) which models tidal production.

## Enumerations

- enum [TidalPowerProductionModel](#) { [TIDAL\\_POWER\\_CUBIC](#) , [TIDAL\\_POWER\\_EXPONENTIAL](#) , [TIDAL\\_POWER\\_LOOKUP](#) , [N\\_TIDAL\\_POWER\\_PRODUCTION\\_MODELS](#) }

### 5.13.1 Detailed Description

Header file for the [Tidal](#) class.

### 5.13.2 Enumeration Type Documentation

#### 5.13.2.1 TidalPowerProductionModel

```
enum TidalPowerProductionModel
```

## Enumerator

TIDAL_POWER_CUBIC	A cubic power production model.
TIDAL_POWER_EXPONENTIAL	An exponential power production model.
TIDAL_POWER_LOOKUP	Lookup from a given set of power curve data.
N_TIDAL_POWER_PRODUCTION_MODELS	A simple hack to get the number of elements in TidalPowerProductionModel.

```

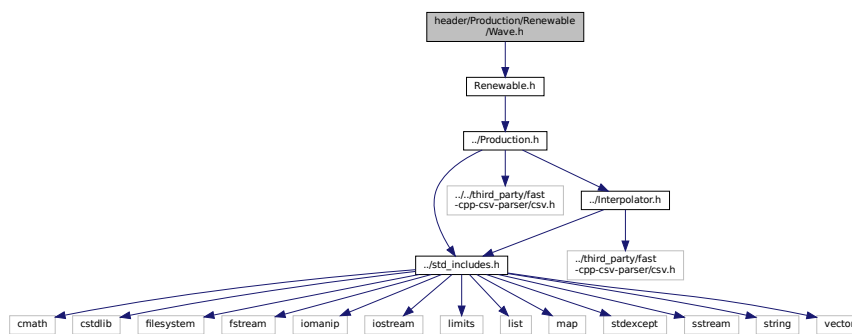
34
35     TIDAL_POWER_CUBIC,
36     TIDAL_POWER_EXPONENTIAL,
37     TIDAL_POWER_LOOKUP,
38     N_TIDAL_POWER_PRODUCTION_MODELS
39 };

```

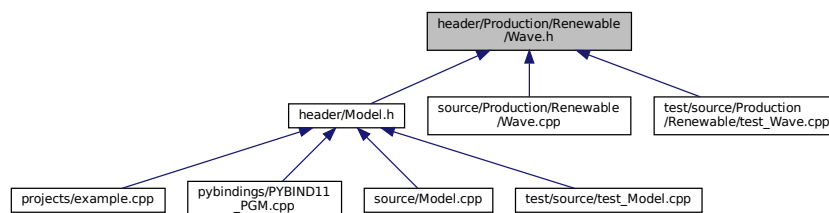
## 5.14 header/Production/Renewable/Wave.h File Reference

Header file for the [Wave](#) class.

```
#include "Renewable.h"
Include dependency graph for Wave.h:
```



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



## Classes

- struct [WaveInputs](#)

A structure which bundles the necessary inputs for the [Wave](#) constructor. Provides default values for every necessary input. Note that this structure encapsulates [RenewableInputs](#).

- class [Wave](#)

A derived class of the [Renewable](#) branch of [Production](#) which models wave production.

## Enumerations

- enum [WavePowerProductionModel](#) { [WAVE\\_POWER\\_GAUSSIAN](#) , [WAVE\\_POWER\\_PARABOLOID](#) , [WAVE\\_POWER\\_LOOKUP](#) , [N\\_WAVE\\_POWER\\_PRODUCTION\\_MODELS](#) }

### 5.14.1 Detailed Description

Header file for the [Wave](#) class.

### 5.14.2 Enumeration Type Documentation

#### 5.14.2.1 WavePowerProductionModel

```
enum WavePowerProductionModel
```

##### Enumerator

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

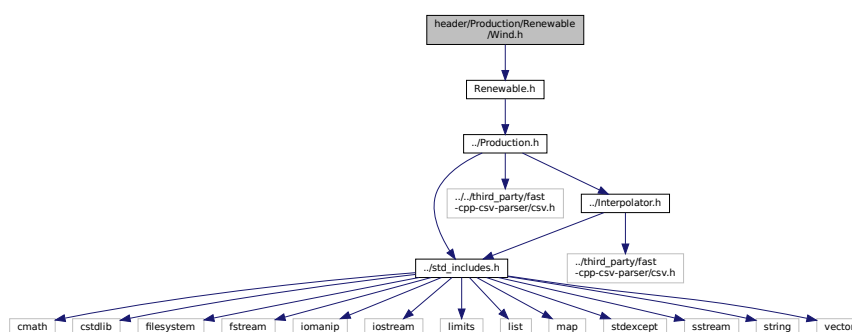
```
34
35     WAVE_POWER_GAUSSIAN,
36     WAVE_POWER_PARABOLOID,
37     WAVE_POWER_LOOKUP,
38     N_WAVE_POWER_PRODUCTION_MODELS
39 };
```

## 5.15 header/Production/Renewable/Wind.h File Reference

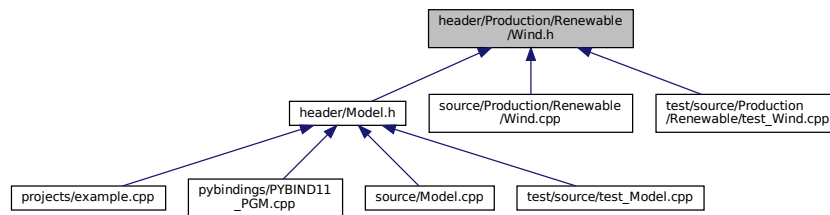
Header file for the [Wind](#) class.

```
#include "Renewable.h"
```

Include dependency graph for Wind.h:



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



## Classes

- struct [WindInputs](#)

A structure which bundles the necessary inputs for the [Wind](#) constructor. Provides default values for every necessary input. Note that this structure encapsulates [RenewableInputs](#).

- class [Wind](#)

A derived class of the [Renewable](#) branch of [Production](#) which models wind production.

## Enumerations

- enum [WindPowerProductionModel](#) { [WIND\\_POWER\\_EXPONENTIAL](#) , [WIND\\_POWER\\_LOOKUP](#) , [N\\_WIND\\_POWER\\_PRODUCTION\\_MODELS](#) }

### 5.15.1 Detailed Description

Header file for the [Wind](#) class.

### 5.15.2 Enumeration Type Documentation

#### 5.15.2.1 WindPowerProductionModel

```
enum WindPowerProductionModel
```

##### Enumerator

<a href="#">WIND_POWER_EXPONENTIAL</a>	An exponential power production model.
<a href="#">WIND_POWER_LOOKUP</a>	Lookup from a given set of power curve data.
<a href="#">N_WIND_POWER_PRODUCTION_MODELS</a>	A simple hack to get the number of elements in <a href="#">WindPowerProductionModel</a> .

```

34
35     WIND\_POWER\_EXPONENTIAL,
36     WIND\_POWER\_LOOKUP,
37     N\_WIND\_POWER\_PRODUCTION\_MODELS

```

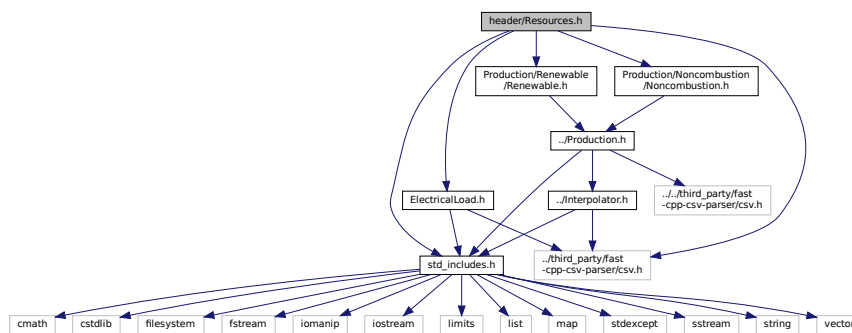
```
38 };
```

## 5.16 header/Resources.h File Reference

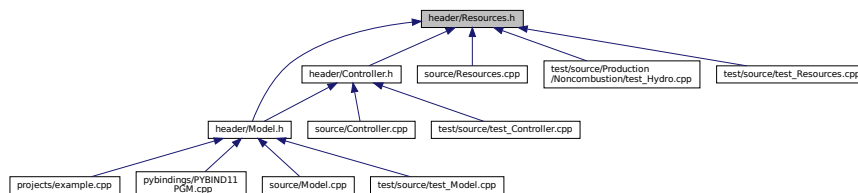
Header file for the [Resources](#) class.

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

Include dependency graph for Resources.h:



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



## Classes

- class [Resources](#)

*A class which contains renewable resource data. Intended to serve as a component class of [Model](#).*

### 5.16.1 Detailed Description

Header file for the [Resources](#) class.

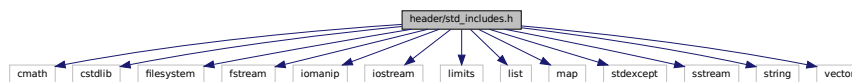


## 5.17 header/std\_includes.h File Reference

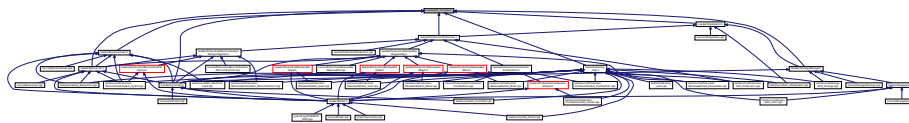
Header file which simply batches together some standard includes.

```
#include <cmath>
#include <cstdlib>
#include <filesystem>
#include <fstream>
#include <iomanip>
#include <iostream>
#include <limits>
#include <list>
#include <map>
#include <stdexcept>
#include <sstream>
#include <string>
#include <vector>
```

Include dependency graph for std\_includes.h:



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



### 5.17.1 Detailed Description

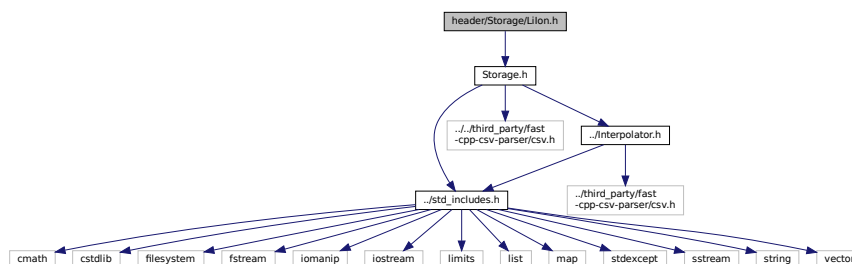
Header file which simply batches together some standard includes.

## 5.18 header/Storage/Lilon.h File Reference

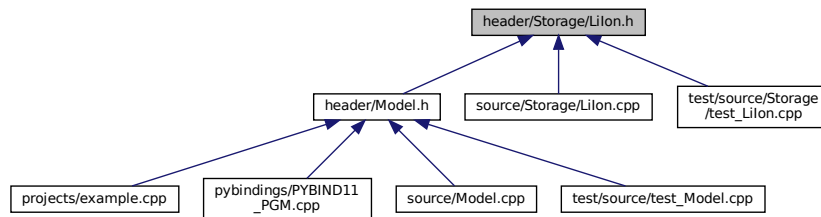
Header file for the [Lilon](#) class.

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

Include dependency graph for Lilon.h:



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



## Classes

- struct [LilonInputs](#)

A structure which bundles the necessary inputs for the [Lilon](#) constructor. Provides default values for every necessary input. Note that this structure encapsulates [StorageInputs](#).

- class [Lilon](#)

A derived class of [Storage](#) which models energy storage by way of lithium-ion batteries.

### 5.18.1 Detailed Description

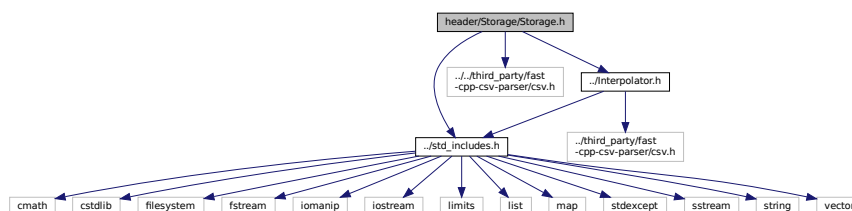
Header file for the [Lilon](#) class.

## 5.19 header/Storage/Storage.h File Reference

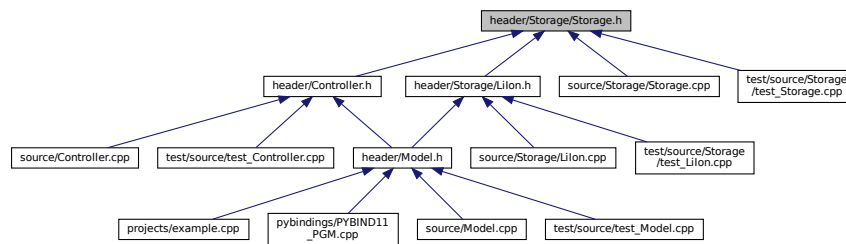
Header file for the [Storage](#) class.

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

Include dependency graph for Storage.h:



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



## Classes

- struct [StorageInputs](#)  
A structure which bundles the necessary inputs for the [Storage](#) constructor. Provides default values for every necessary input.
- class [Storage](#)  
The base class of the [Storage](#) hierarchy. This hierarchy contains derived classes which model the storage of energy.

## Enumerations

- enum [StorageType](#) { [LIION](#) , [N\\_STORAGE\\_TYPES](#) }  
An enumeration of the types of [Storage](#) asset supported by PGMcpp.

### 5.19.1 Detailed Description

Header file for the [Storage](#) class.

### 5.19.2 Enumeration Type Documentation

#### 5.19.2.1 StorageType

```
enum StorageType
```

An enumeration of the types of [Storage](#) asset supported by PGMcpp.

Enumerator

<a href="#">LIION</a>	A system of lithium ion batteries.
<a href="#">N_STORAGE_TYPES</a>	A simple hack to get the number of elements in <a href="#">StorageType</a> .

```
36     {
37         LIION,
```



```

49      * If nothing is given here, then the model will default to simple load following
50      * control. However, one can stipulate which control mode to use by altering the
51      * control_mode attribute of the ModelInputs structure. In this case, the
52      * cycle charging control mode is being set.
53      */
54
55      std::string path_2_electrical_load_time_series =
56          "data/test/electrical_load/electrical_load_generic_peak-500kW_1yr_dt-1hr.csv";
57
58      ModelInputs model_inputs;
59
60      model_inputs.path_2_electrical_load_time_series =
61          path_2_electrical_load_time_series;
62
63      model_inputs.control_mode = ControlMode :: CYCLE_CHARGING;
64
65      Model model(model_inputs);
66
67
68      /*
69      * 2. add Diesel objects to Model
70      *
71      * This block defines and adds a set of diesel generators to the Model object.
72      *
73      * In this example, a single DieselInputs structure is used to define and add
74      * three diesel generators to the model.
75      *
76      * The first diesel generator is defined as a 300 kW generator (which shows an
77      * example of how to access and alter an encapsulated attribute of DieselInputs).
78      * In addition, the diesel generator is taken to be a sunk cost (and so no capital
79      * cost is incurred in the first time step; the opposite is true for non-sunk
80      * assets).
81      *
82      * The last two diesel generators are defined as 150 kW each. Likewise, they are
83      * also sunk assets (since the same DieselInputs structure is being re-used without
84      * overwriting the is_sunk attribute).
85      *
86      * For more details on the various attributes of DieselInputs, refer to the
87      * PGMcpp manual. For instance, note that no economic inputs are given; in this
88      * example, the default values apply.
89      */
90
91      DieselInputs diesel_inputs;
92
93      // 2.1. add 1 x 300 kW diesel generator (since mean load is ~250 kW)
94      diesel_inputs.combustion_inputs.production_inputs.capacity_kW = 300;
95      diesel_inputs.combustion_inputs.production_inputs.is_sunk = true;
96
97      model.addDiesel(diesel_inputs);
98
99      // 2.2. add 2 x 150 kW diesel generators (since max load is 500 kW)
100     diesel_inputs.combustion_inputs.production_inputs.capacity_kW = 150;
101
102     model.addDiesel(diesel_inputs);
103     model.addDiesel(diesel_inputs);
104
105
106     /*
107     * 3. add renewable resources to Model
108     *
109     * This block adds a set of renewable resource time series to the Model object.
110     *
111     * The first resource added is a solar resource time series, which gives
112     * horizontal irradiance [kW/m2] at each point in time. Again, remember that all
113     * given time series must align with the electrical load time series (i.e., same
114     * length, same points). For an example of the expected format, see
115     *
116     * data/test/resources/solar_GHI_peak-1kWm2_1yr_dt-1hr.csv
117     *
118     * Finally, note the declaration of a solar resource key. This variable will be
119     * re-used later to associate a solar PV array object with this particular solar
120     * resource. This method of key association between resource and asset allows for
121     * greater flexibility in modelling production assets that are exposed to different
122     * renewable resources (due to being geographically separated, etc.).
123     *
124     * The second resource added is a tidal resource time series, which gives tidal
125     * stream speed [m/s] at each point in time. For an example of the expected format,
126     * see
127     *
128     * data/test/resources/tidal_speed_peak-3ms_1yr_dt-1hr.csv
129     *
130     * Again, note the tidal resource key.
131     *
132     * The third resource added is a wave resource time series, which gives significant
133     * wave height [m] and energy period [s] at each point in time. For an example of

```

```

136     * the expected format, see
137     *
138     * data/test/resources/waves_H_s_peak-8m_T_e_peak-15s_1yr_dt-1hr.csv
139     *
140     * Again, note the wave resource key.
141     *
142     * The fourth resource added is a wind resource time series, which gives wind speed
143     * [m/s] at each point in time. For an example of the expected format, see
144     *
145     * data/test/resources/wind_speed_peak-25ms_1yr_dt-1hr.csv
146     *
147     * Again, note the wind resource key.
148     *
149     * The fifth resource added is a hydro resource time series, which gives inflow
150     * rate [m3/hr] at each point in time. For an example of the expected format, see
151     *
152     * data/test/resources/hydro_inflow_peak-20000m3hr_1yr_dt-1hr.csv
153     *
154     * Again, note the hydro resource key.
155     */
156
157 // 3.1. add solar resource time series
158 int solar_resource_key = 0;
159 std::string path_2_solar_resource_data =
160     "data/test/resources/solar_GHI_peak-1kWm2_1yr_dt-1hr.csv";
161
162 model.addResource(
163     RenewableType :: SOLAR,
164     path_2_solar_resource_data,
165     solar_resource_key
166 );
167
168 // 3.2. add tidal resource time series
169 int tidal_resource_key = 1;
170 std::string path_2_tidal_resource_data =
171     "data/test/resources/tidal_speed_peak-3ms_1yr_dt-1hr.csv";
172
173 model.addResource(
174     RenewableType :: TIDAL,
175     path_2_tidal_resource_data,
176     tidal_resource_key
177 );
178
179 // 3.3. add wave resource time series
180 int wave_resource_key = 2;
181 std::string path_2_wave_resource_data =
182     "data/test/resources/waves_H_s_peak-8m_T_e_peak-15s_1yr_dt-1hr.csv";
183
184 model.addResource(
185     RenewableType :: WAVE,
186     path_2_wave_resource_data,
187     wave_resource_key
188 );
189
190 // 3.4. add wind resource time series
191 int wind_resource_key = 3;
192 std::string path_2_wind_resource_data =
193     "data/test/resources/wind_speed_peak-25ms_1yr_dt-1hr.csv";
194
195 model.addResource(
196     RenewableType :: WIND,
197     path_2_wind_resource_data,
198     wind_resource_key
199 );
200
201 // 3.5. add hydro resource time series
202 int hydro_resource_key = 4;
203 std::string path_2_hydro_resource_data =
204     "data/test/resources/hydro_inflow_peak-20000m3hr_1yr_dt-1hr.csv";
205
206 model.addResource(
207     NoncombustionType :: HYDRO,
208     path_2_hydro_resource_data,
209     hydro_resource_key
210 );
211
212 /*
213  * 4. add Hydro object to Model
214  *
215  * This block defines and adds a hydroelectric asset to the Model object.
216  *
217  * In this example, a 300 kW hydroelectric station with a 10,000 m3 reservoir
218  * is defined. The initial reservoir state is set to 50% (so half full), and the
219  * hydroelectric asset is taken to be a sunk asset (so no capital cost incurred
220  * in the first time step). Note the association with the previously given hydro

```

```

223     * resource series by way of the hydro resource key.
224     *
225     * For more details on the various attributes of HydroInputs, refer to the
226     * PGMcpp manual. For instance, note that no economic inputs are given; in this
227     * example, the default values apply.
228     */
229
230     HydroInputs hydro_inputs;
231     hydro_inputs.noncombustion_inputs.production_inputs.capacity_kW = 300;
232     hydro_inputs.reservoir_capacity_m3 = 10000;
233     hydro_inputs.init_reservoir_state = 0.5;
234     hydro_inputs.noncombustion_inputs.production_inputs.is_sunk = true;
235     hydro_inputs.resource_key = hydro_resource_key;
236
237     model.addHydro(hydro_inputs);
238
239
240
241     /*
242     * 5. add Renewable objects to Model
243     *
244     * This block defines and adds a set of renewable production assets to the Model
245     * object.
246     *
247     * The first block defines and adds a solar PV array to the Model object. In this
248     * example, the installed solar capacity is set to 250 kW. Note the association
249     * with the previously given solar resource series by way of the solar resource
250     * key. Also, note that this asset is not taken as sunk (as the is_sunk attribute
251     * of the SolarInputs structure is unchanged and thus defaults to true). As such,
252     * this asset will incur a capital cost in the first time step.
253     *
254     * For more details on the various attributes of SolarInputs, refer to the PGMcpp
255     * manual. For instance, note that no economic inputs are given; in this
256     * example, the default values apply.
257     *
258     * The second block defines and adds a tidal turbine to the Model object. In this
259     * example, the installed tidal capacity is set to 120 kW. In addition, the design
260     * speed of the asset (i.e., the speed at which the rated capacity is achieved) is
261     * set to 2.5 m/s. Note the association with the previously given tidal resource
262     * series by way of the tidal resource key.
263     *
264     * For more details on the various attributes of TidalInputs, refer to the PGMcpp
265     * manual. For instance, note that no economic inputs are given; in this
266     * example, the default values apply.
267     *
268     * The third block defines and adds a wind turbine to the Model object. In this
269     * example, the installed wind capacity is set to 150 kW. In addition, the design
270     * speed of the asset is not given, and so will default to 8 m/s. Note the
271     * association with the previously given tidal resource series by way of the wind
272     * resource key.
273     *
274     * For more details on the various attributes of WindInputs, refer to the PGMcpp
275     * manual. For instance, note that no economic inputs are given; in this
276     * example, the default values apply.
277     *
278     * The fourth block defines and adds a wave energy converter to the Model object.
279     * In this example, the installed wave capacity is set to 100 kW. Note the
280     * association with the previously given wave resource series by way of the wave
281     * resource key.
282     *
283     * For more details on the various attributes of WaveInputs, refer to the PGMcpp
284     * manual. For instance, note that no economic inputs are given; in this
285     * example, the default values apply.
286     */
287
288     // 5.1. add 1 x 250 kW solar PV array
289     SolarInputs solar_inputs;
290
291     solar_inputs.renewable_inputs.production_inputs.capacity_kW = 250;
292     solar_inputs.resource_key = solar_resource_key;
293
294     model.addSolar(solar_inputs);
295
296     // 5.2. add 1 x 120 kW tidal turbine
297     TidalInputs tidal_inputs;
298
299     tidal_inputs.renewable_inputs.production_inputs.capacity_kW = 120;
300     tidal_inputs.design_speed_ms = 2.5;
301     tidal_inputs.resource_key = tidal_resource_key;
302
303     model.addTidal(tidal_inputs);
304
305     // 5.3. add 1 x 150 kW wind turbine
306     WindInputs wind_inputs;
307
308     wind_inputs.renewable_inputs.production_inputs.capacity_kW = 150;
309     wind_inputs.resource_key = wind_resource_key;

```

```

310
311     model.addWind(wind_inputs);
312
313     // 5.4. add 1 x 100 kW wave energy converter
314     WaveInputs wave_inputs;
315
316     wave_inputs.renewable_inputs.production_inputs.capacity_kW = 100;
317     wave_inputs.resource_key = wave_resource_key;
318
319     model.addWave(wave_inputs);
320
321
322
323     /*
324     * 6. add LiIon object to Model
325     *
326     * This block defines and adds a lithium ion battery energy storage system to the
327     * Model object.
328     *
329     * In this example, a battery energy storage system with a 500 kW power capacity
330     * and a 1050 kWh energy capacity (which represents about four hours of mean load
331     * autonomy) is defined.
332     *
333     * For more details on the various attributes of LiIonInputs, refer to the PGMcpp
334     * manual. For instance, note that no economic inputs are given; in this
335     * example, the default values apply.
336     */
337
338     // 6.1. add 1 x (500 kW, ) lithium ion battery energy storage system
339     LiIonInputs liion_inputs;
340
341     liion_inputs.storage_inputs.power_capacity_kW = 500;
342     liion_inputs.storage_inputs.energy_capacity_kWh = 1050;
343
344     model.addLiIon(liion_inputs);
345
346
347
348     /*
349     * 7. run and write results
350     *
351     * This block runs the model and then writes results to the given output path
352     * (either relative or absolute). Note that the writeResults() will create the
353     * last directory on the given path, but not any in-between directories, so be
354     * sure those exist before calling out to this method.
355     */
356
357     model.run();
358
359     model.writeResults("projects/example_cpp");
360
361     return 0;
362 } /* main() */

```

## 5.21 pybindings/PYBIND11\_PGM.cpp File Reference

Bindings file for PGMcpp.

```

#include <pybind11/pybind11.h>
#include <pybind11/stl.h>
#include "../header/Model.h"
#include "snippets/PYBIND11_Controller.cpp"
#include "snippets/PYBIND11_ElectricalLoad.cpp"
#include "snippets/PYBIND11_Interpolator.cpp"
#include "snippets/PYBIND11_Model.cpp"
#include "snippets/PYBIND11_Resources.cpp"
#include "snippets/Production/PYBIND11_Production.cpp"
#include "snippets/Production/Noncombustion/PYBIND11_Noncombustion.cpp"
#include "snippets/Production/Noncombustion/PYBIND11_Hydro.cpp"
#include "snippets/Production/Combustion/PYBIND11_Combustion.cpp"
#include "snippets/Production/Combustion/PYBIND11_Diesel.cpp"
#include "snippets/Production/Renewable/PYBIND11_Renewable.cpp"
#include "snippets/Production/Renewable/PYBIND11_Solar.cpp"

```



```
#include "snippets/Production/Renewable/PYBIND11_Tidal.cpp"
#include "snippets/Production/Renewable/PYBIND11_Wave.cpp"
#include "snippets/Production/Renewable/PYBIND11_Wind.cpp"
#include "snippets/Storage/PYBIND11_Storage.cpp"
#include "snippets/Storage/PYBIND11_LiIon.cpp"
```

Include dependency graph for PYBIND11\_PGM.cpp:



## Functions

- [PYBIND11\\_MODULE](#) (PGMcpp, m)

### 5.21.1 Detailed Description

Bindings file for PGMcpp.

Ref: [Jakob \[2023\]](#)

A file which instructs pybind11 how to build Python bindings for PGMcpp. Only public attributes/methods are bound!

### 5.21.2 Function Documentation

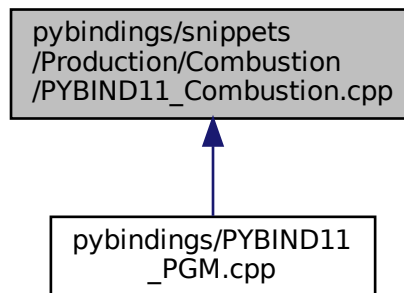
#### 5.21.2.1 PYBIND11\_MODULE()

```
PYBIND11_MODULE (
    PGMcpp ,
    m )
{
31
32
33     #include "snippets/PYBIND11_Controller.cpp"
34     #include "snippets/PYBIND11_ElectricalLoad.cpp"
35     #include "snippets/PYBIND11_Interpolator.cpp"
36     #include "snippets/PYBIND11_Model.cpp"
37     #include "snippets/PYBIND11_Resources.cpp"
38
39     #include "snippets/Production/PYBIND11_Production.cpp"
40
41     #include "snippets/Production/Noncombustion/PYBIND11_Noncombustion.cpp"
42     #include "snippets/Production/Noncombustion/PYBIND11_Hydro.cpp"
43
44     #include "snippets/Production/Combustion/PYBIND11_Combustion.cpp"
45     #include "snippets/Production/Combustion/PYBIND11_Diesel.cpp"
46
47     #include "snippets/Production/Renewable/PYBIND11_Renewable.cpp"
48     #include "snippets/Production/Renewable/PYBIND11_Solar.cpp"
49     #include "snippets/Production/Renewable/PYBIND11_Tidal.cpp"
50     #include "snippets/Production/Renewable/PYBIND11_Wave.cpp"
51     #include "snippets/Production/Renewable/PYBIND11_Wind.cpp"
52
53     #include "snippets/Storage/PYBIND11_Storage.cpp"
54     #include "snippets/Storage/PYBIND11_LiIon.cpp"
55
56 } /* PYBIND11_MODULE() */
```

## 5.22 pybindings/snippets/Production/Combustion/PYBIND11\_↔ Combustion.cpp File Reference

Bindings file for the [Combustion](#) class. Intended to be #include'd in [PYBIND11\\_PGM.cpp](#).

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



### Functions

- [CombustionType::DIESEL](#) [value](#) ("N\_COMBUSTION\_TYPES", [CombustionType::N\\_COMBUSTION\\_↔](#)  
TYPES)
- [FuelMode::FUEL\\_MODE\\_LINEAR](#) [value](#) ("FUEL\_MODE\_LOOKUP", [FuelMode::FUEL\\_MODE\\_LOOKUP](#))  
.value("N\_FUEL\_MODES")
- [&CombustionInputs::production\\_inputs](#) [def\\_readwrite](#) ("fuel\_mode", [&CombustionInputs::fuel\\_mode](#)) [.def\\_↔](#)  
[readwrite](#)("nominal\_fuel\_escalation\_annual")

### Variables

- [&CombustionInputs::production\\_inputs](#) [&CombustionInputs::nominal\\_fuel\\_escalation\\_annual](#) [def\\_↔](#)  
[readwrite](#)("path\_2\_fuel\_interp\_data", [&CombustionInputs::path\\_2\\_fuel\\_interp\\_data](#)) [.def](#)(pybind11 [&Emissions::CO2\\_kg](#)  
[def\\_readwrite](#) ("CO\_kg", [&Emissions::CO\\_kg](#)) [.def\\_readwrite](#)("NOx\_kg")

#### 5.22.1 Detailed Description

Bindings file for the [Combustion](#) class. Intended to be #include'd in [PYBIND11\\_PGM.cpp](#).

Ref: [Jakob \[2023\]](#)

A file which instructs pybind11 how to build Python bindings for the [Combustion](#) class. Only public attributes/methods are bound!

#### 5.22.2 Function Documentation

### 5.22.2.1 def\_readwrite()

```
& CombustionInputs::production_inputs def_readwrite (
    "fuel_mode" ,
    &CombustionInputs::fuel_mode )
```

### 5.22.2.2 value() [1/2]

```
FuelMode::FUEL_MODE_LINEAR value (
    "FUEL_MODE_LOOKUP" ,
    FuelMode::FUEL_MODE_LOOKUP )
```

### 5.22.2.3 value() [2/2]

```
CombustionType::DIESEL value (
    "N_COMBUSTION_TYPES" ,
    CombustionType::N_COMBUSTION_TYPES )
```

## 5.22.3 Variable Documentation

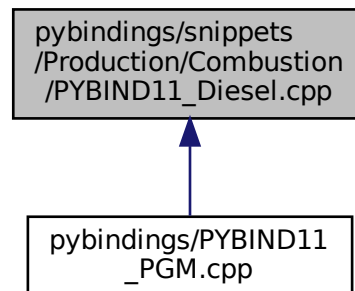
### 5.22.3.1 def\_readwrite

```
&StorageInputs::print_flag &StorageInputs::power_capacity_kW &StorageInputs::nominal_inflation_annual
def_readwrite (
    "CO_kg" ,
    &Emissions::CO_kg )
```

## 5.23 pybindings/snippets/Production/Combustion/PYBIND11\_Diesel.cpp File Reference

Bindings file for the [Diesel](#) class. Intended to be #include'd in [PYBIND11\\_PGM.cpp](#).

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



## Functions

- `&DiesellInputs::combustion_inputs def_readwrite ("replace_running_hrs", &DiesellInputs::replace_running_hrs) .def_readwrite("capital_cost"`
- `&DiesellInputs::combustion_inputs &DiesellInputs::capital_cost def_readwrite ("operation_maintenance_cost_kWh", &DiesellInputs::operation_maintenance_cost_kWh) .def_readwrite("fuel_cost_L"`
- `&DiesellInputs::combustion_inputs &DiesellInputs::capital_cost &DiesellInputs::fuel_cost_L def_readwrite ("minimum_load_ratio", &DiesellInputs::minimum_load_ratio) .def_readwrite("minimum_runtime_hrs"`
- `&DiesellInputs::combustion_inputs &DiesellInputs::capital_cost &DiesellInputs::fuel_cost_L &DiesellInputs::minimum_runtime_hrs def_readwrite ("linear_fuel_slope_LkWh", &DiesellInputs::linear_fuel_slope_LkWh) .def_readwrite("linear_fuel_intercept_LkWh"`
- `&DiesellInputs::combustion_inputs &DiesellInputs::capital_cost &DiesellInputs::fuel_cost_L &DiesellInputs::minimum_runtime_hrs &DiesellInputs::linear_fuel_intercept_LkWh def_readwrite ("CO2_emissions_intensity_kgL", &DiesellInputs::CO2_emissions_intensity_kgL) .def_readwrite("CO_emissions_intensity_kgL"`
- `&DiesellInputs::combustion_inputs &DiesellInputs::capital_cost &DiesellInputs::fuel_cost_L &DiesellInputs::minimum_runtime_hrs &DiesellInputs::linear_fuel_intercept_LkWh &DiesellInputs::CO_emissions_intensity_kgL def_readwrite ("NOx_emissions_intensity_kgL", &DiesellInputs::NOx_emissions_intensity_kgL) .def_readwrite("SOx_emissions_intensity_kgL"`
- `&DiesellInputs::combustion_inputs &DiesellInputs::capital_cost &DiesellInputs::fuel_cost_L &DiesellInputs::minimum_runtime_hrs &DiesellInputs::linear_fuel_intercept_LkWh &DiesellInputs::CO_emissions_intensity_kgL &DiesellInputs::SOx_emissions_intensity_kgL def_readwrite ("CH4_emissions_intensity_kgL", &DiesellInputs::CH4_emissions_intensity_kgL) .def_readwrite("PM_emissions_intensity_kgL"`
- `&DiesellInputs::combustion_inputs &DiesellInputs::capital_cost &DiesellInputs::fuel_cost_L &DiesellInputs::minimum_runtime_hrs &DiesellInputs::linear_fuel_intercept_LkWh &DiesellInputs::CO_emissions_intensity_kgL &DiesellInputs::SOx_emissions_intensity_kgL &DiesellInputs::PM_emissions_intensity_kgL def (pybind11::init())`
- `&Diesel::minimum_load_ratio def_readwrite ("minimum_runtime_hrs", &Diesel::minimum_runtime_hrs) .def_readwrite("time_since_last_start_hrs"`

### 5.23.1 Detailed Description

Bindings file for the [Diesel](#) class. Intended to be #include'd in `PYBIND11_PGM.cpp`.

Ref: [Jakob \[2023\]](#)

A file which instructs pybind11 how to build Python bindings for the [Diesel](#) class. Only public attributes/methods are bound!

## 5.23.2 Function Documentation

### 5.23.2.1 def()

```
&InterpolatorStruct2D::n_rows &InterpolatorStruct2D::x_vec &InterpolatorStruct2D::max_x &InterpolatorStruct2D::
&InterpolatorStruct2D::z_matrix def (
    pybind11::init() )
```

### 5.23.2.2 def\_readwrite() [1/8]

```
& DieselInputs::combustion_inputs & DieselInputs::capital_cost & DieselInputs::fuel_cost_L &
DieselInputs::minimum_runtime_hrs & DieselInputs::linear_fuel_intercept_LkWh & DieselInputs::CO_emissions_inte
& DieselInputs::SOx_emissions_intensity_kgL def_readwrite (
    "CH4_emissions_intensity_kgL" ,
    &DieselInputs::CH4_emissions_intensity_kgL )
```

### 5.23.2.3 def\_readwrite() [2/8]

```
& DieselInputs::combustion_inputs & DieselInputs::capital_cost & DieselInputs::fuel_cost_L &
DieselInputs::minimum_runtime_hrs & DieselInputs::linear_fuel_intercept_LkWh def_readwrite (
    "CO2_emissions_intensity_kgL" ,
    &DieselInputs::CO2_emissions_intensity_kgL )
```

### 5.23.2.4 def\_readwrite() [3/8]

```
& DieselInputs::combustion_inputs & DieselInputs::capital_cost & DieselInputs::fuel_cost_L &
DieselInputs::minimum_runtime_hrs def_readwrite (
    "linear_fuel_slope_LkWh" ,
    &DieselInputs::linear_fuel_slope_LkWh )
```

### 5.23.2.5 def\_readwrite() [4/8]

```
& DieselInputs::combustion_inputs & DieselInputs::capital_cost & DieselInputs::fuel_cost_L
def_readwrite (
    "minimum_load_ratio" ,
    &DieselInputs::minimum_load_ratio )
```

### 5.23.2.6 def\_readwrite() [5/8]

```
& Diesel::minimum_load_ratio def_readwrite (
    "minimum_runtime_hrs" ,
    &Diesel::minimum_runtime_hrs )
```

### 5.23.2.7 def\_readwrite() [6/8]

```
& DieselInputs::combustion_inputs & DieselInputs::capital_cost & DieselInputs::fuel_cost_L &
DieselInputs::minimum_runtime_hrs & DieselInputs::linear_fuel_intercept_LkWh & DieselInputs::CO_emissions_inte
def_readwrite (
    "NOx_emissions_intensity_kgL" ,
    &DieselInputs::NOx_emissions_intensity_kgL )
```

### 5.23.2.8 def\_readwrite() [7/8]

```
& DieselInputs::combustion_inputs & DieselInputs::capital_cost def_readwrite (
    "operation_maintenance_cost_kWh" ,
    &DieselInputs::operation_maintenance_cost_kWh )
```

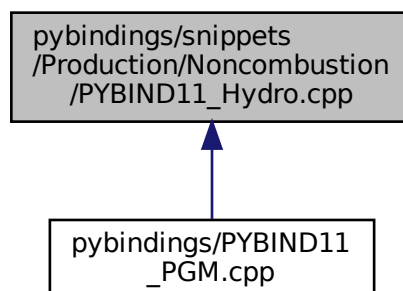
### 5.23.2.9 def\_readwrite() [8/8]

```
& DieselInputs::combustion_inputs def_readwrite (
    "replace_running_hrs" ,
    &DieselInputs::replace_running_hrs )
```

## 5.24 pybindings/snippets/Production/Noncombustion/PYBIND11\_↔ Hydro.cpp File Reference

Bindings file for the [Hydro](#) class. Intended to be #include'd in [PYBIND11\\_PGM.cpp](#).

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



## Functions

- `HydroTurbineType::HYDRO_TURBINE_PELTON` `value` ("HYDRO\_TURBINE\_FRANCIS", `HydroTurbineType::HYDRO_TURBINE_FRANCIS`) `.value`("HYDRO\_TURBINE\_KAPLAN"
- `HydroTurbineType::HYDRO_TURBINE_PELTON` `HydroTurbineType::HYDRO_TURBINE_KAPLAN` `value` ("N\_HYDRO\_TURBINES", `HydroTurbineType::N_HYDRO_TURBINES`)
- `&HydroInputs::noncombustion_inputs` `def_readwrite` ("resource\_key", `&HydroInputs::resource_key`) `.def_readwrite`("capital\_cost"
- `&HydroInputs::noncombustion_inputs` `&HydroInputs::capital_cost` `def_readwrite` ("operation\_maintenance\_cost\_kWh", `&HydroInputs::operation_maintenance_cost_kWh`) `.def_readwrite`("fluid\_density\_kgm3"
- `&HydroInputs::noncombustion_inputs` `&HydroInputs::capital_cost` `&HydroInputs::fluid_density_kgm3` `def_readwrite` ("net\_head\_m", `&HydroInputs::net_head_m`) `.def_readwrite`("reservoir\_capacity\_m3"
- `&HydroInputs::noncombustion_inputs` `&HydroInputs::capital_cost` `&HydroInputs::fluid_density_kgm3` `&HydroInputs::reservoir_capacity_m3` `def_readwrite` ("init\_reservoir\_state", `&HydroInputs::init_reservoir_state`) `.def_readwrite`("turbine\_type"
- `&HydroInputs::noncombustion_inputs` `&HydroInputs::capital_cost` `&HydroInputs::fluid_density_kgm3` `&HydroInputs::reservoir_capacity_m3` `&HydroInputs::turbine_type` `def` (`pybind11::init()`)
- `&Hydro::turbine_type` `def_readwrite` ("fluid\_density\_kgm3", `&Hydro::fluid_density_kgm3`) `.def_readwrite`("net\_head\_m"
- `&Hydro::turbine_type` `&Hydro::net_head_m` `def_readwrite` ("reservoir\_capacity\_m3", `&Hydro::reservoir_capacity_m3`) `.def_readwrite`("init\_reservoir\_state"
- `&Hydro::turbine_type` `&Hydro::net_head_m` `&Hydro::init_reservoir_state` `def_readwrite` ("stored\_volume\_m3", `&Hydro::stored_volume_m3`) `.def_readwrite`("minimum\_power\_kW"
- `&Hydro::turbine_type` `&Hydro::net_head_m` `&Hydro::init_reservoir_state` `&Hydro::minimum_power_kW` `def_readwrite` ("minimum\_flow\_m3hr", `&Hydro::minimum_flow_m3hr`) `.def_readwrite`("maximum\_flow\_m3hr"
- `&Hydro::turbine_type` `&Hydro::net_head_m` `&Hydro::init_reservoir_state` `&Hydro::minimum_power_kW` `&Hydro::maximum_flow_m3hr` `def_readwrite` ("turbine\_flow\_vec\_m3hr", `&Hydro::turbine_flow_vec_m3hr`) `.def_readwrite`("spill\_rate\_vec\_m3hr"

### 5.24.1 Detailed Description

Bindings file for the `Hydro` class. Intended to be #include'd in `PYBIND11_PGM.cpp`.

Ref: [Jakob \[2023\]](#)

A file which instructs `pybind11` how to build Python bindings for the `Hydro` class. Only public attributes/methods are bound!

### 5.24.2 Function Documentation

#### 5.24.2.1 `def()`

```
& HydroInputs::noncombustion_inputs & HydroInputs::capital_cost & HydroInputs::fluid_density_kgm3
& HydroInputs::reservoir_capacity_m3 & HydroInputs::turbine_type def (
    pybind11::init() )
```

#### 5.24.2.2 def\_readwrite() [1/9]

```
& Hydro::turbine_type def_readwrite (
    "fluid_density_kgm3" ,
    &Hydro::fluid_density_kgm3 )
```

#### 5.24.2.3 def\_readwrite() [2/9]

```
& HydroInputs::noncombustion_inputs & HydroInputs::capital_cost & HydroInputs::fluid_density_kgm3
& HydroInputs::reservoir_capacity_m3 def_readwrite (
    "init_reservoir_state" ,
    &HydroInputs::init_reservoir_state )
```

#### 5.24.2.4 def\_readwrite() [3/9]

```
& Hydro::turbine_type & Hydro::net_head_m & Hydro::init_reservoir_state & Hydro::minimum_power_kW
def_readwrite (
    "minimum_flow_m3hr" ,
    &Hydro::minimum_flow_m3hr )
```

#### 5.24.2.5 def\_readwrite() [4/9]

```
& HydroInputs::noncombustion_inputs & HydroInputs::capital_cost & HydroInputs::fluid_density_kgm3
def_readwrite (
    "net_head_m" ,
    &HydroInputs::net_head_m )
```

#### 5.24.2.6 def\_readwrite() [5/9]

```
& HydroInputs::noncombustion_inputs & HydroInputs::capital_cost def_readwrite (
    "operation_maintenance_cost_kWh" ,
    &HydroInputs::operation_maintenance_cost_kWh )
```

#### 5.24.2.7 def\_readwrite() [6/9]

```
& Hydro::turbine_type & Hydro::net_head_m def_readwrite (
    "reservoir_capacity_m3" ,
    &Hydro::reservoir_capacity_m3 )
```



#### 5.24.2.8 def\_readwrite() [7/9]

```
& HydroInputs::noncombustion_inputs def_readwrite (
    "resource_key" ,
    &HydroInputs::resource_key )
```

#### 5.24.2.9 def\_readwrite() [8/9]

```
& Hydro::turbine_type & Hydro::net_head_m & Hydro::init_reservoir_state def_readwrite (
    "stored_volume_m3" ,
    &Hydro::stored_volume_m3 )
```

#### 5.24.2.10 def\_readwrite() [9/9]

```
& Hydro::turbine_type & Hydro::net_head_m & Hydro::init_reservoir_state & Hydro::minimum_power_kW
& Hydro::maximum_flow_m3hr def_readwrite (
    "turbine_flow_vec_m3hr" ,
    &Hydro::turbine_flow_vec_m3hr )
```

#### 5.24.2.11 value() [1/2]

```
HydroTurbineType::HYDRO_TURBINE_PELTON value (
    "HYDRO_TURBINE_FRANCIS" ,
    HydroTurbineType::HYDRO_TURBINE_FRANCIS )
```

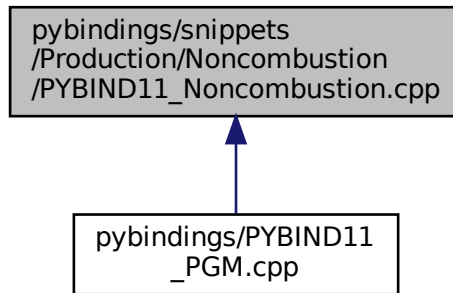
#### 5.24.2.12 value() [2/2]

```
HydroTurbineType::HYDRO_TURBINE_PELTON HydroTurbineType::HYDRO_TURBINE_KAPLAN value (
    "N_HYDRO_TURBINES" ,
    HydroTurbineType::N_HYDRO_TURBINES )
```

## 5.25 pybindings/snippets/Production/Noncombustion/PYBIND11\_↔ Noncombustion.cpp File Reference

Bindings file for the [Noncombustion](#) class. Intended to be #include'd in [PYBIND11\\_PGM.cpp](#).

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



### Functions

- [NoncombustionType::HYDRO](#) [value](#) ("N\_NONCOMBUSTION\_TYPES", [NoncombustionType::N\\_↔NONCOMBUSTION\\_TYPES](#))
- [&NoncombustionInputs::production\\_inputs](#) [def](#) (pybind11::init())

### 5.25.1 Detailed Description

Bindings file for the [Noncombustion](#) class. Intended to be #include'd in [PYBIND11\\_PGM.cpp](#).

Ref: [Jakob \[2023\]](#)

A file which instructs pybind11 how to build Python bindings for the [Noncombustion](#) class. Only public attributes/methods are bound!

### 5.25.2 Function Documentation

#### 5.25.2.1 def()

```
& NoncombustionInputs::production\_inputs def (
    pybind11::init() )
```

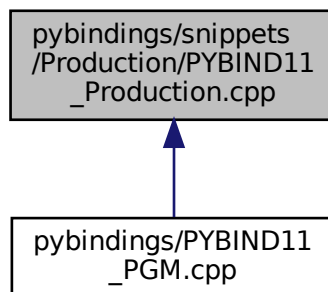
### 5.25.2.2 value()

```
NoncombustionType::HYDRO value (
    "N_NONCOMBUSTION_TYPES" ,
    NoncombustionType::N_NONCOMBUSTION_TYPES )
```

## 5.26 pybindings/snippets/Production/PYBIND11\_Production.cpp File Reference

Bindings file for the [Production](#) class. Intended to be #include'd in [PYBIND11\\_PGM.cpp](#).

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



### Functions

- [&ProductionInputs::print\\_flag](#) [def\\_readwrite](#) ("is\_sunk", &ProductionInputs::is\_sunk) .def\_readwrite("capacity\_kW↔\_kW"
- [&ProductionInputs::print\\_flag](#) [&ProductionInputs::capacity\\_kW](#) [def\\_readwrite](#) ("nominal\_inflation\_annual", &ProductionInputs::nominal\_inflation\_annual) .def\_readwrite("nominal\_discount\_annual"

### Variables

- [&ProductionInputs::print\\_flag](#) [&ProductionInputs::capacity\\_kW](#) [&ProductionInputs::nominal\\_discount\\_annual](#) [def\\_readwrite](#)("replace\_running\_hrs", &ProductionInputs::replace\_running\_hrs) .def(pybind11 [&Production::interpolator](#) [def\\_readwrite](#) ("print\_flag", &Production::print\_flag) .def\_readwrite("is\_running"

### 5.26.1 Detailed Description

Bindings file for the [Production](#) class. Intended to be #include'd in [PYBIND11\\_PGM.cpp](#).

Ref: [Jakob \[2023\]](#)

A file which instructs pybind11 how to build Python bindings for the [Production](#) class. Only public attributes/methods are bound!

## 5.26.2 Function Documentation

### 5.26.2.1 `def_readwrite()` [1/2]

```
& ProductionInputs::print_flag def_readwrite (
    "is_sunk" ,
    &ProductionInputs::is_sunk )
```

### 5.26.2.2 `def_readwrite()` [2/2]

```
& ProductionInputs::print_flag & ProductionInputs::capacity_kW def_readwrite (
    "nominal_inflation_annual" ,
    &ProductionInputs::nominal_inflation_annual )
```

## 5.26.3 Variable Documentation

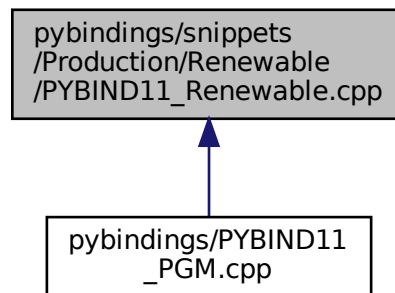
### 5.26.3.1 `def_readwrite`

```
& ProductionInputs::print_flag & ProductionInputs::capacity_kW & ProductionInputs::nominal_discount_annual
def_readwrite ("replace_running_hrs", &ProductionInputs::replace_running_hrs) .def(pybind11 &
Production::interpolator & Production::is_running & Production::n_points & Production::n_replacements
& Production::running_hours & Production::capacity_kW & Production::nominal_discount_annual &
Production::capital_cost & Production::net_present_cost & Production::levellized_cost_of_energy_kWh
& Production::is_running_vec & Production::dispatch_vec_kW & Production::curtailment_vec_kW
def_readwrite("capital_cost_vec", &Production::capital_cost_vec) .def_readwrite("operation↵
maintenance_cost_vec" (
    "print_flag" ,
    &Production::print_flag )
```

## 5.27 `pybindings/snippets/Production/Renewable/PYBIND11_↵` Renewable.cpp File Reference

Bindings file for the [Renewable](#) class. Intended to be `#include'd` in `PYBIND11_PGM.cpp`.

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



## Functions

- [RenewableType::SOLAR](#) [value](#) ("TIDAL", RenewableType::TIDAL) .value("WAVE"
- [RenewableType::SOLAR](#) [RenewableType::WAVE](#) [value](#) ("WIND", RenewableType::WIND) .value("N\_↔RENEWABLE\_TYPES"
- &[RenewableInputs::production\\_inputs](#) [def](#) (pybind11::init())

### 5.27.1 Detailed Description

Bindings file for the [Renewable](#) class. Intended to be #include'd in [PYBIND11\\_PGM.cpp](#).

Ref: [Jakob \[2023\]](#)

A file which instructs pybind11 how to build Python bindings for the [Renewable](#) class. Only public attributes/methods are bound!

### 5.27.2 Function Documentation

#### 5.27.2.1 [def\(\)](#)

```
& RenewableInputs::production\_inputs def (
    pybind11::init() )
```

#### 5.27.2.2 [value\(\)](#) [1/2]

```
RenewableType::SOLAR value (
    "TIDAL" ,
    RenewableType::TIDAL )
```

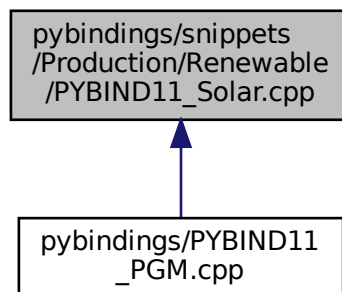
### 5.27.2.3 value() [2/2]

```
RenewableType::SOLAR RenewableType::WAVE value (
    "WIND" ,
    RenewableType::WIND )
```

## 5.28 pybindings/snippets/Production/Renewable/PYBIND11\_Solar.cpp File Reference

Bindings file for the [Solar](#) class. Intended to be #include'd in [PYBIND11\\_PGM.cpp](#).

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



## Functions

- `&SolarInputs::renewable_inputs def_readwrite ("resource_key", &SolarInputs::resource_key) .def_↔ readwrite("capital_cost"`
- `&SolarInputs::renewable_inputs &SolarInputs::capital_cost def_readwrite ("operation_maintenance_cost_↔ kWh", &SolarInputs::operation_maintenance_cost_kWh) .def_readwrite("derating"`
- `&SolarInputs::renewable_inputs &SolarInputs::capital_cost &SolarInputs::derating def (pybind11::init())`

### 5.28.1 Detailed Description

Bindings file for the [Solar](#) class. Intended to be #include'd in [PYBIND11\\_PGM.cpp](#).

Ref: [Jakob \[2023\]](#)

A file which instructs pybind11 how to build Python bindings for the [Solar](#) class. Only public attributes/methods are bound!

### 5.28.2 Function Documentation

### 5.28.2.1 def()

```
& SolarInputs::renewable_inputs & SolarInputs::capital_cost & SolarInputs::derating def (
    pybind11::init() )
```

### 5.28.2.2 def\_readwrite() [1/2]

```
& SolarInputs::renewable_inputs & SolarInputs::capital_cost def_readwrite (
    "operation_maintenance_cost_kWh" ,
    &SolarInputs::operation_maintenance_cost_kWh )
```

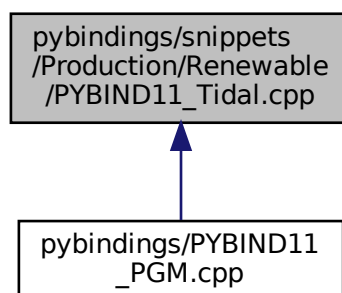
### 5.28.2.3 def\_readwrite() [2/2]

```
& SolarInputs::renewable_inputs def_readwrite (
    "resource_key" ,
    &SolarInputs::resource_key )
```

## 5.29 pybindings/snippets/Production/Renewable/PYBIND11\_Tidal.cpp File Reference

Bindings file for the [Tidal](#) class. Intended to be #include'd in [PYBIND11\\_PGM.cpp](#).

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



## Functions

- `TidalPowerProductionModel::TIDAL_POWER_CUBIC` `value` ("TIDAL\_POWER\_EXPONENTIAL", `TidalPowerProductionModel::TIDAL_POWER_EXPONENTIAL`) `.value`("TIDAL\_POWER\_LOOKUP"
- `TidalPowerProductionModel::TIDAL_POWER_CUBIC` `TidalPowerProductionModel::TIDAL_POWER_LOOKUP` `value` ("N\_TIDAL\_POWER\_PRODUCTION\_MODELS", `TidalPowerProductionModel::N_TIDAL_POWER_PRODUCTION_MODELS`)
- `&TidalInputs::renewable_inputs` `def_readwrite` ("resource\_key", `&TidalInputs::resource_key`) `.def_readwrite`("capital\_cost"
- `&TidalInputs::renewable_inputs` `&TidalInputs::capital_cost` `def_readwrite` ("operation\_maintenance\_cost\_kWh", `&TidalInputs::operation_maintenance_cost_kWh`) `.def_readwrite`("design\_speed\_ms"

## Variables

- `&TidalInputs::renewable_inputs` `&TidalInputs::capital_cost` `&TidalInputs::design_speed_ms` `def_readwrite`("power\_model", `&TidalInputs::power_model`) `.def`(`pybind11` `&Tidal::design_speed_ms` `def_readwrite` ("power\_model", `&Tidal::power_model`) `.def_readwrite`("power\_model\_string"

### 5.29.1 Detailed Description

Bindings file for the `Tidal` class. Intended to be `#include'd` in `PYBIND11_PGM.cpp`.

Ref: [Jakob \[2023\]](#)

A file which instructs `pybind11` how to build Python bindings for the `Tidal` class. Only public attributes/methods are bound!

### 5.29.2 Function Documentation

#### 5.29.2.1 `def_readwrite()` [1/2]

```
& TidalInputs::renewable_inputs & TidalInputs::capital_cost def_readwrite (
    "operation_maintenance_cost_kWh" ,
    &TidalInputs::operation_maintenance_cost_kWh )
```

#### 5.29.2.2 `def_readwrite()` [2/2]

```
& TidalInputs::renewable_inputs def_readwrite (
    "resource_key" ,
    &TidalInputs::resource_key )
```



**5.29.2.3 value() [1/2]**

```
TidalPowerProductionModel::TIDAL_POWER_CUBIC TidalPowerProductionModel::TIDAL_POWER_LOOKUP
value (
    "N_TIDAL_POWER_PRODUCTION_MODELS" ,
    TidalPowerProductionModel::N_TIDAL_POWER_PRODUCTION_MODELS )
```

**5.29.2.4 value() [2/2]**

```
TidalPowerProductionModel::TIDAL_POWER_CUBIC value (
    "TIDAL_POWER_EXPONENTIAL" ,
    TidalPowerProductionModel::TIDAL_POWER_EXPONENTIAL )
```

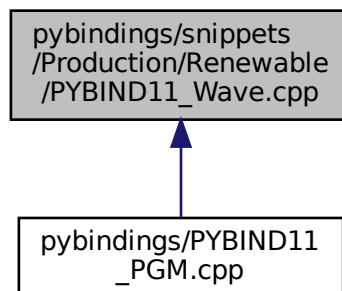
**5.29.3 Variable Documentation****5.29.3.1 def\_readwrite**

```
& TidalInputs::renewable_inputs & TidalInputs::capital_cost & TidalInputs::design_speed_ms
def_readwrite ("power_model", &TidalInputs::power_model) .def(pybind11 & Tidal::design_speed_ms
def_readwrite("power_model", &Tidal::power_model) .def_readwrite("power_model_string" (
    "power_model" ,
    &Tidal::power_model )
```

**5.30 pybindings/snippets/Production/Renewable/PYBIND11\_Wave.cpp File Reference**

Bindings file for the [Wave](#) class. Intended to be #include'd in [PYBIND11\\_PGM.cpp](#).

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



## Functions

- `WavePowerProductionModel::WAVE_POWER_GAUSSIAN` `value` ("WAVE\_POWER\_PARABOLOID", `WavePowerProductionModel::WAVE_POWER_PARABOLOID`) `.value`("WAVE\_POWER\_LOOKUP"
- `WavePowerProductionModel::WAVE_POWER_GAUSSIAN` `WavePowerProductionModel::WAVE_POWER_LOOKUP` `value` ("N\_WAVE\_POWER\_PRODUCTION\_MODELS", `WavePowerProductionModel::N_WAVE_POWER_PRODUCTION_MODELS`)
- `&WaveInputs::renewable_inputs` `def_readwrite` ("resource\_key", `&WaveInputs::resource_key`) `.def_readwrite`("capital\_cost"
- `&WaveInputs::renewable_inputs` `&WaveInputs::capital_cost` `def_readwrite` ("operation\_maintenance\_cost\_kWh", `&WaveInputs::operation_maintenance_cost_kWh`) `.def_readwrite`("design\_significant\_wave\_height\_m"
- `&WaveInputs::renewable_inputs` `&WaveInputs::capital_cost` `&WaveInputs::design_significant_wave_height_m` `def_readwrite` ("design\_energy\_period\_s", `&WaveInputs::design_energy_period_s`) `.def_readwrite`("power\_model"

## Variables

- `&WaveInputs::renewable_inputs` `&WaveInputs::capital_cost` `&WaveInputs::design_significant_wave_height_m` `&WaveInputs::power_model` `def_readwrite`("path\_2\_normalized\_performance\_matrix", `&WaveInputs::path_2_normalized_performance_matrix`) `.def`(`pybind11` `&Wave::design_significant_wave_height_m` `def_readwrite` ("design\_energy\_period\_s", `&Wave::design_energy_period_s`) `.def_readwrite`("power\_model"

### 5.30.1 Detailed Description

Bindings file for the `Wave` class. Intended to be `#include'd` in `PYBIND11_PGM.cpp`.

Ref: [Jakob \[2023\]](#)

A file which instructs `pybind11` how to build Python bindings for the `Wave` class. Only public attributes/methods are bound!

### 5.30.2 Function Documentation

#### 5.30.2.1 `def_readwrite()` [1/3]

```
& WaveInputs::renewable_inputs & WaveInputs::capital_cost & WaveInputs::design_significant_wave_height_m
def_readwrite (
    "design_energy_period_s" ,
    &WaveInputs::design_energy_period_s )
```

#### 5.30.2.2 `def_readwrite()` [2/3]

```
& WaveInputs::renewable_inputs & WaveInputs::capital_cost def_readwrite (
    "operation_maintenance_cost_kWh" ,
    &WaveInputs::operation_maintenance_cost_kWh )
```

**5.30.2.3 def\_readwrite()** [3/3]

```
& WaveInputs::renewable_inputs def_readwrite (
    "resource_key" ,
    &WaveInputs::resource_key )
```

**5.30.2.4 value()** [1/2]

```
WavePowerProductionModel::WAVE_POWER_GAUSSIAN WavePowerProductionModel::WAVE_POWER_LOOKUP
value (
    "N_WAVE_POWER_PRODUCTION_MODELS" ,
    WavePowerProductionModel::N_WAVE_POWER_PRODUCTION_MODELS )
```

**5.30.2.5 value()** [2/2]

```
WavePowerProductionModel::WAVE_POWER_GAUSSIAN value (
    "WAVE_POWER_PARABOLOID" ,
    WavePowerProductionModel::WAVE_POWER_PARABOLOID )
```

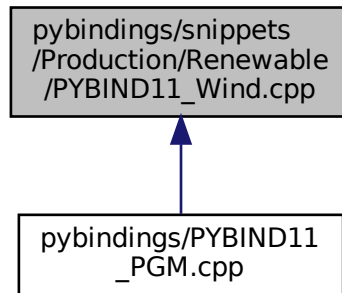
**5.30.3 Variable Documentation****5.30.3.1 def\_readwrite**

```
& WaveInputs::renewable_inputs & WaveInputs::capital_cost & WaveInputs::design_significant_wave_height_m
& WaveInputs::power_model def_readwrite ( "path_2_normalized_performance_matrix", &Wave↵
Inputs::path_2_normalized_performance_matrix ) .def(pybind11 & Wave::design_significant_wave_height_m
def_readwrite("design_energy_period_s", &Wave::design_energy_period_s) .def_readwrite("power↵
_model" (
    "design_energy_period_s" ,
    &Wave::design_energy_period_s )
```

## 5.31 pybindings/snippets/Production/Renewable/PYBIND11\_Wind.cpp File Reference

Bindings file for the [Wind](#) class. Intended to be #include'd in [PYBIND11\\_PGM.cpp](#).

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



### Functions

- [WindPowerProductionModel::WIND\\_POWER\\_EXPONENTIAL](#) [value](#) ("WIND\_POWER\_LOOKUP", [WindPowerProductionModel::WIND\\_POWER\\_LOOKUP](#)) [.value](#)("N\_WIND\_POWER\_PRODUCTION\_MODELS"
- [&WindInputs::renewable\\_inputs](#) [def\\_readwrite](#) ("resource\_key", [&WindInputs::resource\\_key](#)) [.def\\_readwrite](#)("capital\_cost"
- [&WindInputs::renewable\\_inputs](#) [&WindInputs::capital\\_cost](#) [def\\_readwrite](#) ("operation\_maintenance\_cost\_kWh", [&WindInputs::operation\\_maintenance\\_cost\\_kWh](#)) [.def\\_readwrite](#)("design\_speed\_ms"

### Variables

- [&WindInputs::renewable\\_inputs](#) [&WindInputs::capital\\_cost](#) [&WindInputs::design\\_speed\\_ms](#) [def\\_readwrite](#)("power\_model", [&WindInputs::power\\_model](#)) [.def](#)(pybind11 [&Wind::design\\_speed\\_ms](#) [def\\_readwrite](#)("power\_model", [&Wind::power\\_model](#)) [.def\\_readwrite](#)("power\_model\_string"

#### 5.31.1 Detailed Description

Bindings file for the [Wind](#) class. Intended to be #include'd in [PYBIND11\\_PGM.cpp](#).

Ref: [Jakob \[2023\]](#)

A file which instructs pybind11 how to build Python bindings for the [Wind](#) class. Only public attributes/methods are bound!

#### 5.31.2 Function Documentation

**5.31.2.1 def\_readwrite() [1/2]**

```
& WindInputs::renewable_inputs & WindInputs::capital_cost def_readwrite (
    "operation_maintenance_cost_kWh" ,
    &WindInputs::operation_maintenance_cost_kWh )
```

**5.31.2.2 def\_readwrite() [2/2]**

```
& WindInputs::renewable_inputs def_readwrite (
    "resource_key" ,
    &WindInputs::resource_key )
```

**5.31.2.3 value()**

```
WindPowerProductionModel::WIND_POWER_EXPONENTIAL value (
    "WIND_POWER_LOOKUP" ,
    WindPowerProductionModel::WIND_POWER_LOOKUP )
```

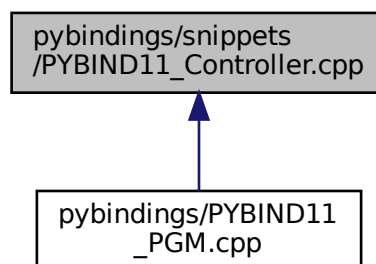
**5.31.3 Variable Documentation****5.31.3.1 def\_readwrite**

```
& WindInputs::renewable_inputs & WindInputs::capital_cost & WindInputs::design_speed_ms def↔
_readwrite ("power_model", &WindInputs::power_model) .def(pybind11 & Wind::design_speed_ms
def_readwrite("power_model", &Wind::power_model) .def_readwrite("power_model_string" (
    "power_model" ,
    &Wind::power_model )
```

**5.32 pybindings/snippets/PYBIND11\_Controller.cpp File Reference**

Bindings file for the [Controller](#) class. Intended to be #include'd in [PYBIND11\\_PGM.cpp](#).

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



## Functions

- `ControlMode::LOAD_FOLLOWING` `value` ("CYCLE\_CHARGING", `ControlMode::CYCLE_CHARGING`)  
.value("N\_CONTROL\_MODES"
- `&Controller::control_mode` `def_readwrite` ("control\_string", `&Controller::control_string`) `.def_readwrite`("net↔  
\_load\_vec\_kW"
- `&Controller::control_mode` `&Controller::net_load_vec_kW` `def_readwrite` ("missed\_load\_vec\_kW", `&Controller↔  
::missed_load_vec_kW`) `.def_readwrite`("combustion\_map"
- `&Controller::control_mode` `&Controller::net_load_vec_kW` `&Controller::combustion_map` `def` (pybind11↔  
::init<>()) `.def`("setControlMode"
- `&Controller::control_mode` `&Controller::net_load_vec_kW` `&Controller::combustion_map` `&Controller::setControlMode`  
`def` ("init", `&Controller::init`) `.def`("applyDispatchControl"
- `&Controller::control_mode` `&Controller::net_load_vec_kW` `&Controller::combustion_map` `&Controller::setControlMode`  
`&Controller::applyDispatchControl` `def` ("clear", `&Controller::clear`)

### 5.32.1 Detailed Description

Bindings file for the `Controller` class. Intended to be `#include'd` in `PYBIND11_PGM.cpp`.

Ref: [Jakob \[2023\]](#)

A file which instructs pybind11 how to build Python bindings for the `Controller` class. Only public attributes/methods are bound!

### 5.32.2 Function Documentation

#### 5.32.2.1 `def()` [1/3]

```
& Controller::control_mode & Controller::net_load_vec_kW & Controller::combustion_map & Controller::setControl
& Controller::applyDispatchControl def (
    "clear" ,
    &Controller::clear )
```

#### 5.32.2.2 `def()` [2/3]

```
& Controller::control_mode & Controller::net_load_vec_kW & Controller::combustion_map & Controller::setControl
def (
    "init" ,
    &Controller::init )
```

#### 5.32.2.3 `def()` [3/3]

```
& Controller::control_mode & Controller::net_load_vec_kW & Controller::combustion_map def (
    pybind11::init<> () )
```

**5.32.2.4 def\_readwrite()** [1/2]

```
& Controller::control_mode def_readwrite (
    "control_string" ,
    &Controller::control_string )
```

**5.32.2.5 def\_readwrite()** [2/2]

```
& Controller::control_mode & Controller::net_load_vec_kW def_readwrite (
    "missed_load_vec_kW" ,
    &Controller::missed_load_vec_kW )
```

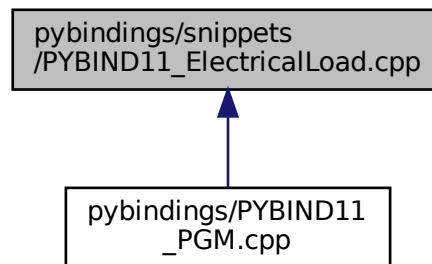
**5.32.2.6 value()**

```
ControlMode::LOAD_FOLLOWING value (
    "CYCLE_CHARGING" ,
    ControlMode::CYCLE_CHARGING )
```

**5.33 pybindings/snippets/PYBIND11\_ElectricalLoad.cpp File Reference**

Bindings file for the [ElectricalLoad](#) class. Intended to be #include'd in [PYBIND11\\_PGM.cpp](#).

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

**Functions**

- [&ElectricalLoad::n\\_points](#) [def\\_readwrite](#) ("n\_years", &ElectricalLoad::n\_years) [.def\\_readwrite](#)("min\_load\_kW"
- [&ElectricalLoad::n\\_points](#) [&ElectricalLoad::min\\_load\\_kW](#) [def\\_readwrite](#) ("mean\_load\_kW", &ElectricalLoad::mean\_load\_kW) [.def\\_readwrite](#)("max\_load\_kW"
- [&ElectricalLoad::n\\_points](#) [&ElectricalLoad::min\\_load\\_kW](#) [&ElectricalLoad::max\\_load\\_kW](#) [def\\_readwrite](#) ("path\_2\_electrical\_load\_time\_series", &ElectricalLoad::path\_2\_electrical\_load\_time\_series) [.def\\_readwrite](#)("time\_vec\_hrs"
- [&ElectricalLoad::n\\_points](#) [&ElectricalLoad::min\\_load\\_kW](#) [&ElectricalLoad::max\\_load\\_kW](#) [&ElectricalLoad::time\\_vec\\_hrs](#) [def\\_readwrite](#) ("dt\_vec\_hrs", &ElectricalLoad::dt\_vec\_hrs) [.def\\_readwrite](#)("load\_vec\_kW"

### 5.33.1 Detailed Description

Bindings file for the [ElectricalLoad](#) class. Intended to be #include'd in [PYBIND11\\_PGM.cpp](#).

Ref: [Jakob \[2023\]](#)

A file which instructs pybind11 how to build Python bindings for the [ElectricalLoad](#) class. Only public attributes/methods are bound!

### 5.33.2 Function Documentation

#### 5.33.2.1 `def_readwrite()` [1/4]

```
& ElectricalLoad::n\_points & ElectricalLoad::min\_load\_kW & ElectricalLoad::max\_load\_kW & ElectricalLoad::time\_
def_readwrite (
    "dt_vec_hrs" ,
    &ElectricalLoad::dt\_vec\_hrs )
```

#### 5.33.2.2 `def_readwrite()` [2/4]

```
& ElectricalLoad::n\_points & ElectricalLoad::min\_load\_kW def_readwrite (
    "mean_load_kW" ,
    &ElectricalLoad::mean\_load\_kW )
```

#### 5.33.2.3 `def_readwrite()` [3/4]

```
& ElectricalLoad::n\_points def_readwrite (
    "n_years" ,
    &ElectricalLoad::n\_years )
```

#### 5.33.2.4 `def_readwrite()` [4/4]

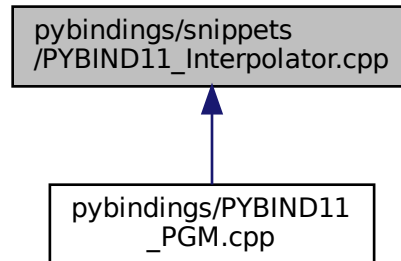
```
& ElectricalLoad::n\_points & ElectricalLoad::min\_load\_kW & ElectricalLoad::max\_load\_kW def_↵
readwrite (
    "path_2_electrical_load_time_series" ,
    &ElectricalLoad::path\_2\_electrical\_load\_time\_series )
```



## 5.34 pybindings/snippets/PYBIND11\_Interpolator.cpp File Reference

Bindings file for the [Interpolator](#) class. Intended to be #include'd in [PYBIND11\\_PGM.cpp](#).

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



### Functions

- [&InterpolatorStruct1D::n\\_points](#) [def\\_readwrite](#) ("x\_vec", &InterpolatorStruct1D::x\_vec) [.def\\_readwrite](#)("min\_x", &InterpolatorStruct1D::min\_x) [def\\_readwrite](#)("max\_x", &InterpolatorStruct1D::max\_x) [.def\\_readwrite](#)("y\_vec", &InterpolatorStruct1D::y\_vec) [.def\\_readwrite](#)("z\_matrix", &InterpolatorStruct1D::z\_matrix)
- [&InterpolatorStruct1D::n\\_points](#) [&InterpolatorStruct1D::min\\_x](#) [def\\_readwrite](#) ("max\_x", &InterpolatorStruct1D::max\_x) [.def\\_readwrite](#)("y\_vec", &InterpolatorStruct1D::y\_vec) [.def\\_readwrite](#)("z\_matrix", &InterpolatorStruct1D::z\_matrix)
- [&InterpolatorStruct1D::n\\_points](#) [&InterpolatorStruct1D::min\\_x](#) [&InterpolatorStruct1D::y\\_vec](#) [def](#) (pybind11::init())
- [&InterpolatorStruct2D::n\\_rows](#) [def\\_readwrite](#) ("n\_cols", &InterpolatorStruct2D::n\_cols) [.def\\_readwrite](#)("x\_vec", &InterpolatorStruct2D::x\_vec) [.def\\_readwrite](#)("y\_vec", &InterpolatorStruct2D::y\_vec) [.def\\_readwrite](#)("z\_matrix", &InterpolatorStruct2D::z\_matrix)
- [&InterpolatorStruct2D::n\\_rows](#) [&InterpolatorStruct2D::x\\_vec](#) [def\\_readwrite](#) ("min\_x", &InterpolatorStruct2D::min\_x) [.def\\_readwrite](#)("max\_x", &InterpolatorStruct2D::max\_x) [.def\\_readwrite](#)("y\_vec", &InterpolatorStruct2D::y\_vec) [.def\\_readwrite](#)("z\_matrix", &InterpolatorStruct2D::z\_matrix)
- [&InterpolatorStruct2D::n\\_rows](#) [&InterpolatorStruct2D::x\\_vec](#) [&InterpolatorStruct2D::max\\_x](#) [def\\_readwrite](#) ("y\_vec", &InterpolatorStruct2D::y\_vec) [.def\\_readwrite](#)("min\_y", &InterpolatorStruct2D::min\_y) [.def\\_readwrite](#)("max\_y", &InterpolatorStruct2D::max\_y) [.def\\_readwrite](#)("z\_matrix", &InterpolatorStruct2D::z\_matrix)
- [&InterpolatorStruct2D::n\\_rows](#) [&InterpolatorStruct2D::x\\_vec](#) [&InterpolatorStruct2D::max\\_x](#) [&InterpolatorStruct2D::min\\_y](#) [def\\_readwrite](#) ("max\_y", &InterpolatorStruct2D::max\_y) [.def\\_readwrite](#)("z\_matrix", &InterpolatorStruct2D::z\_matrix)
- [&Interpolator::interp\\_map\\_1D](#) [def\\_readwrite](#) ("path\_map\_1D", &Interpolator::path\_map\_1D) [.def\\_readwrite](#)("interp\_map\_2D", &Interpolator::path\_map\_2D)

### 5.34.1 Detailed Description

Bindings file for the [Interpolator](#) class. Intended to be #include'd in [PYBIND11\\_PGM.cpp](#).

Ref: [Jakob \[2023\]](#)

A file which instructs pybind11 how to build Python bindings for the [Interpolator](#) class. Only public attributes/methods are bound!

### 5.34.2 Function Documentation

**5.34.2.1 def()**

```
& InterpolatorStruct1D::n_points & InterpolatorStruct1D::min_x & InterpolatorStruct1D::y_vec
def (
    pybind11::init() )
```

**5.34.2.2 def\_readwrite() [1/7]**

```
& InterpolatorStruct1D::n_points & InterpolatorStruct1D::min_x def_readwrite (
    "max_x" ,
    &InterpolatorStruct1D::max_x )
```

**5.34.2.3 def\_readwrite() [2/7]**

```
& InterpolatorStruct2D::n_rows & InterpolatorStruct2D::x_vec & InterpolatorStruct2D::max_x &
InterpolatorStruct2D::min_y def_readwrite (
    "max_y" ,
    &InterpolatorStruct2D::max_y )
```

**5.34.2.4 def\_readwrite() [3/7]**

```
& InterpolatorStruct2D::n_rows & InterpolatorStruct2D::x_vec def_readwrite (
    "min_x" ,
    &InterpolatorStruct2D::min_x )
```

**5.34.2.5 def\_readwrite() [4/7]**

```
& InterpolatorStruct2D::n_rows def_readwrite (
    "n_cols" ,
    &InterpolatorStruct2D::n_cols )
```

**5.34.2.6 def\_readwrite() [5/7]**

```
& Interpolator::interp_map_1D def_readwrite (
    "path_map_1D" ,
    &Interpolator::path_map_1D )
```

**5.34.2.7** `def_readwrite()` [6/7]

```
& InterpolatorStruct1D::n_points def_readwrite (
    "x_vec" ,
    &InterpolatorStruct1D::x_vec )
```

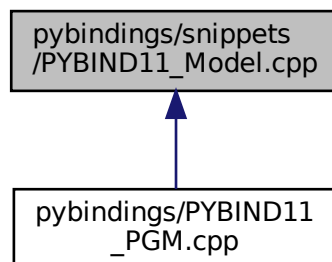
**5.34.2.8** `def_readwrite()` [7/7]

```
& InterpolatorStruct2D::n_rows & InterpolatorStruct2D::x_vec & InterpolatorStruct2D::max_x
def_readwrite (
    "y_vec" ,
    &InterpolatorStruct2D::y_vec )
```

**5.35** `pybindings/snippets/PYBIND11_Model.cpp` File Reference

Bindings file for the [Model](#) class. Intended to be #include'd in [PYBIND11\\_PGM.cpp](#).

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

**Variables**

- `&ModelInputs::path_2_electrical_load_time_series` `def_readwrite("control_mode", &ModelInputs::control_mode)` `.def(pybind11 &Model::total_fuel_consumed_L` `def_readwrite ("total_emissions", &Model::total_emissions)` `.def_readwrite("net_present_cost"`

**5.35.1** Detailed Description

Bindings file for the [Model](#) class. Intended to be #include'd in [PYBIND11\\_PGM.cpp](#).

Ref: [Jakob \[2023\]](#)

A file which instructs pybind11 how to build Python bindings for the [Model](#) class. Only public attributes/methods are bound!

## 5.35.2 Variable Documentation

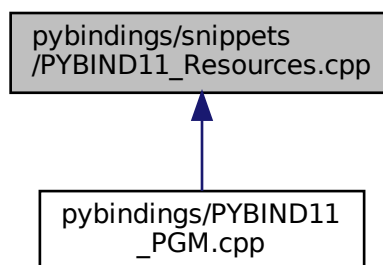
### 5.35.2.1 def\_readwrite

```
& ModelInputs::path_2_electrical_load_time_series def_readwrite ("control_mode", &Model↵
Inputs::control_mode) .def(pybind11 & Model::total_fuel_consumed_L & Model::net_present_cost
& Model::levellized_cost_of_energy_kWh & Model::electrical_load & Model::combustion_ptr_vec
def_readwrite("renewable_ptr_vec", &Model::renewable_ptr_vec) .def_readwrite("storage_ptr_vec"
(
    "total_emissions" ,
    &Model::total_emissions )
```

## 5.36 pybindings/snippets/PYBIND11\_Resources.cpp File Reference

Bindings file for the [Resources](#) class. Intended to be #include'd in [PYBIND11\\_PGM.cpp](#).

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



## Functions

- [&Resources::resource\\_map\\_1D](#) [def\\_readwrite](#) ("string\_map\_1D", &Resources::string\_map\_1D) [.def↵](#)  
[readwrite](#)("path\_map\_1D"
- [&Resources::resource\\_map\\_1D](#) &Resources::path\_map\_1D [def\\_readwrite](#) ("resource\_map\_2D", &Resources↵  
::resource\_map\_2D) [.def\\_readwrite](#)("string\_map\_2D"

### 5.36.1 Detailed Description

Bindings file for the [Resources](#) class. Intended to be #include'd in [PYBIND11\\_PGM.cpp](#).

Ref: [Jakob \[2023\]](#)

A file which instructs pybind11 how to build Python bindings for the [Resources](#) class. Only public attributes/methods are bound!

## 5.36.2 Function Documentation

### 5.36.2.1 def\_readwrite() [1/2]

```
& Resources::resource_map_1D & Resources::path_map_1D def_readwrite (
    "resource_map_2D" ,
    &Resources::resource_map_2D )
```

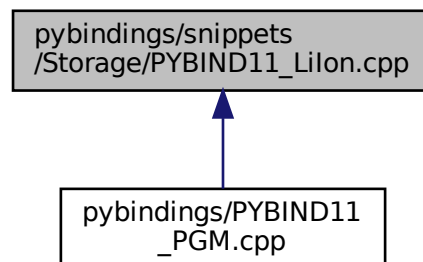
### 5.36.2.2 def\_readwrite() [2/2]

```
& Resources::resource_map_1D def_readwrite (
    "string_map_1D" ,
    &Resources::string_map_1D )
```

## 5.37 pybindings/snippets/Storage/PYBIND11\_Lilon.cpp File Reference

Bindings file for the [Lilon](#) class. Intended to be #include'd in [PYBIND11\\_PGM.cpp](#).

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



## Functions

- [&LilonInputs::storage\\_inputs](#) [def\\_readwrite](#) ("capital\_cost", &LilonInputs::capital\_cost) .def\_readwrite("operation↵\_maintenance\_cost\_kWh"
- [&LilonInputs::storage\\_inputs](#) &LilonInputs::operation\_maintenance\_cost\_kWh [def\\_readwrite](#) ("init\_SOC", &LilonInputs::init\_SOC) .def\_readwrite("min\_SOC"
- [&LilonInputs::storage\\_inputs](#) &LilonInputs::operation\_maintenance\_cost\_kWh &LilonInputs::min\_SOC [def\\_readwrite](#) ("hysteresis\_SOC", &LilonInputs::hysteresis\_SOC) .def\_readwrite("max\_SOC"

- `&LilonInputs::storage_inputs &LilonInputs::operation_maintenance_cost_kWh &LilonInputs::min_SOC &LilonInputs::max_SOC def_readwrite ("charging_efficiency", &LilonInputs::charging_efficiency) .def_readwrite("discharging_efficiency"`
- `&LilonInputs::storage_inputs &LilonInputs::operation_maintenance_cost_kWh &LilonInputs::min_SOC &LilonInputs::max_SOC &LilonInputs::discharging_efficiency def_readwrite ("replace_SOH", &LilonInputs::replace_SOH) .def_readwrite("degradation_alpha"`
- `&LilonInputs::storage_inputs &LilonInputs::operation_maintenance_cost_kWh &LilonInputs::min_SOC &LilonInputs::max_SOC &LilonInputs::discharging_efficiency &LilonInputs::degradation_alpha def_readwrite ("degradation_beta", &LilonInputs::degradation_beta) .def_readwrite("degradation_B_hat_cal_0"`
- `&LilonInputs::storage_inputs &LilonInputs::operation_maintenance_cost_kWh &LilonInputs::min_SOC &LilonInputs::max_SOC &LilonInputs::discharging_efficiency &LilonInputs::degradation_alpha &LilonInputs::degradation_B_hat_cal_0 def_readwrite ("degradation_r_cal", &LilonInputs::degradation_r_cal) .def_readwrite("degradation_Ea_cal_0"`
- `&LilonInputs::storage_inputs &LilonInputs::operation_maintenance_cost_kWh &LilonInputs::min_SOC &LilonInputs::max_SOC &LilonInputs::discharging_efficiency &LilonInputs::degradation_alpha &LilonInputs::degradation_B_hat_cal_0 &LilonInputs::degradation_Ea_cal_0 def_readwrite ("degradation_a_cal", &LilonInputs::degradation_a_cal) .def_readwrite("degradation_s_cal"`
- `&LilonInputs::storage_inputs &LilonInputs::operation_maintenance_cost_kWh &LilonInputs::min_SOC &LilonInputs::max_SOC &LilonInputs::discharging_efficiency &LilonInputs::degradation_alpha &LilonInputs::degradation_B_hat_cal_0 &LilonInputs::degradation_Ea_cal_0 &LilonInputs::degradation_s_cal def_readwrite ("gas_constant_JmolK", &LilonInputs::gas_constant_JmolK) .def_readwrite("gas_constant_JmolK"`
- `&LilonInputs::storage_inputs &LilonInputs::operation_maintenance_cost_kWh &LilonInputs::min_SOC &LilonInputs::max_SOC &LilonInputs::discharging_efficiency &LilonInputs::degradation_alpha &LilonInputs::degradation_B_hat_cal_0 &LilonInputs::degradation_Ea_cal_0 &LilonInputs::degradation_s_cal &LilonInputs::gas_constant_JmolK def (pybind11::init())`
- `&Lilon::dynamic_energy_capacity_kWh def_readwrite ("SOH", &Lilon::SOH) .def_readwrite("replace_SOH"`
- `&Lilon::dynamic_energy_capacity_kWh &Lilon::replace_SOH def_readwrite ("degradation_alpha", &Lilon::degradation_alpha) .def_readwrite("degradation_beta"`
- `&Lilon::dynamic_energy_capacity_kWh &Lilon::replace_SOH &Lilon::degradation_beta def_readwrite ("degradation_B_hat_cal_0", &Lilon::degradation_B_hat_cal_0) .def_readwrite("degradation_r_cal"`
- `&Lilon::dynamic_energy_capacity_kWh &Lilon::replace_SOH &Lilon::degradation_beta &Lilon::degradation_r_cal def_readwrite ("degradation_Ea_cal_0", &Lilon::degradation_Ea_cal_0) .def_readwrite("degradation_a_cal"`
- `&Lilon::dynamic_energy_capacity_kWh &Lilon::replace_SOH &Lilon::degradation_beta &Lilon::degradation_r_cal &Lilon::degradation_a_cal def_readwrite ("degradation_s_cal", &Lilon::degradation_s_cal) .def_readwrite("gas_constant_JmolK"`
- `&Lilon::dynamic_energy_capacity_kWh &Lilon::replace_SOH &Lilon::degradation_beta &Lilon::degradation_r_cal &Lilon::degradation_a_cal &Lilon::gas_constant_JmolK def_readwrite ("temperature_K", &Lilon::temperature_K) .def_readwrite("init_SOC"`
- `&Lilon::dynamic_energy_capacity_kWh &Lilon::replace_SOH &Lilon::degradation_beta &Lilon::degradation_r_cal &Lilon::degradation_a_cal &Lilon::gas_constant_JmolK &Lilon::init_SOC def_readwrite ("min_SOC", &Lilon::min_SOC) .def_readwrite("hysteresis_SOC"`
- `&Lilon::dynamic_energy_capacity_kWh &Lilon::replace_SOH &Lilon::degradation_beta &Lilon::degradation_r_cal &Lilon::degradation_a_cal &Lilon::gas_constant_JmolK &Lilon::init_SOC &Lilon::hysteresis_SOC def_readwrite ("max_SOC", &Lilon::max_SOC) .def_readwrite("charging_efficiency"`
- `&Lilon::dynamic_energy_capacity_kWh &Lilon::replace_SOH &Lilon::degradation_beta &Lilon::degradation_r_cal &Lilon::degradation_a_cal &Lilon::gas_constant_JmolK &Lilon::init_SOC &Lilon::hysteresis_SOC &Lilon::charging_efficiency def_readwrite ("discharging_efficiency", &Lilon::discharging_efficiency) .def_readwrite("SOH_vec"`

### 5.37.1 Detailed Description

Bindings file for the `Lilon` class. Intended to be `#include'd` in `PYBIND11_PGM.cpp`.

Ref: [Jakob \[2023\]](#)

A file which instructs `pybind11` how to build Python bindings for the `Lilon` class. Only public attributes/methods are bound!

## 5.37.2 Function Documentation

### 5.37.2.1 def()

```
& LiIonInputs::storage_inputs & LiIonInputs::operation_maintenance_cost_kWh & LiIonInputs::min_SOC
& LiIonInputs::max_SOC & LiIonInputs::discharging_efficiency & LiIonInputs::degradation_alpha
& LiIonInputs::degradation_B_hat_cal_0 & LiIonInputs::degradation_Ea_cal_0 & LiIonInputs::degradation_s_cal
& LiIonInputs::gas_constant_JmolK def (
    pybind11::init() )
```

### 5.37.2.2 def\_readwrite() [1/18]

```
& LiIonInputs::storage_inputs def_readwrite (
    "capital_cost" ,
    &LiIonInputs::capital_cost )
```

### 5.37.2.3 def\_readwrite() [2/18]

```
& LiIonInputs::storage_inputs & LiIonInputs::operation_maintenance_cost_kWh & LiIonInputs::min_SOC
& LiIonInputs::max_SOC def_readwrite (
    "charging_efficiency" ,
    &LiIonInputs::charging_efficiency )
```

### 5.37.2.4 def\_readwrite() [3/18]

```
& LiIonInputs::storage_inputs & LiIonInputs::operation_maintenance_cost_kWh & LiIonInputs::min_SOC
& LiIonInputs::max_SOC & LiIonInputs::discharging_efficiency & LiIonInputs::degradation_alpha
& LiIonInputs::degradation_B_hat_cal_0 & LiIonInputs::degradation_Ea_cal_0 def_readwrite (
    "degradation_a_cal" ,
    &LiIonInputs::degradation_a_cal )
```

### 5.37.2.5 def\_readwrite() [4/18]

```
& LiIon::dynamic_energy_capacity_kWh & LiIon::replace_SOH def_readwrite (
    "degradation_alpha" ,
    &LiIon::degradation_alpha )
```

**5.37.2.6 def\_readwrite()** [5/18]

```
& LiIon::dynamic_energy_capacity_kWh & LiIon::replace_SOH & LiIon::degradation_beta def_readwrite (
    "degradation_B_hat_cal_0" ,
    &LiIon::degradation_B_hat_cal_0 )
```

**5.37.2.7 def\_readwrite()** [6/18]

```
& LiIonInputs::storage_inputs & LiIonInputs::operation_maintenance_cost_kWh & LiIonInputs::min_SOC
& LiIonInputs::max_SOC & LiIonInputs::discharging_efficiency & LiIonInputs::degradation_alpha
def_readwrite (
    "degradation_beta" ,
    &LiIonInputs::degradation_beta )
```

**5.37.2.8 def\_readwrite()** [7/18]

```
& LiIon::dynamic_energy_capacity_kWh & LiIon::replace_SOH & LiIon::degradation_beta & LiIon::degradation_r_cal
def_readwrite (
    "degradation_Ea_cal_0" ,
    &LiIon::degradation_Ea_cal_0 )
```

**5.37.2.9 def\_readwrite()** [8/18]

```
& LiIonInputs::storage_inputs & LiIonInputs::operation_maintenance_cost_kWh & LiIonInputs::min_SOC
& LiIonInputs::max_SOC & LiIonInputs::discharging_efficiency & LiIonInputs::degradation_alpha
& LiIonInputs::degradation_B_hat_cal_0 def_readwrite (
    "degradation_r_cal" ,
    &LiIonInputs::degradation_r_cal )
```

**5.37.2.10 def\_readwrite()** [9/18]

```
& LiIon::dynamic_energy_capacity_kWh & LiIon::replace_SOH & LiIon::degradation_beta & LiIon::degradation_r_cal
& LiIon::degradation_a_cal def_readwrite (
    "degradation_s_cal" ,
    &LiIon::degradation_s_cal )
```



**5.37.2.11 def\_readwrite() [10/18]**

```
& LiIon::dynamic_energy_capacity_kWh & LiIon::replace_SOH & LiIon::degradation_beta & LiIon::degradation_r_cal
& LiIon::degradation_a_cal & LiIon::gas_constant_JmolK & LiIon::init_SOC & LiIon::hysteresis_SOC
& LiIon::charging_efficiency def_readwrite (
    "discharging_efficiency" ,
    &LiIon::discharging_efficiency )
```

**5.37.2.12 def\_readwrite() [11/18]**

```
& LiIonInputs::storage_inputs & LiIonInputs::operation_maintenance_cost_kWh & LiIonInputs::min_SOC
& LiIonInputs::max_SOC & LiIonInputs::discharging_efficiency & LiIonInputs::degradation_alpha
& LiIonInputs::degradation_B_hat_cal_0 & LiIonInputs::degradation_Ea_cal_0 & LiIonInputs::degradation_s_cal
def_readwrite (
    "gas_constant_JmolK" ,
    &LiIonInputs::gas_constant_JmolK )
```

**5.37.2.13 def\_readwrite() [12/18]**

```
& LiIonInputs::storage_inputs & LiIonInputs::operation_maintenance_cost_kWh & LiIonInputs::min_SOC
def_readwrite (
    "hysteresis_SOC" ,
    &LiIonInputs::hysteresis_SOC )
```

**5.37.2.14 def\_readwrite() [13/18]**

```
& LiIonInputs::storage_inputs & LiIonInputs::operation_maintenance_cost_kWh def_readwrite (
    "init_SOC" ,
    &LiIonInputs::init_SOC )
```

**5.37.2.15 def\_readwrite() [14/18]**

```
& LiIon::dynamic_energy_capacity_kWh & LiIon::replace_SOH & LiIon::degradation_beta & LiIon::degradation_r_cal
& LiIon::degradation_a_cal & LiIon::gas_constant_JmolK & LiIon::init_SOC & LiIon::hysteresis_SOC
def_readwrite (
    "max_SOC" ,
    &LiIon::max_SOC )
```

**5.37.2.16 def\_readwrite() [15/18]**

```
& LiIon::dynamic_energy_capacity_kWh & LiIon::replace_SOH & LiIon::degradation_beta & LiIon::degradation_r_cal
& LiIon::degradation_a_cal & LiIon::gas_constant_JmolK & LiIon::init_SOC def_readwrite (
    "min_SOC" ,
    &LiIon::min_SOC )
```

**5.37.2.17 def\_readwrite() [16/18]**

```
& LiIonInputs::storage_inputs & LiIonInputs::operation_maintenance_cost_kWh & LiIonInputs::min_SOC
& LiIonInputs::max_SOC & LiIonInputs::discharging_efficiency def_readwrite (
    "replace_SOH" ,
    &LiIonInputs::replace_SOH )
```

**5.37.2.18 def\_readwrite() [17/18]**

```
& LiIon::dynamic_energy_capacity_kWh def_readwrite (
    "SOH" ,
    &LiIon::SOH )
```

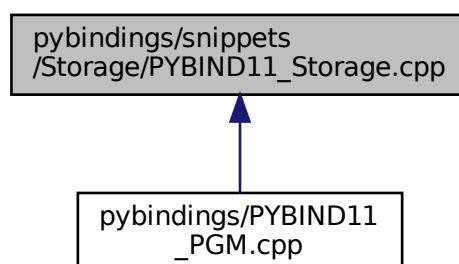
**5.37.2.19 def\_readwrite() [18/18]**

```
& LiIon::dynamic_energy_capacity_kWh & LiIon::replace_SOH & LiIon::degradation_beta & LiIon::degradation_r_cal
& LiIon::degradation_a_cal & LiIon::gas_constant_JmolK def_readwrite (
    "temperature_K" ,
    &LiIon::temperature_K )
```

## 5.38 pybindings/snippets/Storage/PYBIND11\_Storage.cpp File Reference

Bindings file for the [Storage](#) class. Intended to be #include'd in [PYBIND11\\_PGM.cpp](#).

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



## Functions

- [StorageType::LIION value](#) ("N\_STORAGE\_TYPES", StorageType::N\_STORAGE\_TYPES)
- [&StorageInputs::print\\_flag def\\_readwrite](#) ("is\_sunk", &StorageInputs::is\_sunk) .def\_readwrite("power\_capacity\_kW"
- [&StorageInputs::print\\_flag &StorageInputs::power\\_capacity\\_kW def\\_readwrite](#) ("energy\_capacity\_kWh", &StorageInputs::energy\_capacity\_kWh) .def\_readwrite("nominal\_inflation\_annual"

## Variables

- [&StorageInputs::print\\_flag &StorageInputs::power\\_capacity\\_kW &StorageInputs::nominal\\_inflation\\_annual def\\_readwrite](#) ("nominal\_discount\_annual", &StorageInputs::nominal\_discount\_annual) .def(pybind11 &Storage::type def\_readwrite ("interpolator", &Storage::interpolator) .def\_readwrite("print\_flag"

### 5.38.1 Detailed Description

Bindings file for the [Storage](#) class. Intended to be #include'd in [PYBIND11\\_PGM.cpp](#).

Ref: [Jakob \[2023\]](#)

A file which instructs pybind11 how to build Python bindings for the [Storage](#) class. Only public attributes/methods are bound!

### 5.38.2 Function Documentation

#### 5.38.2.1 [def\\_readwrite\(\)](#) [1/2]

```
& StorageInputs::print_flag & StorageInputs::power_capacity_kW def_readwrite (
    "energy_capacity_kWh" ,
    &StorageInputs::energy_capacity_kWh )
```

#### 5.38.2.2 [def\\_readwrite\(\)](#) [2/2]

```
& StorageInputs::print_flag def_readwrite (
    "is_sunk" ,
    &StorageInputs::is_sunk )
```

#### 5.38.2.3 [value\(\)](#)

```
StorageType::LIION value (
    "N_STORAGE_TYPES" ,
    StorageType::N_STORAGE_TYPES )
```

### 5.38.3 Variable Documentation

#### 5.38.3.1 def\_readwrite

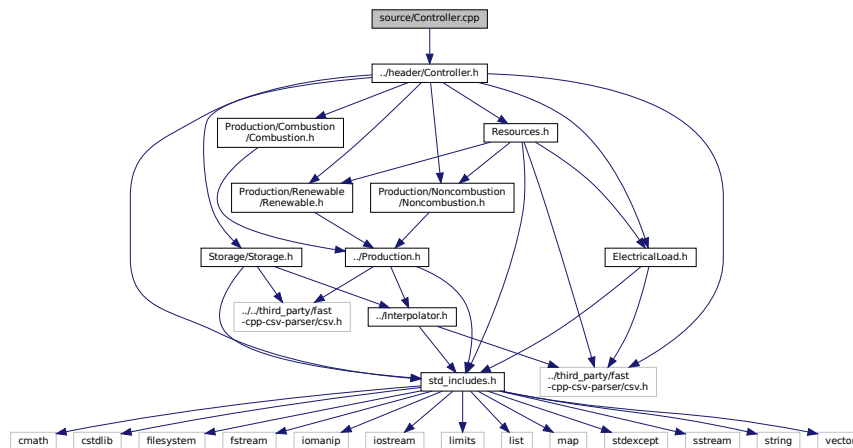
```
& StorageInputs::print_flag & StorageInputs::power_capacity_kW & StorageInputs::nominal_inflation_annual
def_readwrite ("nominal_discount_annual", &StorageInputs::nominal_discount_annual) .def(pybind11
& Storage::type & Storage::print_flag & Storage::is_sunk & Storage::n_replacements & Storage::power_capacity_kW
& Storage::charge_kWh & Storage::nominal_inflation_annual & Storage::real_discount_annual &
Storage::operation_maintenance_cost_kWh & Storage::total_discharge_kWh & Storage::type_str &
Storage::charging_power_vec_kW def_readwrite("discharging_power_vec_kW", &Storage::discharging←
_power_vec_kW) .def_readwrite("capital_cost_vec" (
    "interpolator" ,
    &Storage::interpolator )
```

## 5.39 source/Controller.cpp File Reference

Implementation file for the [Controller](#) class.

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

Include dependency graph for Controller.cpp:



#### 5.39.1 Detailed Description

Implementation file for the [Controller](#) class.

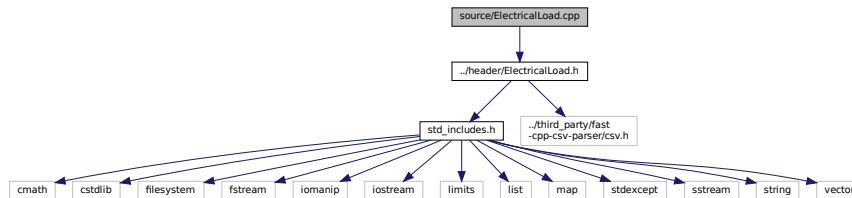
A class which contains a various dispatch control logic. Intended to serve as a component class of [Controller](#).

## 5.40 source/ElectricalLoad.cpp File Reference

Implementation file for the [ElectricalLoad](#) class.

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

Include dependency graph for ElectricalLoad.cpp:



### 5.40.1 Detailed Description

Implementation file for the [ElectricalLoad](#) class.

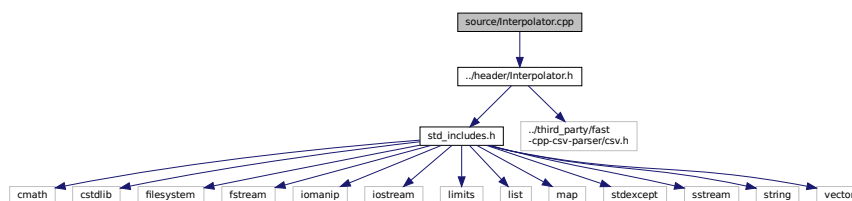
A class which contains time and electrical load data. Intended to serve as a component class of [Model](#).

## 5.41 source/Interpolator.cpp File Reference

Implementation file for the [Interpolator](#) class.

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

Include dependency graph for Interpolator.cpp:



### 5.41.1 Detailed Description

Implementation file for the [Interpolator](#) class.

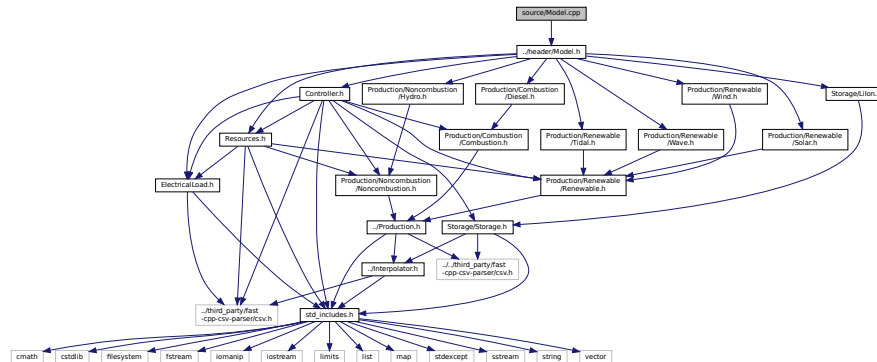
A class which contains interpolation data and functionality. Intended to serve as a component of the [Production](#) and [Storage](#) hierarchies.

## 5.42 source/Model.cpp File Reference

Implementation file for the [Model](#) class.

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

Include dependency graph for Model.cpp:



### 5.42.1 Detailed Description

Implementation file for the [Model](#) class.

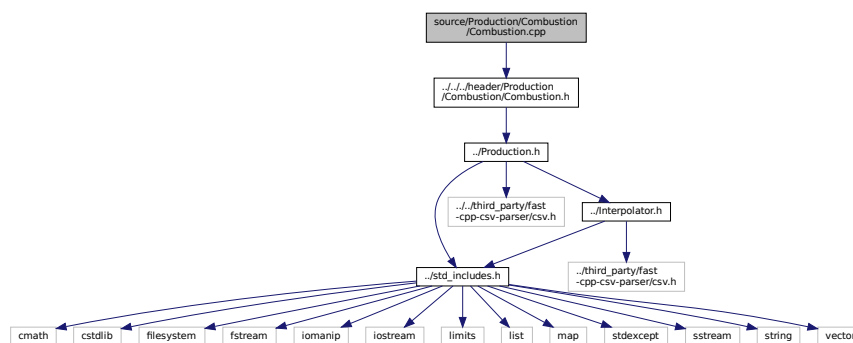
A container class which forms the centre of PGMcpp. The [Model](#) class is intended to serve as the primary user interface with the functionality of PGMcpp, and as such it contains all other classes.

## 5.43 source/Production/Combustion/Combustion.cpp File Reference

Implementation file for the [Combustion](#) class.

```
#include "../../../header/Production/Combustion/Combustion.h"
```

Include dependency graph for Combustion.cpp:



### 5.43.1 Detailed Description

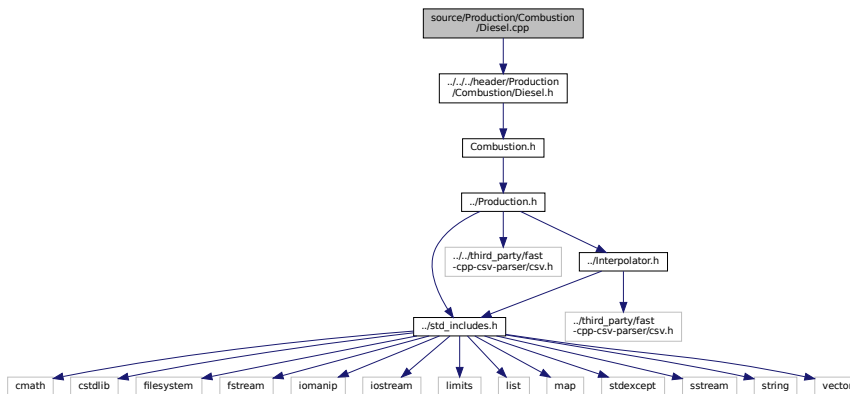
Implementation file for the [Combustion](#) class.

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

## 5.44 source/Production/Combustion/Diesel.cpp File Reference

Implementation file for the [Diesel](#) class.

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



### 5.44.1 Detailed Description

Implementation file for the [Diesel](#) class.

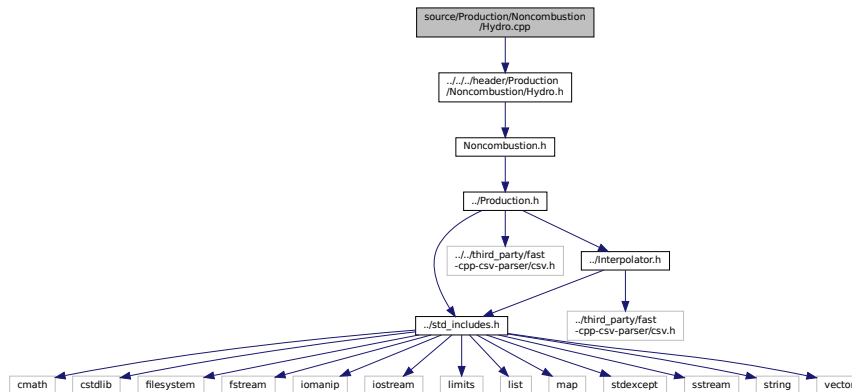
A derived class of the [Combustion](#) branch of [Production](#) which models production using a diesel generator.

## 5.45 source/Production/Noncombustion/Hydro.cpp File Reference

Implementation file for the [Hydro](#) class.

```
#include "../../../../../header/Production/Noncombustion/Hydro.h"
```

Include dependency graph for Hydro.cpp:



### 5.45.1 Detailed Description

Implementation file for the [Hydro](#) class.

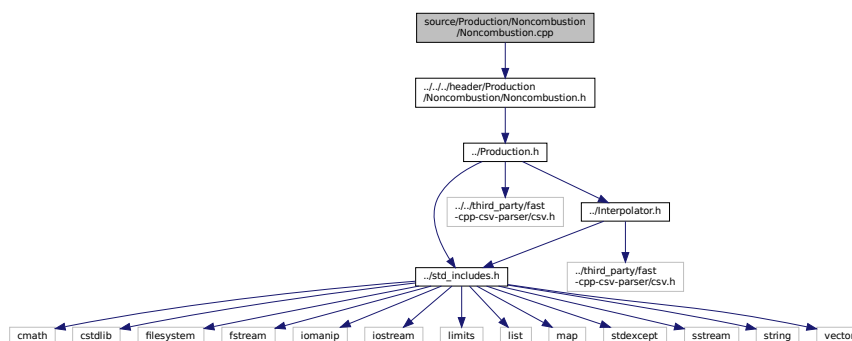
A derived class of the [Noncombustion](#) branch of [Production](#) which models production using a hydroelectric asset (either with reservoir or not).

## 5.46 source/Production/Noncombustion/Noncombustion.cpp File Reference

Implementation file for the [Noncombustion](#) class.

```
#include "../../../../../header/Production/Noncombustion/Noncombustion.h"
```

Include dependency graph for Noncombustion.cpp:



### 5.46.1 Detailed Description

Implementation file for the [Noncombustion](#) class.

The root of the [Noncombustion](#) branch of the [Production](#) hierarchy. This branch contains derived classes which model controllable production which is not based on combustion.

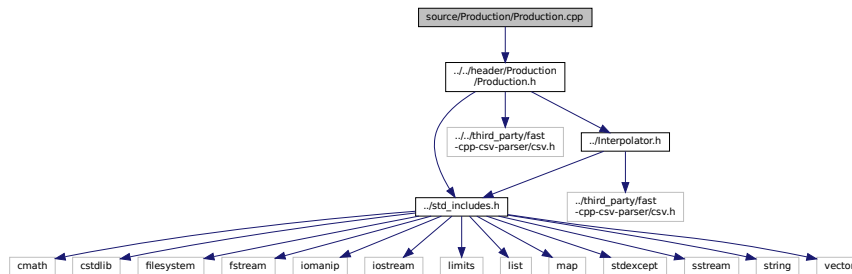


## 5.47 source/Production/Production.cpp File Reference

Implementation file for the [Production](#) class.

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

Include dependency graph for Production.cpp:



### 5.47.1 Detailed Description

Implementation file for the [Production](#) class.

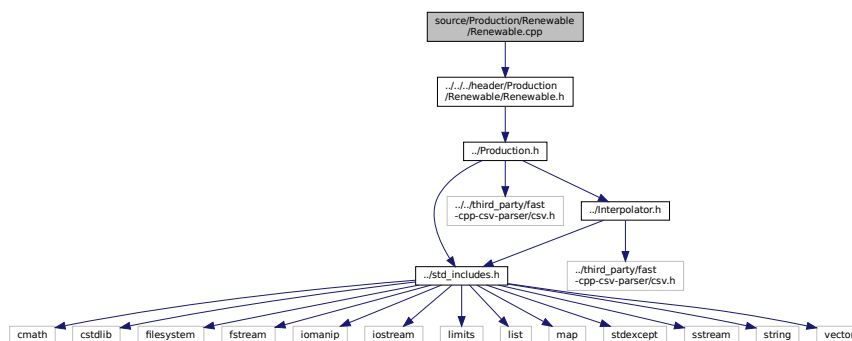
The base class of the [Production](#) hierarchy. This hierarchy contains derived classes which model the production of energy, be it renewable or otherwise.

## 5.48 source/Production/Renewable/Renewable.cpp File Reference

Implementation file for the [Renewable](#) class.

```
#include "../..//header/Production/Renewable/Renewable.h"
```

Include dependency graph for Renewable.cpp:



### 5.48.1 Detailed Description

Implementation file for the [Renewable](#) class.

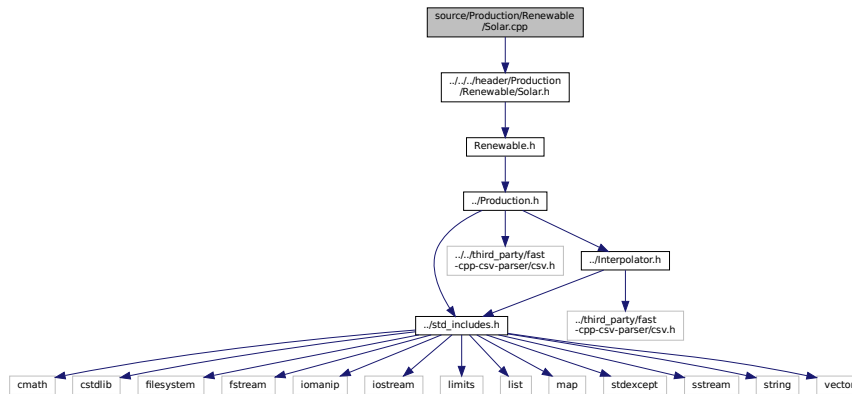
The root of the [Renewable](#) branch of the [Production](#) hierarchy. This branch contains derived classes which model the renewable production of energy.

## 5.49 source/Production/Renewable/Solar.cpp File Reference

Implementation file for the [Solar](#) class.

```
#include "../../../header/Production/Renewable/Solar.h"
```

Include dependency graph for Solar.cpp:



### 5.49.1 Detailed Description

Implementation file for the [Solar](#) class.

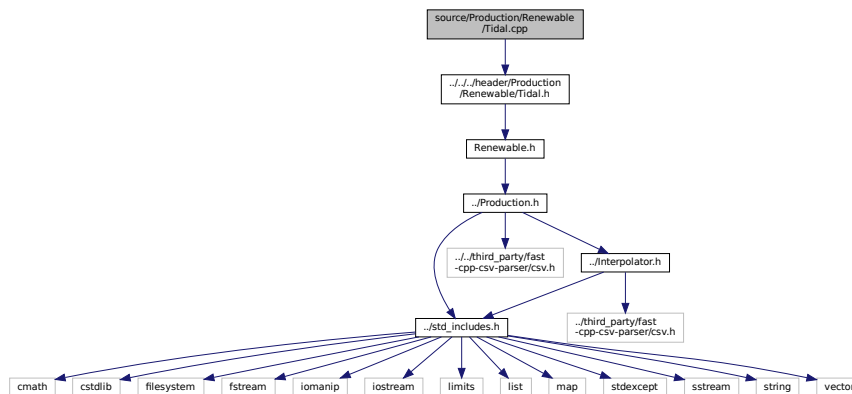
A derived class of the [Renewable](#) branch of [Production](#) which models solar production.

## 5.50 source/Production/Renewable/Tidal.cpp File Reference

Implementation file for the [Tidal](#) class.

```
#include "../../../header/Production/Renewable/Tidal.h"
```

Include dependency graph for Tidal.cpp:



### 5.50.1 Detailed Description

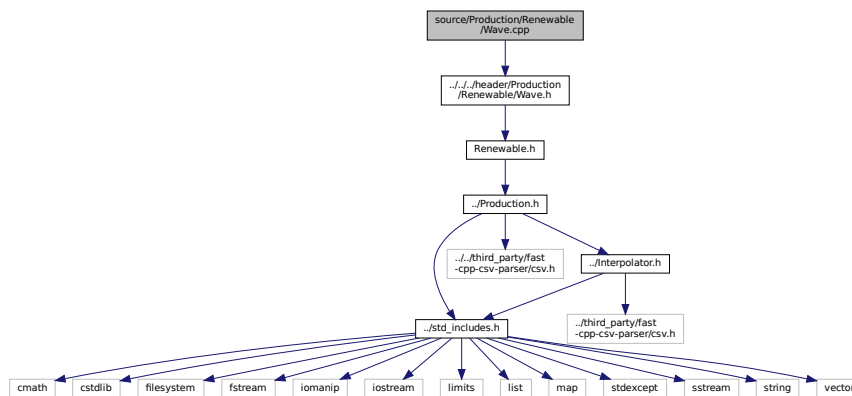
Implementation file for the [Tidal](#) class.

A derived class of the [Renewable](#) branch of [Production](#) which models tidal production.

## 5.51 source/Production/Renewable/Wave.cpp File Reference

Implementation file for the [Wave](#) class.

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



### 5.51.1 Detailed Description

Implementation file for the [Wave](#) class.

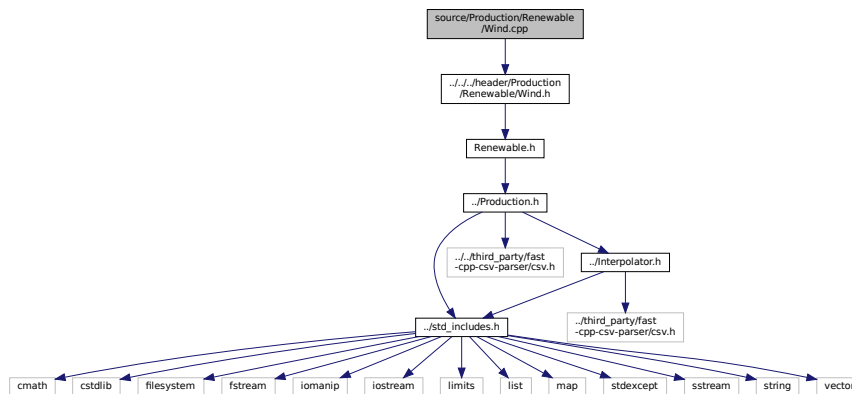
A derived class of the [Renewable](#) branch of [Production](#) which models wave production.

## 5.52 source/Production/Renewable/Wind.cpp File Reference

Implementation file for the [Wind](#) class.

```
#include "../../../header/Production/Renewable/Wind.h"
```

Include dependency graph for Wind.cpp:



### 5.52.1 Detailed Description

Implementation file for the [Wind](#) class.

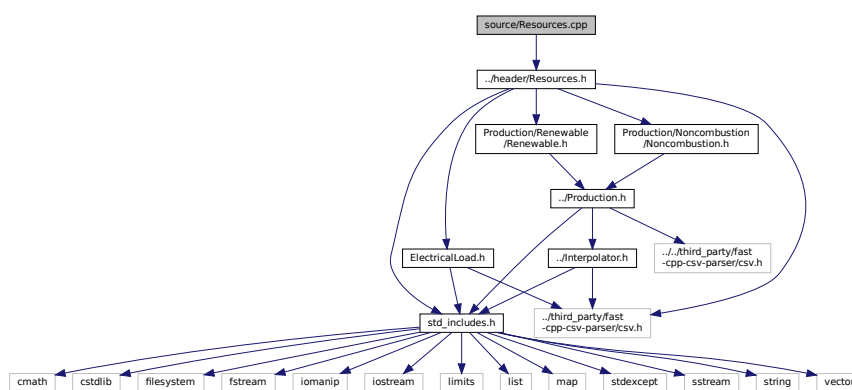
A derived class of the [Renewable](#) branch of [Production](#) which models wind production.

## 5.53 source/Resources.cpp File Reference

Implementation file for the [Resources](#) class.

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

Include dependency graph for Resources.cpp:



### 5.53.1 Detailed Description

Implementation file for the [Resources](#) class.

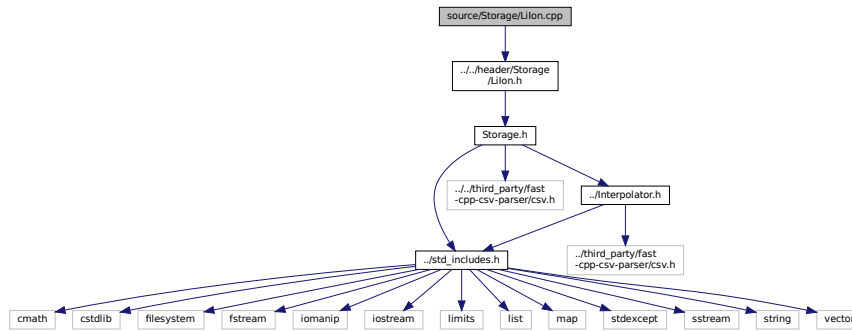
A class which contains renewable resource data. Intended to serve as a component class of [Model](#).

## 5.54 source/Storage/Lilon.cpp File Reference

Implementation file for the [Lilon](#) class.

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

Include dependency graph for Lilon.cpp:



### 5.54.1 Detailed Description

Implementation file for the [Lilon](#) class.

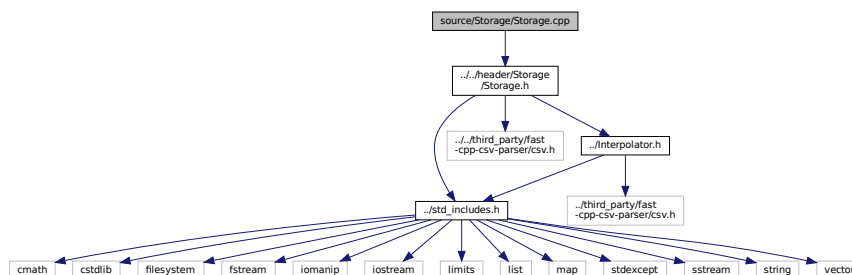
A derived class of [Storage](#) which models energy storage by way of lithium-ion batteries.

## 5.55 source/Storage/Storage.cpp File Reference

Implementation file for the [Storage](#) class.

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

Include dependency graph for Storage.cpp:



### 5.55.1 Detailed Description

Implementation file for the [Storage](#) class.

The base class of the [Storage](#) hierarchy. This hierarchy contains derived classes which model the storage of energy.



## 5.56.2.1 main()

```

int main (
    int argc,
    char ** argv )
115 {
116     #ifdef _WIN32
117         activateVirtualTerminal();
118     #endif /* _WIN32 */
119
120     printGold("\tTesting Production <-- Combustion");
121
122     srand(time(NULL));
123
124
125     Combustion* test_combustion_ptr = testConstruct_Combustion();
126
127
128     try {
129         //...
130     }
131
132
133     catch (...) {
134         delete test_combustion_ptr;
135
136         printGold(" ..... ");
137         printRed("FAIL");
138         std::cout << std::endl;
139         throw;
140     }
141
142
143     delete test_combustion_ptr;
144
145     printGold(" ..... ");
146     printGreen("PASS");
147     std::cout << std::endl;
148     return 0;
149
150 } /* main() */

```

## 5.56.2.2 testConstruct\_Combustion()

```

Combustion * testConstruct_Combustion (
    void )

```

A function to construct a [Combustion](#) object and spot check some post-construction attributes.

## Returns

A pointer to a test [Combustion](#) object.

```

38 {
39     CombustionInputs combustion_inputs;
40
41     Combustion* test_combustion_ptr = new Combustion(8760, 1, combustion_inputs);
42
43     testTruth(
44         not combustion_inputs.production_inputs.print_flag,
45         __FILE__,
46         __LINE__
47     );
48
49     testFloatEquals(
50         test_combustion_ptr->fuel_consumption_vec_L.size(),
51         8760,
52         __FILE__,
53         __LINE__
54     );
55
56     testFloatEquals(
57         test_combustion_ptr->fuel_cost_vec.size(),

```

```

58         8760,
59         __FILE__,
60         __LINE__
61     );
62
63     testFloatEquals(
64         test_combustion_ptr->CO2_emissions_vec_kg.size(),
65         8760,
66         __FILE__,
67         __LINE__
68     );
69
70     testFloatEquals(
71         test_combustion_ptr->CO_emissions_vec_kg.size(),
72         8760,
73         __FILE__,
74         __LINE__
75     );
76
77     testFloatEquals(
78         test_combustion_ptr->NOx_emissions_vec_kg.size(),
79         8760,
80         __FILE__,
81         __LINE__
82     );
83
84     testFloatEquals(
85         test_combustion_ptr->SOx_emissions_vec_kg.size(),
86         8760,
87         __FILE__,
88         __LINE__
89     );
90
91     testFloatEquals(
92         test_combustion_ptr->CH4_emissions_vec_kg.size(),
93         8760,
94         __FILE__,
95         __LINE__
96     );
97
98     testFloatEquals(
99         test_combustion_ptr->PM_emissions_vec_kg.size(),
100        8760,
101        __FILE__,
102        __LINE__
103    );
104
105    return test_combustion_ptr;
106 } /* testConstruct_Combustion() */

```

## 5.57 test/source/Production/Combustion/test\_Diesel.cpp File Reference

Testing suite for [Diesel](#) class.

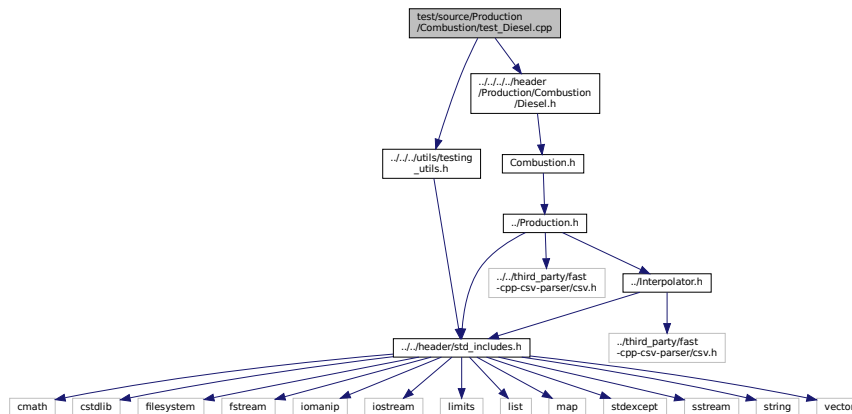
```

#include "../.../utils/testing_utils.h"
#include "../.../header/Production/Combustion/Diesel.h"

```



Include dependency graph for test\_Diesel.cpp:



## Functions

- **Combustion** \* **testConstruct\_Diesel** (void)  
A function to construct a **Diesel** object and spot check some post-construction attributes.
- **Combustion** \* **testConstructLookup\_Diesel** (void)  
A function to construct a **Diesel** object using fuel consumption lookup.
- void **testBadConstruct\_Diesel** (void)  
Function to test the trying to construct a **Diesel** object given bad inputs is being handled as expected.
- void **testCapacityConstraint\_Diesel** (**Combustion** \*test\_diesel\_ptr)  
Test to check that the installed capacity constraint is active and behaving as expected.
- void **testMinimumLoadRatioConstraint\_Diesel** (**Combustion** \*test\_diesel\_ptr)  
Test to check that the minimum load ratio constraint is active and behaving as expected.
- void **testCommit\_Diesel** (**Combustion** \*test\_diesel\_ptr)  
Function to test if the commit method is working as expected, by checking some post-call attributes of the test **Diesel** object.
- void **testMinimumRuntimeConstraint\_Diesel** (**Combustion** \*test\_diesel\_ptr)  
Function to check that the minimum runtime constraint is active and behaving as expected.
- void **testFuelConsumptionEmissions\_Diesel** (**Combustion** \*test\_diesel\_ptr)  
Function to test that post-commit fuel consumption and emissions are > 0 when the test **Diesel** object is running, and = 0 when it is not (as expected).
- void **testEconomics\_Diesel** (**Combustion** \*test\_diesel\_ptr)  
Function to test that the post-commit model economics for the test **Diesel** object are as expected (> 0 when running, = 0 when not).
- void **testFuelLookup\_Diesel** (**Combustion** \*test\_diesel\_lookup\_ptr)  
Function to test that fuel consumption lookup (i.e., interpolation) is returning the expected values.
- int **main** (int argc, char \*\*argv)

### 5.57.1 Detailed Description

Testing suite for **Diesel** class.

A suite of tests for the **Diesel** class.

## 5.57.2 Function Documentation

### 5.57.2.1 main()

```

int main (
    int argc,
    char ** argv )
677 {
678     #ifdef _WIN32
679         activateVirtualTerminal();
680     #endif /* _WIN32 */
681
682     printGold("\tTesting Production <-- Combustion <-- Diesel");
683
684     srand(time(NULL));
685
686
687     Combustion* test_diesel_ptr = testConstruct_Diesel();
688     Combustion* test_diesel_lookup_ptr = testConstructLookup_Diesel();
689
690     try {
691         testBadConstruct_Diesel();
692
693         testCapacityConstraint_Diesel(test_diesel_ptr);
694         testMinimumLoadRatioConstraint_Diesel(test_diesel_ptr);
695
696         testCommit_Diesel(test_diesel_ptr);
697
698         testMinimumRuntimeConstraint_Diesel(test_diesel_ptr);
699
700         testFuelConsumptionEmissions_Diesel(test_diesel_ptr);
701         testEconomics_Diesel(test_diesel_ptr);
702
703         testFuelLookup_Diesel(test_diesel_lookup_ptr);
704     }
705
706
707     catch (...) {
708         delete test_diesel_ptr;
709         delete test_diesel_lookup_ptr;
710
711         printGold(" ..... ");
712         printRed("FAIL");
713         std::cout << std::endl;
714         throw;
715     }
716
717
718     delete test_diesel_ptr;
719     delete test_diesel_lookup_ptr;
720
721     printGold(" ..... ");
722     printGreen("PASS");
723     std::cout << std::endl;
724     return 0;
725
726 } /* main() */

```

### 5.57.2.2 testBadConstruct\_Diesel()

```

void testBadConstruct_Diesel (
    void )

```

Function to test the trying to construct a [Diesel](#) object given bad inputs is being handled as expected.

```

155 {
156     bool error_flag = true;
157
158     try {
159         DieselInputs bad_diesel_inputs;

```

```

160         bad_diesel_inputs.fuel_cost_L = -1;
161
162         Diesel bad_diesel(8760, 1, bad_diesel_inputs);
163
164         error_flag = false;
165     } catch (...) {
166         // Task failed successfully! =P
167     }
168     if (not error_flag) {
169         expectedErrorNotDetected(__FILE__, __LINE__);
170     }
171
172     return;
173 } /* testBadConstruct_Diesel() */

```

### 5.57.2.3 testCapacityConstraint\_Diesel()

```

void testCapacityConstraint_Diesel (
    Combustion * test_diesel_ptr )

```

Test to check that the installed capacity constraint is active and behaving as expected.

#### Parameters

<i>test_diesel_ptr</i>	A <a href="#">Combustion</a> pointer to the test <a href="#">Diesel</a> object.
------------------------	---

```

191 {
192     testFloatEquals(
193         test_diesel_ptr->requestProductionkW(0, 1, 2 * test_diesel_ptr->capacity_kW),
194         test_diesel_ptr->capacity_kW,
195         __FILE__,
196         __LINE__
197     );
198
199     return;
200 } /* testCapacityConstraint_Diesel() */

```

### 5.57.2.4 testCommit\_Diesel()

```

void testCommit_Diesel (
    Combustion * test_diesel_ptr )

```

Function to test if the commit method is working as expected, by checking some post-call attributes of the test [Diesel](#) object.

#### Parameters

<i>test_diesel_ptr</i>	A <a href="#">Combustion</a> pointer to the test <a href="#">Diesel</a> object.
------------------------	---

```

250 {
251     std::vector<double> dt_vec_hrs (48, 1);
252
253     std::vector<double> load_vec_kW = {
254         1, 1, 0, 1, 0, 0, 1, 1, 1, 0, 1, 1,
255         1, 1, 1, 0, 0, 0, 0, 0, 0, 1, 1, 0,
256         1, 1, 1, 1, 1, 0, 1, 1, 1, 1, 0, 1,
257         1, 0, 0, 0, 1, 1, 1, 0, 1, 1, 0, 0
258     };
259
260     double load_kW = 0;
261     double production_kW = 0;

```

```

262     double roll = 0;
263
264     for (int i = 0; i < 48; i++) {
265         roll = (double)rand() / RAND_MAX;
266
267         if (roll >= 0.95) {
268             roll = 1.25;
269         }
270
271         load_vec_kW[i] *= roll * test_diesel_ptr->capacity_kW;
272         load_kW = load_vec_kW[i];
273
274         production_kW = test_diesel_ptr->requestProductionkW(
275             i,
276             dt_vec_hrs[i],
277             load_kW
278         );
279
280         load_kW = test_diesel_ptr->commit(
281             i,
282             dt_vec_hrs[i],
283             production_kW,
284             load_kW
285         );
286
287         // load_kW <= load_vec_kW (i.e., after vs before)
288         testLessThanOrEqualTo(
289             load_kW,
290             load_vec_kW[i],
291             __FILE__,
292             __LINE__
293         );
294
295         // production = dispatch + storage + curtailment
296         testFloatEquals(
297             test_diesel_ptr->production_vec_kW[i] -
298             test_diesel_ptr->dispatch_vec_kW[i] -
299             test_diesel_ptr->storage_vec_kW[i] -
300             test_diesel_ptr->curtailment_vec_kW[i],
301             0,
302             __FILE__,
303             __LINE__
304         );
305
306         // capacity constraint
307         if (load_vec_kW[i] > test_diesel_ptr->capacity_kW) {
308             testFloatEquals(
309                 test_diesel_ptr->production_vec_kW[i],
310                 test_diesel_ptr->capacity_kW,
311                 __FILE__,
312                 __LINE__
313             );
314         }
315
316         // minimum load ratio constraint
317         else if (
318             test_diesel_ptr->is_running and
319             test_diesel_ptr->production_vec_kW[i] > 0 and
320             load_vec_kW[i] <
321             ((Diesel*)test_diesel_ptr)->minimum_load_ratio * test_diesel_ptr->capacity_kW
322         ) {
323             testFloatEquals(
324                 test_diesel_ptr->production_vec_kW[i],
325                 ((Diesel*)test_diesel_ptr)->minimum_load_ratio *
326                 test_diesel_ptr->capacity_kW,
327                 __FILE__,
328                 __LINE__
329             );
330         }
331     }
332
333     return;
334 } /* testCommit_Diesel() */

```

### 5.57.2.5 testConstruct\_Diesel()

```

Combustion * testConstruct_Diesel (
    void )

```

A function to construct a [Diesel](#) object and spot check some post-construction attributes.

## Returns

A [Combustion](#) pointer to a test [Diesel](#) object.

```

38 {
39     DieselInputs diesel_inputs;
40
41     Combustion* test_diesel_ptr = new Diesel(8760, 1, diesel_inputs);
42
43     testTruth(
44         not diesel_inputs.combustion_inputs.production_inputs.print_flag,
45         __FILE__,
46         __LINE__
47     );
48
49     testFloatEquals(
50         test_diesel_ptr->type,
51         CombustionType :: DIESEL,
52         __FILE__,
53         __LINE__
54     );
55
56     testTruth(
57         test_diesel_ptr->type_str == "DIESEL",
58         __FILE__,
59         __LINE__
60     );
61
62     testFloatEquals(
63         test_diesel_ptr->linear_fuel_slope_LkWh,
64         0.265675,
65         __FILE__,
66         __LINE__
67     );
68
69     testFloatEquals(
70         test_diesel_ptr->linear_fuel_intercept_LkWh,
71         0.026676,
72         __FILE__,
73         __LINE__
74     );
75
76     testFloatEquals(
77         test_diesel_ptr->capital_cost,
78         94125.375446,
79         __FILE__,
80         __LINE__
81     );
82
83     testFloatEquals(
84         test_diesel_ptr->operation_maintenance_cost_kWh,
85         0.069905,
86         __FILE__,
87         __LINE__
88     );
89
90     testFloatEquals(
91         ((Diesel*)test_diesel_ptr)->minimum_load_ratio,
92         0.2,
93         __FILE__,
94         __LINE__
95     );
96
97     testFloatEquals(
98         ((Diesel*)test_diesel_ptr)->minimum_runtime_hrs,
99         4,
100        __FILE__,
101        __LINE__
102    );
103
104    testFloatEquals(
105        test_diesel_ptr->replace_running_hrs,
106        30000,
107        __FILE__,
108        __LINE__
109    );
110
111    return test_diesel_ptr;
112 } /* testConstruct_Diesel() */

```

## 5.57.2.6 testConstructLookup\_Diesel()

```
Combustion * testConstructLookup_Diesel (
```

```
void )
```

A function to construct a [Diesel](#) object using fuel consumption lookup.

#### Returns

A [Combustion](#) pointer to a test [Diesel](#) object.

```
129 {
130     DieselInputs diesel_inputs;
131
132     diesel_inputs.combustion_inputs.fuel_mode = FuelMode :: FUEL_MODE_LOOKUP;
133     diesel_inputs.combustion_inputs.path_2_fuel_interp_data =
134         "data/test/interpolation/diesel_fuel_curve.csv";
135
136     Combustion* test_diesel_lookup_ptr = new Diesel(8760, 1, diesel_inputs);
137
138     return test_diesel_lookup_ptr;
139 } /* testConstructLookupDiesel() */
```

#### 5.57.2.7 testEconomics\_Diesel()

```
void testEconomics_Diesel (
    Combustion * test_diesel_ptr )
```

Function to test that the post-commit model economics for the test [Diesel](#) object are as expected (> 0 when running, = 0 when not).

#### Parameters

<i>test_diesel_ptr</i>	A <a href="#">Combustion</a> pointer to the test <a href="#">Diesel</a> object.
------------------------	---

```
554 {
555     std::vector<bool> expected_is_running_vec = {
556         1, 1, 1, 1, 0, 0, 1, 1, 1, 1, 1, 1,
557         1, 1, 1, 0, 0, 0, 0, 0, 0, 1, 1, 1,
558         1, 1, 1, 1, 1, 0, 1, 1, 1, 1, 0, 1,
559         1, 1, 1, 0, 1, 1, 1, 1, 1, 1, 0, 0
560     };
561
562     bool is_running = false;
563
564     for (int i = 0; i < 48; i++) {
565         is_running = test_diesel_ptr->is_running_vec[i];
566
567         testFloatEquals(
568             is_running,
569             expected_is_running_vec[i],
570             __FILE__,
571             __LINE__
572         );
573
574         // O&M, fuel consumption, and emissions > 0 whenever diesel is running
575         if (is_running) {
576             testGreaterThan(
577                 test_diesel_ptr->operation_maintenance_cost_vec[i],
578                 0,
579                 __FILE__,
580                 __LINE__
581             );
582         }
583
584         // O&M, fuel consumption, and emissions = 0 whenever diesel is not running
585         else {
586             testFloatEquals(
587                 test_diesel_ptr->operation_maintenance_cost_vec[i],
588                 0,
589                 __FILE__,
590                 __LINE__
591             );
592         }
593     }
```

```

593     }
594
595     return;
596 } /* testEconomics_Diesel() */

```

### 5.57.2.8 testFuelConsumptionEmissions\_Diesel()

```

void testFuelConsumptionEmissions_Diesel (
    Combustion * test_diesel_ptr )

```

Function to test that post-commit fuel consumption and emissions are  $> 0$  when the test Diesel object is running, and  $= 0$  when it is not (as expected).

#### Parameters

<i>test_diesel_ptr</i>	A Combustion pointer to the test Diesel object.
------------------------	---

```

396 {
397     std::vector<bool> expected_is_running_vec = {
398         1, 1, 1, 1, 0, 0, 1, 1, 1, 1, 1, 1,
399         1, 1, 1, 0, 0, 0, 0, 0, 1, 1, 1,
400         1, 1, 1, 1, 1, 0, 1, 1, 1, 1, 0, 1,
401         1, 1, 1, 0, 1, 1, 1, 1, 1, 1, 0, 0
402     };
403
404     bool is_running = false;
405
406     for (int i = 0; i < 48; i++) {
407         is_running = test_diesel_ptr->is_running_vec[i];
408
409         testFloatEquals(
410             is_running,
411             expected_is_running_vec[i],
412             __FILE__,
413             __LINE__
414         );
415
416         // O&M, fuel consumption, and emissions > 0 whenever diesel is running
417         if (is_running) {
418             testGreaterThan(
419                 test_diesel_ptr->fuel_consumption_vec_L[i],
420                 0,
421                 __FILE__,
422                 __LINE__
423             );
424
425             testGreaterThan(
426                 test_diesel_ptr->fuel_cost_vec[i],
427                 0,
428                 __FILE__,
429                 __LINE__
430             );
431
432             testGreaterThan(
433                 test_diesel_ptr->CO2_emissions_vec_kg[i],
434                 0,
435                 __FILE__,
436                 __LINE__
437             );
438
439             testGreaterThan(
440                 test_diesel_ptr->CO_emissions_vec_kg[i],
441                 0,
442                 __FILE__,
443                 __LINE__
444             );
445
446             testGreaterThan(
447                 test_diesel_ptr->NOx_emissions_vec_kg[i],
448                 0,
449                 __FILE__,
450                 __LINE__
451             );
452

```

```

453         testGreaterThan(
454             test_diesel_ptr->SOx_emissions_vec_kg[i],
455             0,
456             __FILE__,
457             __LINE__
458         );
459
460         testGreaterThan(
461             test_diesel_ptr->CH4_emissions_vec_kg[i],
462             0,
463             __FILE__,
464             __LINE__
465         );
466
467         testGreaterThan(
468             test_diesel_ptr->PM_emissions_vec_kg[i],
469             0,
470             __FILE__,
471             __LINE__
472         );
473     }
474
475     // O&M, fuel consumption, and emissions = 0 whenever diesel is not running
476     else {
477         testFloatEquals(
478             test_diesel_ptr->fuel_consumption_vec_L[i],
479             0,
480             __FILE__,
481             __LINE__
482         );
483
484         testFloatEquals(
485             test_diesel_ptr->fuel_cost_vec[i],
486             0,
487             __FILE__,
488             __LINE__
489         );
490
491         testFloatEquals(
492             test_diesel_ptr->CO2_emissions_vec_kg[i],
493             0,
494             __FILE__,
495             __LINE__
496         );
497
498         testFloatEquals(
499             test_diesel_ptr->CO_emissions_vec_kg[i],
500             0,
501             __FILE__,
502             __LINE__
503         );
504
505         testFloatEquals(
506             test_diesel_ptr->NOx_emissions_vec_kg[i],
507             0,
508             __FILE__,
509             __LINE__
510         );
511
512         testFloatEquals(
513             test_diesel_ptr->SOx_emissions_vec_kg[i],
514             0,
515             __FILE__,
516             __LINE__
517         );
518
519         testFloatEquals(
520             test_diesel_ptr->CH4_emissions_vec_kg[i],
521             0,
522             __FILE__,
523             __LINE__
524         );
525
526         testFloatEquals(
527             test_diesel_ptr->PM_emissions_vec_kg[i],
528             0,
529             __FILE__,
530             __LINE__
531         );
532     }
533 }
534
535 return;
536 } /* testFuelConsumptionEmissions_Diesel() */

```



### 5.57.2.9 testFuelLookup\_Diesel()

```
void testFuelLookup_Diesel (
    Combustion * test_diesel_lookup_ptr )
```

Function to test that fuel consumption lookup (i.e., interpolation) is returning the expected values.

#### Parameters

<code>test_diesel_lookup_ptr</code>	A <a href="#">Combustion</a> pointer to the test <a href="#">Diesel</a> object using fuel consumption lookup.
-------------------------------------	---

```
615 {
616     std::vector<double> load_ratio_vec = {
617         0,
618         0.170812859791767,
619         0.322739274162545,
620         0.369750203682042,
621         0.443532869135929,
622         0.471567864244626,
623         0.536513734479662,
624         0.586125806988674,
625         0.601101175455075,
626         0.658356862575221,
627         0.70576929893201,
628         0.784069734739331,
629         0.805765927542453,
630         0.884747873186048,
631         0.930870496062112,
632         0.979415217694769,
633         1
634     };
635
636     std::vector<double> expected_fuel_consumption_vec_L = {
637         4.68079520372916,
638         8.35159603357656,
639         11.7422361561399,
640         12.9931187917615,
641         14.8786636301325,
642         15.5746957307243,
643         17.1419229487141,
644         18.3041866133728,
645         18.6530540913696,
646         19.9569217633299,
647         21.012354614584,
648         22.7142305879957,
649         23.1916726441968,
650         24.8602332554707,
651         25.8172124624032,
652         26.8256741279932,
653         27.254952
654     };
655
656     for (size_t i = 0; i < load_ratio_vec.size(); i++) {
657         testFloatEquals(
658             test_diesel_lookup_ptr->getFuelConsumptionL(
659                 1, load_ratio_vec[i] * test_diesel_lookup_ptr->capacity_kW
660             ),
661             expected_fuel_consumption_vec_L[i],
662             __FILE__,
663             __LINE__
664         );
665     }
666
667     return;
668 } /* testFuelLookup_Diesel() */
```

### 5.57.2.10 testMinimumLoadRatioConstraint\_Diesel()

```
void testMinimumLoadRatioConstraint_Diesel (
    Combustion * test_diesel_ptr )
```

Test to check that the minimum load ratio constraint is active and behaving as expected.

## Parameters

<code>test_diesel_ptr</code>	A <a href="#">Combustion</a> pointer to the test <a href="#">Diesel</a> object.
------------------------------	---

```

218 {
219     testFloatEquals(
220         test_diesel_ptr->requestProductionkW(
221             0,
222             1,
223             0.5 * ((Diesel*)test_diesel_ptr)->minimum_load_ratio *
224                 test_diesel_ptr->capacity_kW
225         ),
226         ((Diesel*)test_diesel_ptr)->minimum_load_ratio * test_diesel_ptr->capacity_kW,
227         __FILE__,
228         __LINE__
229     );
230
231     return;
232 } /* testMinimumLoadRatioConstraint_Diesel() */

```

## 5.57.2.11 testMinimumRuntimeConstraint\_Diesel()

```

void testMinimumRuntimeConstraint_Diesel (
    Combustion * test_diesel_ptr )

```

Function to check that the minimum runtime constraint is active and behaving as expected.

## Parameters

<code>test_diesel_ptr</code>	A <a href="#">Combustion</a> pointer to the test <a href="#">Diesel</a> object.
------------------------------	---

```

352 {
353     std::vector<double> load_vec_kW = {
354         1, 1, 0, 1, 0, 0, 1, 1, 1, 0, 1, 1,
355         1, 1, 1, 0, 0, 0, 0, 0, 0, 1, 1, 0,
356         1, 1, 1, 1, 1, 0, 1, 1, 1, 1, 0, 1,
357         1, 0, 0, 0, 1, 1, 1, 0, 1, 1, 0, 0
358     };
359
360     std::vector<bool> expected_is_running_vec = {
361         1, 1, 1, 1, 0, 0, 1, 1, 1, 1, 1, 1,
362         1, 1, 1, 0, 0, 0, 0, 0, 0, 1, 1, 1,
363         1, 1, 1, 1, 1, 0, 1, 1, 1, 1, 0, 1,
364         1, 1, 1, 0, 1, 1, 1, 1, 1, 1, 0, 0
365     };
366
367     for (int i = 0; i < 48; i++) {
368         testFloatEquals(
369             test_diesel_ptr->is_running_vec[i],
370             expected_is_running_vec[i],
371             __FILE__,
372             __LINE__
373         );
374     }
375
376     return;
377 } /* testMinimumRuntimeConstraint_Diesel() */

```

## 5.58 test/source/Production/Noncombustion/test\_Hydro.cpp File Reference

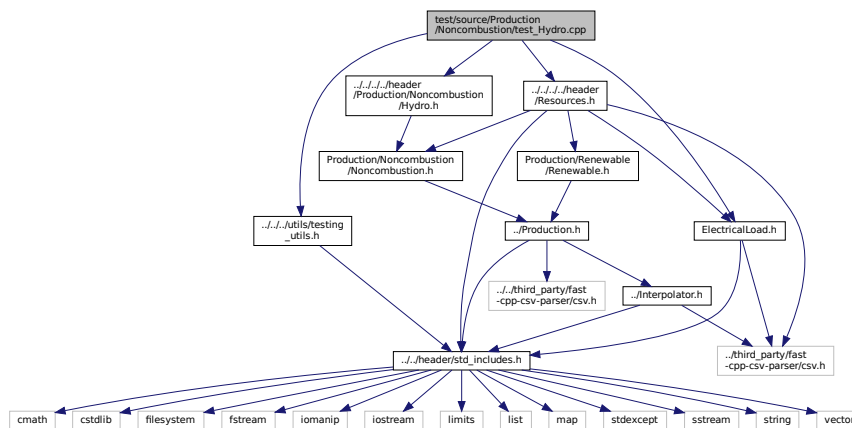
Testing suite for [Hydro](#) class.

```

#include "../.../utils/testing_utils.h"
#include "../.../header/Resources.h"

```

```
#include "../../../header/ElectricalLoad.h"
#include "../../../header/Production/Noncombustion/Hydro.h"
Include dependency graph for test_Hydro.cpp:
```



## Functions

- [Noncombustion](#) \* [testConstruct\\_Hydro](#) ([HydroInputs](#) hydro\_inputs)
- void [testEfficiencyInterpolation\\_Hydro](#) ([Noncombustion](#) \*test\_hydro\_ptr)
 

*Function to test that the generator and turbine efficiency maps are being initialized as expected, and that efficiency interpolation is returning the expected values.*
- void [testCommit\\_Hydro](#) ([Noncombustion](#) \*test\_hydro\_ptr, [Resources](#) \*test\_resources\_ptr)
- int [main](#) (int argc, char \*\*argv)

### 5.58.1 Detailed Description

Testing suite for [Hydro](#) class.

A suite of tests for the [Hydro](#) class.

### 5.58.2 Function Documentation

#### 5.58.2.1 main()

```
int main (
    int argc,
    char ** argv )
294 {
295     #ifdef _WIN32
296         activateVirtualTerminal();
297     #endif /* _WIN32 */
298
299     printGold("\tTesting Production <-- Noncombustion <-- Hydro");
300
301     srand(time(NULL));
```

```

302
303
304     std::string path_2_electrical_load_time_series =
305         "data/test/electrical_load/electrical_load_generic_peak-500kW_1yr_dt-1hr.csv";
306
307     ElectricalLoad* test_electrical_load_ptr =
308         new ElectricalLoad(path_2_electrical_load_time_series);
309
310     Resources* test_resources_ptr = new Resources();
311
312     HydroInputs hydro_inputs;
313     int hydro_resource_key = 0;
314
315     hydro_inputs.reservoir_capacity_m3 = 10000;
316     hydro_inputs.resource_key = hydro_resource_key;
317
318     Noncombustion* test_hydro_ptr = testConstruct_Hydro(hydro_inputs);
319
320     std::string path_2_hydro_resource_data =
321         "data/test/resources/hydro_inflow_peak-20000m3hr_1yr_dt-1hr.csv";
322
323     test_resources_ptr->addResource(
324         NoncombustionType::HYDRO,
325         path_2_hydro_resource_data,
326         hydro_resource_key,
327         test_electrical_load_ptr
328     );
329
330
331     try {
332         testEfficiencyInterpolation_Hydro(test_hydro_ptr);
333         testCommit_Hydro(test_hydro_ptr, test_resources_ptr);
334     }
335
336     catch (...) {
337         delete test_electrical_load_ptr;
338         delete test_resources_ptr;
339         delete test_hydro_ptr;
340
341         printGold(" ... ");
342         printRed("FAIL");
343         std::cout << std::endl;
344         throw;
345     }
346
347
348     delete test_electrical_load_ptr;
349     delete test_resources_ptr;
350     delete test_hydro_ptr;
351
352     printGold(" ... ");
353     printGreen("PASS");
354     std::cout << std::endl;
355     return 0;
356
357
358 } /* main() */

```

### 5.58.2.2 testCommit\_Hydro()

```

void testCommit_Hydro (
    Noncombustion * test_hydro_ptr,
    Resources * test_resources_ptr )
211 {
212     double load_kW = 100 * (double)rand() / RAND_MAX;
213     double production_kW = 0;
214
215     for (int i = 0; i < 8760; i++) {
216         production_kW = test_hydro_ptr->requestProductionkW(
217             i,
218             1,
219             load_kW,
220             test_resources_ptr->resource_map_1D[test_hydro_ptr->resource_key][i]
221         );
222
223         load_kW = test_hydro_ptr->commit(
224             i,
225             1,
226             production_kW,

```

```

227         load_kW,
228         test_resources_ptr->resource_map_1D[test_hydro_ptr->resource_key][i]
229     );
230
231     testGreaterThanOrEqualTo(
232         test_hydro_ptr->production_vec_kW[i],
233         0,
234         __FILE__,
235         __LINE__
236     );
237
238     testLessThanOrEqualTo(
239         test_hydro_ptr->production_vec_kW[i],
240         test_hydro_ptr->capacity_kW,
241         __FILE__,
242         __LINE__
243     );
244
245     testFloatEquals(
246         test_hydro_ptr->production_vec_kW[i] -
247         test_hydro_ptr->dispatch_vec_kW[i] -
248         test_hydro_ptr->curtailment_vec_kW[i] -
249         test_hydro_ptr->storage_vec_kW[i],
250         0,
251         __FILE__,
252         __LINE__
253     );
254
255     testGreaterThanOrEqualTo(
256         ((Hydro*)test_hydro_ptr)->turbine_flow_vec_m3hr[i],
257         0,
258         __FILE__,
259         __LINE__
260     );
261
262     testLessThanOrEqualTo(
263         ((Hydro*)test_hydro_ptr)->turbine_flow_vec_m3hr[i],
264         ((Hydro*)test_hydro_ptr)->maximum_flow_m3hr,
265         __FILE__,
266         __LINE__
267     );
268
269     testGreaterThanOrEqualTo(
270         ((Hydro*)test_hydro_ptr)->stored_volume_vec_m3[i],
271         0,
272         __FILE__,
273         __LINE__
274     );
275
276     testLessThanOrEqualTo(
277         ((Hydro*)test_hydro_ptr)->stored_volume_vec_m3[i],
278         ((Hydro*)test_hydro_ptr)->reservoir_capacity_m3,
279         __FILE__,
280         __LINE__
281     );
282 }
283
284 return;
285 } /* testCommit_Hydro() */

```

### 5.58.2.3 testConstruct\_Hydro()

```

Noncombustion* testConstruct_Hydro (
    HydroInputs hydro_inputs )
41 {
42     Noncombustion* test_hydro_ptr = new Hydro(8760, 1, hydro_inputs);
43
44     testTruth(
45         not hydro_inputs.noncombustion_inputs.production_inputs.print_flag,
46         __FILE__,
47         __LINE__
48     );
49
50     testFloatEquals(
51         test_hydro_ptr->n_points,
52         8760,
53         __FILE__,
54         __LINE__
55     );

```

```

56
57     testFloatEquals(
58         test_hydro_ptr->type,
59         NoncombustionType :: HYDRO,
60         __FILE__,
61         __LINE__
62     );
63
64     testTruth(
65         test_hydro_ptr->type_str == "HYDRO",
66         __FILE__,
67         __LINE__
68     );
69
70     testFloatEquals(
71         ((Hydro*)test_hydro_ptr)->turbine_type,
72         HydroTurbineType :: HYDRO_TURBINE_PELTON,
73         __FILE__,
74         __LINE__
75     );
76
77     testFloatEquals(
78         ((Hydro*)test_hydro_ptr)->reservoir_capacity_m3,
79         10000,
80         __FILE__,
81         __LINE__
82     );
83
84     return test_hydro_ptr;
85 } /* testConstruct_Hydro() */

```

#### 5.58.2.4 testEfficiencyInterpolation\_Hydro()

```

void testEfficiencyInterpolation_Hydro (
    Noncombustion * test_hydro_ptr )

```

Function to test that the generator and turbine efficiency maps are being initialized as expected, and that efficiency interpolation is returning the expected values.

##### Parameters

<i>test_hydro_ptr</i>	A <a href="#">Noncombustion</a> pointer to the test <a href="#">Hydro</a> object.
-----------------------	---

```

104 {
105     std::vector<double> expected_gen_power_ratios = {
106         0, 0.1, 0.2, 0.3, 0.4, 0.5,
107         0.6, 0.7, 0.75, 0.8, 0.9, 1
108     };
109
110     std::vector<double> expected_gen_efficiencies = {
111         0.000, 0.800, 0.900, 0.913,
112         0.925, 0.943, 0.947, 0.950,
113         0.953, 0.954, 0.956, 0.958
114     };
115
116     double query = 0;
117     for (size_t i = 0; i < expected_gen_power_ratios.size(); i++) {
118         testFloatEquals(
119             test_hydro_ptr->interpolator.interp_map_1D[
120                 HydroInterpKeys :: GENERATOR_EFFICIENCY_INTERP_KEY
121             ].x_vec[i],
122             expected_gen_power_ratios[i],
123             __FILE__,
124             __LINE__
125         );
126
127         testFloatEquals(
128             test_hydro_ptr->interpolator.interp_map_1D[
129                 HydroInterpKeys :: GENERATOR_EFFICIENCY_INTERP_KEY
130             ].y_vec[i],
131             expected_gen_efficiencies[i],
132             __FILE__,
133             __LINE__
134         );

```

```

135
136     if (i < expected_gen_power_ratios.size() - 1) {
137         query = expected_gen_power_ratios[i] + ((double)rand() / RAND_MAX) *
138             (expected_gen_power_ratios[i + 1] - expected_gen_power_ratios[i]);
139
140         test_hydro_ptr->interpolator.interp1D(
141             HydroInterpKeys :: GENERATOR_EFFICIENCY_INTERP_KEY,
142             query
143         );
144     }
145 }
146
147 std::vector<double> expected_turb_power_ratios = {
148     0, 0.1, 0.2, 0.3, 0.4,
149     0.5, 0.6, 0.7, 0.8, 0.9,
150     1
151 };
152
153 std::vector<double> expected_turb_efficiencies = {
154     0.000, 0.780, 0.855, 0.875, 0.890,
155     0.900, 0.908, 0.913, 0.918, 0.908,
156     0.880
157 };
158
159 for (size_t i = 0; i < expected_turb_power_ratios.size(); i++) {
160     testFloatEquals(
161         test_hydro_ptr->interpolator.interp_map_1D[
162             HydroInterpKeys :: TURBINE_EFFICIENCY_INTERP_KEY
163         ].x_vec[i],
164         expected_turb_power_ratios[i],
165         __FILE__,
166         __LINE__
167     );
168
169     testFloatEquals(
170         test_hydro_ptr->interpolator.interp_map_1D[
171             HydroInterpKeys :: TURBINE_EFFICIENCY_INTERP_KEY
172         ].y_vec[i],
173         expected_turb_efficiencies[i],
174         __FILE__,
175         __LINE__
176     );
177
178     if (i < expected_turb_power_ratios.size() - 1) {
179         query = expected_turb_power_ratios[i] + ((double)rand() / RAND_MAX) *
180             (expected_turb_power_ratios[i + 1] - expected_turb_power_ratios[i]);
181
182         test_hydro_ptr->interpolator.interp1D(
183             HydroInterpKeys :: TURBINE_EFFICIENCY_INTERP_KEY,
184             query
185         );
186     }
187 }
188
189 return;
190 } /* testEfficiencyInterpolation_Hydro() */

```

## 5.59 test/source/Production/Noncombustion/test\_Noncombustion.cpp File Reference

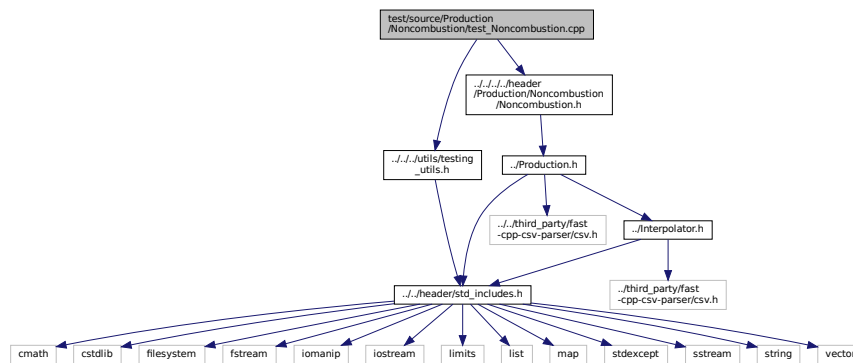
Testing suite for [Noncombustion](#) class.

```

#include "../.../utils/testing_utils.h"
#include "../.../header/Production/Noncombustion/Noncombustion.h"

```

Include dependency graph for test\_Noncombustion.cpp:



## Functions

- [Noncombustion](#) \* [testConstruct\\_Noncombustion](#) (void)  
A function to construct a [Noncombustion](#) object and spot check some post-construction attributes.
- int [main](#) (int argc, char \*\*argv)

### 5.59.1 Detailed Description

Testing suite for [Noncombustion](#) class.

A suite of tests for the [Noncombustion](#) class.

### 5.59.2 Function Documentation

#### 5.59.2.1 main()

```

int main (
    int argc,
    char ** argv )
{
    67 {
    68     #ifdef _WIN32
    69         activateVirtualTerminal();
    70     #endif /* _WIN32 */
    71
    72     printGold("\tTesting Production <-- Noncombustion");
    73
    74     srand(time(NULL));
    75
    76
    77     Noncombustion* test_noncombustion_ptr = testConstruct_Noncombustion();
    78
    79
    80     try {
    81         //...
    82     }
    83
    84
    85     catch (...) {

```



```

86         delete test_noncombustion_ptr;
87
88         printGold(" ..... ");
89         printRed("FAIL");
90         std::cout << std::endl;
91         throw;
92     }
93
94
95     delete test_noncombustion_ptr;
96
97     printGold(" ..... ");
98     printGreen("PASS");
99     std::cout << std::endl;
100     return 0;
101
102 } /* main() */

```

### 5.59.2.2 testConstruct\_Noncombustion()

```

Noncombustion * testConstruct_Noncombustion (
    void )

```

A function to construct a [Noncombustion](#) object and spot check some post-construction attributes.

#### Returns

A pointer to a test [Noncombustion](#) object.

```

38 {
39     NoncombustionInputs noncombustion_inputs;
40
41     Noncombustion* test_noncombustion_ptr =
42         new Noncombustion(8760, 1, noncombustion_inputs);
43
44     testTruth(
45         not noncombustion_inputs.production_inputs.print_flag,
46         __FILE__,
47         __LINE__
48     );
49
50     testFloatEquals(
51         test_noncombustion_ptr->n_points,
52         8760,
53         __FILE__,
54         __LINE__
55     );
56
57     return test_noncombustion_ptr;
58 } /* testConstruct_Noncombustion() */

```

## 5.60 test/source/Production/Renewable/test\_Renewable.cpp File Reference

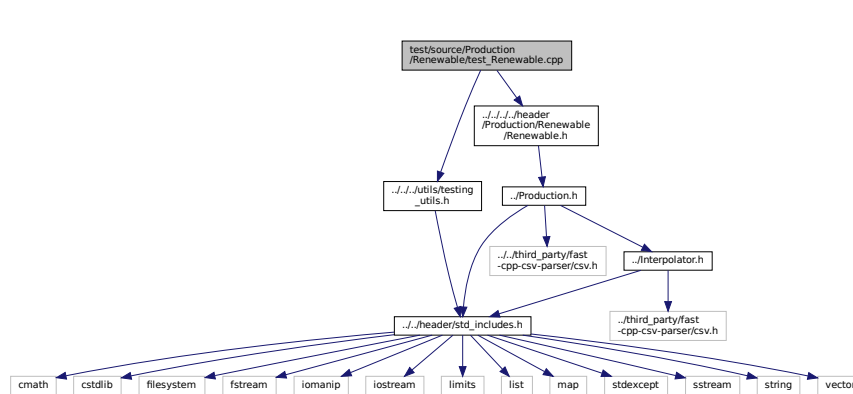
Testing suite for [Renewable](#) class.

```

#include "../.../utils/testing_utils.h"
#include "../.../header/Production/Renewable/Renewable.h"

```

Include dependency graph for test\_Renewable.cpp:



## Functions

- [Renewable](#) \* [testConstruct\\_Renewable](#) (void)  
A function to construct a [Renewable](#) object and spot check some post-construction attributes.
- int [main](#) (int argc, char \*\*argv)

### 5.60.1 Detailed Description

Testing suite for [Renewable](#) class.

A suite of tests for the [Renewable](#) class.

### 5.60.2 Function Documentation

#### 5.60.2.1 main()

```

int main (
    int argc,
    char ** argv )
66 {
67     #ifdef _WIN32
68         activateVirtualTerminal();
69     #endif /* _WIN32 */
70
71     printGold("\tTesting Production <-- Renewable");
72
73     srand(time(NULL));
74
75
76     Renewable* test_renewable_ptr = testConstruct_Renewable();
77
78
79     try {
80         //...
81     }
82
83
84     catch (...) {

```

```

85         delete test_renewable_ptr;
86
87         printGold(" ..... ");
88         printRed("FAIL");
89         std::cout << std::endl;
90         throw;
91     }
92
93
94     delete test_renewable_ptr;
95
96     printGold(" ..... ");
97     printGreen("PASS");
98     std::cout << std::endl;
99     return 0;
100
101 } /* main() */

```

### 5.60.2.2 testConstruct\_Renewable()

```

Renewable * testConstruct_Renewable (
    void )

```

A function to construct a [Renewable](#) object and spot check some post-construction attributes.

#### Returns

A pointer to a test [Renewable](#) object.

```

38 {
39     RenewableInputs renewable_inputs;
40
41     Renewable* test_renewable_ptr = new Renewable(8760, 1, renewable_inputs);
42
43     testTruth(
44         not renewable_inputs.production_inputs.print_flag,
45         __FILE__,
46         __LINE__
47     );
48
49     testFloatEquals(
50         test_renewable_ptr->n_points,
51         8760,
52         __FILE__,
53         __LINE__
54     );
55
56     return test_renewable_ptr;
57 } /* testConstruct_Renewable() */

```

## 5.61 test/source/Production/Renewable/test\_Solar.cpp File Reference

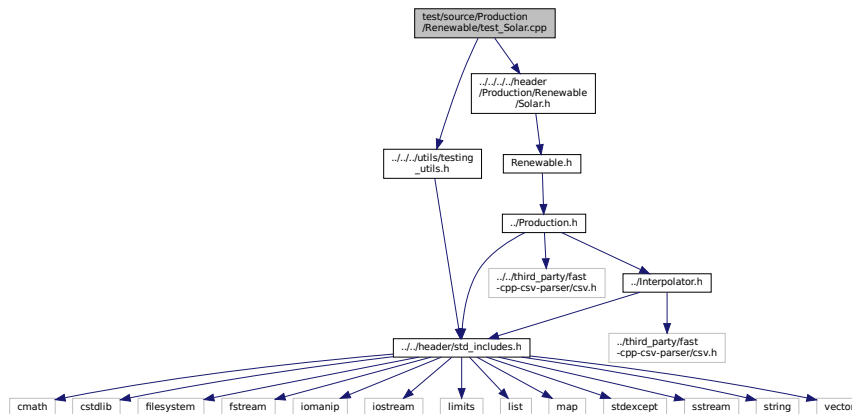
Testing suite for [Solar](#) class.

```

#include "../.../utils/testing_utils.h"
#include "../.../header/Production/Renewable/Solar.h"

```

Include dependency graph for test\_Solar.cpp:



## Functions

- `Renewable * testConstruct_Solar` (void)  
A function to construct a `Solar` object and spot check some post-construction attributes.
- `void testBadConstruct_Solar` (void)  
Function to test the trying to construct a `Solar` object given bad inputs is being handled as expected.
- `void testProductionConstraint_Solar` (`Renewable *test_solar_ptr`)  
Function to test that the production constraint is active and behaving as expected.
- `void testCommit_Solar` (`Renewable *test_solar_ptr`)  
Function to test if the commit method is working as expected, by checking some post-call attributes of the test `Solar` object. Uses a randomized resource input.
- `void testEconomics_Solar` (`Renewable *test_solar_ptr`)
- `int main` (int argc, char \*\*argv)

### 5.61.1 Detailed Description

Testing suite for `Solar` class.

A suite of tests for the `Solar` class.

### 5.61.2 Function Documentation

## 5.61.2.1 main()

```

int main (
    int argc,
    char ** argv )
322 {
323     #ifdef _WIN32
324         activateVirtualTerminal();
325     #endif /* _WIN32 */
326
327     printGold("\tTesting Production <-- Renewable <-- Solar");
328
329     srand(time(NULL));
330
331
332     Renewable* test_solar_ptr = testConstruct_Solar();
333
334
335     try {
336         testBadConstruct_Solar();
337
338         testProductionConstraint_Solar(test_solar_ptr);
339
340         testCommit_Solar(test_solar_ptr);
341         testEconomics_Solar(test_solar_ptr);
342     }
343
344
345     catch (...) {
346         delete test_solar_ptr;
347
348         printGold(" ..... ");
349         printRed("FAIL");
350         std::cout << std::endl;
351         throw;
352     }
353
354
355     delete test_solar_ptr;
356
357     printGold(" ..... ");
358     printGreen("PASS");
359     std::cout << std::endl;
360     return 0;
361
362 } /* main() */

```

## 5.61.2.2 testBadConstruct\_Solar()

```

void testBadConstruct_Solar (
    void )

```

Function to test the trying to construct a [Solar](#) object given bad inputs is being handled as expected.

```

100 {
101     bool error_flag = true;
102
103     try {
104         SolarInputs bad_solar_inputs;
105         bad_solar_inputs.derating = -1;
106
107         Solar bad_solar(8760, 1, bad_solar_inputs);
108
109         error_flag = false;
110     } catch (...) {
111         // Task failed successfully! =P
112     }
113     if (not error_flag) {
114         expectedErrorNotDetected(__FILE__, __LINE__);
115     }
116
117     return;
118 } /* testBadConstruct_Solar() */

```

### 5.61.2.3 testCommit\_Solar()

```
void testCommit_Solar (
    Renewable * test_solar_ptr )
```

Function to test if the commit method is working as expected, by checking some post-call attributes of the test [Solar](#) object. Uses a randomized resource input.

#### Parameters

<i>test_solar_ptr</i>	A <a href="#">Renewable</a> pointer to the test <a href="#">Solar</a> object.
-----------------------	---

```
171 {
172     std::vector<double> dt_vec_hrs (48, 1);
173
174     std::vector<double> load_vec_kW = {
175         1, 1, 0, 1, 0, 0, 1, 1, 1, 0, 1, 1,
176         1, 1, 1, 0, 0, 0, 0, 0, 0, 1, 1, 0,
177         1, 1, 1, 1, 1, 0, 1, 1, 1, 1, 0, 1,
178         1, 0, 0, 0, 1, 1, 1, 0, 1, 1, 0, 0
179     };
180
181     double load_kW = 0;
182     double production_kW = 0;
183     double roll = 0;
184     double solar_resource_kWm2 = 0;
185
186     for (int i = 0; i < 48; i++) {
187         roll = (double)rand() / RAND_MAX;
188
189         solar_resource_kWm2 = roll;
190
191         roll = (double)rand() / RAND_MAX;
192
193         if (roll <= 0.1) {
194             solar_resource_kWm2 = 0;
195         }
196
197         else if (roll >= 0.95) {
198             solar_resource_kWm2 = 1.25;
199         }
200
201         roll = (double)rand() / RAND_MAX;
202
203         if (roll >= 0.95) {
204             roll = 1.25;
205         }
206
207         load_vec_kW[i] *= roll * test_solar_ptr->capacity_kW;
208         load_kW = load_vec_kW[i];
209
210         production_kW = test_solar_ptr->computeProductionkW(
211             i,
212             dt_vec_hrs[i],
213             solar_resource_kWm2
214         );
215
216         load_kW = test_solar_ptr->commit(
217             i,
218             dt_vec_hrs[i],
219             production_kW,
220             load_kW
221         );
222
223         // is running (or not) as expected
224         if (solar_resource_kWm2 > 0) {
225             testTruth(
226                 test_solar_ptr->is_running,
227                 __FILE__,
228                 __LINE__
229             );
230         }
231
232         else {
233             testTruth(
234                 not test_solar_ptr->is_running,
235                 __FILE__,
236                 __LINE__
237             );
238         }
239     }
```

```

239
240     // load_kW <= load_vec_kW (i.e., after vs before)
241     testLessThanOrEqualTo(
242         load_kW,
243         load_vec_kW[i],
244         __FILE__,
245         __LINE__
246     );
247
248     // production = dispatch + storage + curtailment
249     testFloatEquals(
250         test_solar_ptr->production_vec_kW[i] -
251         test_solar_ptr->dispatch_vec_kW[i] -
252         test_solar_ptr->storage_vec_kW[i] -
253         test_solar_ptr->curtailment_vec_kW[i],
254         0,
255         __FILE__,
256         __LINE__
257     );
258
259     // capacity constraint
260     if (solar_resource_kWm2 > 1) {
261         testFloatEquals(
262             test_solar_ptr->production_vec_kW[i],
263             test_solar_ptr->capacity_kW,
264             __FILE__,
265             __LINE__
266         );
267     }
268 }
269
270 return;
271 } /* testCommit_Solar() */

```

#### 5.61.2.4 testConstruct\_Solar()

```

Renewable * testConstruct_Solar (
    void )

```

A function to construct a [Solar](#) object and spot check some post-construction attributes.

##### Returns

A [Renewable](#) pointer to a test [Solar](#) object.

```

38 {
39     SolarInputs solar_inputs;
40
41     Renewable* test_solar_ptr = new Solar(8760, 1, solar_inputs);
42
43     testTruth(
44         not solar_inputs.renewable_inputs.production_inputs.print_flag,
45         __FILE__,
46         __LINE__
47     );
48
49     testFloatEquals(
50         test_solar_ptr->n_points,
51         8760,
52         __FILE__,
53         __LINE__
54     );
55
56     testFloatEquals(
57         test_solar_ptr->type,
58         RenewableType :: SOLAR,
59         __FILE__,
60         __LINE__
61     );
62
63     testTruth(
64         test_solar_ptr->type_str == "SOLAR",
65         __FILE__,
66         __LINE__
67     );
68

```

```

69     testFloatEquals(
70         test_solar_ptr->capital_cost,
71         350118.723363,
72         __FILE__,
73         __LINE__
74     );
75
76     testFloatEquals(
77         test_solar_ptr->operation_maintenance_cost_kWh,
78         0.01,
79         __FILE__,
80         __LINE__
81     );
82
83     return test_solar_ptr;
84 } /* testConstruct_Solar() */

```

### 5.61.2.5 testEconomics\_Solar()

```

void testEconomics_Solar (
    Renewable * test_solar_ptr )
289 {
290     for (int i = 0; i < 48; i++) {
291         // resource, O&M > 0 whenever solar is running (i.e., producing)
292         if (test_solar_ptr->is_running_vec[i]) {
293             testGreaterThan(
294                 test_solar_ptr->operation_maintenance_cost_vec[i],
295                 0,
296                 __FILE__,
297                 __LINE__
298             );
299         }
300
301         // resource, O&M = 0 whenever solar is not running (i.e., not producing)
302         else {
303             testFloatEquals(
304                 test_solar_ptr->operation_maintenance_cost_vec[i],
305                 0,
306                 __FILE__,
307                 __LINE__
308             );
309         }
310     }
311
312     return;
313 } /* testEconomics_Solar() */

```

### 5.61.2.6 testProductionConstraint\_Solar()

```

void testProductionConstraint_Solar (
    Renewable * test_solar_ptr )

```

Function to test that the production constraint is active and behaving as expected.

#### Parameters

<i>test_solar_ptr</i>	A <a href="#">Renewable</a> pointer to the test <a href="#">Solar</a> object.
-----------------------	---

```

136 {
137     testFloatEquals(
138         test_solar_ptr->computeProductionkW(0, 1, 2),
139         100,
140         __FILE__,
141         __LINE__
142     );
143

```



```

144     testFloatEquals (
145         test_solar_ptr->computeProductionkW(0, 1, -1),
146         0,
147         __FILE__,
148         __LINE__
149     );
150
151     return;
152 } /* testProductionConstraint_Solar() */

```

## 5.62 test/source/Production/Renewable/test\_Tidal.cpp File Reference

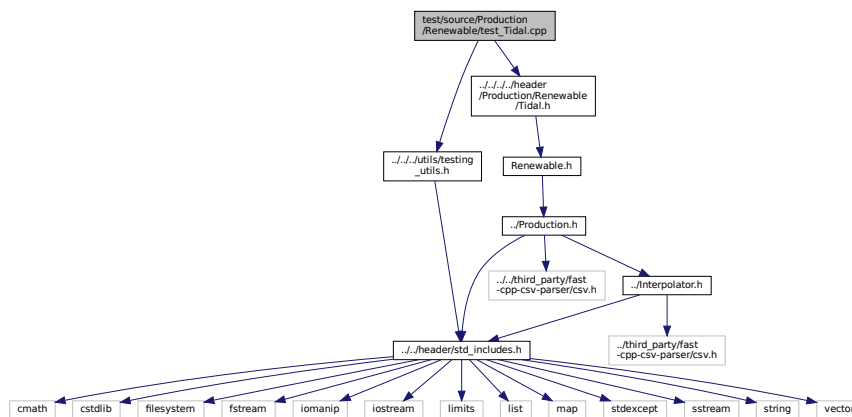
Testing suite for [Tidal](#) class.

```

#include "../.../utils/testing_utils.h"
#include "../.../header/Production/Renewable/Tidal.h"

```

Include dependency graph for test\_Tidal.cpp:



## Functions

- [Renewable](#) \* [testConstruct\\_Tidal](#) (void)  
A function to construct a [Tidal](#) object and spot check some post-construction attributes.
- void [testBadConstruct\\_Tidal](#) (void)  
Function to test the trying to construct a [Tidal](#) object given bad inputs is being handled as expected.
- void [testProductionConstraint\\_Tidal](#) ([Renewable](#) \*test\_tidal\_ptr)  
Function to test that the production constraint is active and behaving as expected.
- void [testCommit\\_Tidal](#) ([Renewable](#) \*test\_tidal\_ptr)  
Function to test if the commit method is working as expected, by checking some post-call attributes of the test [Tidal](#) object. Uses a randomized resource input.
- void [testEconomics\\_Tidal](#) ([Renewable](#) \*test\_tidal\_ptr)
- int [main](#) (int argc, char \*\*argv)

### 5.62.1 Detailed Description

Testing suite for [Tidal](#) class.

A suite of tests for the [Tidal](#) class.

## 5.62.2 Function Documentation

### 5.62.2.1 main()

```

int main (
    int argc,
    char ** argv )
323 {
324     #ifdef _WIN32
325         activateVirtualTerminal();
326     #endif /* _WIN32 */
327
328     printGold("\tTesting Production <-- Renewable <-- Tidal");
329
330     srand(time(NULL));
331
332
333     Renewable* test_tidal_ptr = testConstruct_Tidal();
334
335
336     try {
337         testBadConstruct_Tidal();
338
339         testProductionConstraint_Tidal(test_tidal_ptr);
340
341         testCommit_Tidal(test_tidal_ptr);
342         testEconomics_Tidal(test_tidal_ptr);
343     }
344
345
346     catch (...) {
347         delete test_tidal_ptr;
348
349         printGold(" ..... ");
350         printRed("FAIL");
351         std::cout << std::endl;
352         throw;
353     }
354
355
356     delete test_tidal_ptr;
357
358     printGold(" ..... ");
359     printGreen("PASS");
360     std::cout << std::endl;
361     return 0;
362
363 } /* main() */

```

### 5.62.2.2 testBadConstruct\_Tidal()

```

void testBadConstruct_Tidal (
    void )

```

Function to test the trying to construct a [Tidal](#) object given bad inputs is being handled as expected.

```

100 {
101     bool error_flag = true;
102
103     try {
104         TidalInputs bad_tidal_inputs;
105         bad_tidal_inputs.design_speed_ms = -1;
106
107         Tidal bad_tidal(8760, 1, bad_tidal_inputs);
108
109         error_flag = false;
110     } catch (...) {
111         // Task failed successfully! =P
112     }
113     if (not error_flag) {

```

```

114         expectedErrorNotDetected(__FILE__, __LINE__);
115     }
116
117     return;
118 } /* testBadConstruct_Tidal() */

```

### 5.62.2.3 testCommit\_Tidal()

```

void testCommit_Tidal (
    Renewable * test_tidal_ptr )

```

Function to test if the commit method is working as expected, by checking some post-call attributes of the test [Tidal](#) object. Uses a randomized resource input.

#### Parameters

<i>test_tidal_ptr</i>	A <a href="#">Renewable</a> pointer to the test <a href="#">Tidal</a> object.
-----------------------	---

```

182 {
183     std::vector<double> dt_vec_hrs (48, 1);
184
185     std::vector<double> load_vec_kW = {
186         1, 1, 0, 1, 0, 0, 1, 1, 1, 0, 1, 1,
187         1, 1, 1, 0, 0, 0, 0, 0, 1, 1, 0,
188         1, 1, 1, 1, 1, 0, 1, 1, 1, 1, 0, 1,
189         1, 0, 0, 0, 1, 1, 1, 0, 1, 1, 0, 0
190     };
191
192     double load_kW = 0;
193     double production_kW = 0;
194     double roll = 0;
195     double tidal_resource_ms = 0;
196
197     for (int i = 0; i < 48; i++) {
198         roll = (double)rand() / RAND_MAX;
199
200         tidal_resource_ms = roll * ((Tidal*)test_tidal_ptr)->design_speed_ms;
201
202         roll = (double)rand() / RAND_MAX;
203
204         if (roll <= 0.1) {
205             tidal_resource_ms = 0;
206         }
207
208         else if (roll >= 0.95) {
209             tidal_resource_ms = 3 * ((Tidal*)test_tidal_ptr)->design_speed_ms;
210         }
211
212         roll = (double)rand() / RAND_MAX;
213
214         if (roll >= 0.95) {
215             roll = 1.25;
216         }
217
218         load_vec_kW[i] *= roll * test_tidal_ptr->capacity_kW;
219         load_kW = load_vec_kW[i];
220
221         production_kW = test_tidal_ptr->computeProductionkW(
222             i,
223             dt_vec_hrs[i],
224             tidal_resource_ms
225         );
226
227         load_kW = test_tidal_ptr->commit(
228             i,
229             dt_vec_hrs[i],
230             production_kW,
231             load_kW
232         );
233
234         // is running (or not) as expected
235         if (production_kW > 0) {
236             testTruth(
237                 test_tidal_ptr->is_running,

```

```

238         __FILE__,
239         __LINE__
240     );
241 }
242
243 else {
244     testTruth(
245         not test_tidal_ptr->is_running,
246         __FILE__,
247         __LINE__
248     );
249 }
250
251 // load_kW <= load_vec_kW (i.e., after vs before)
252 testLessThanOrEqualTo(
253     load_kW,
254     load_vec_kW[i],
255     __FILE__,
256     __LINE__
257 );
258
259 // production = dispatch + storage + curtailment
260 testFloatEquals(
261     test_tidal_ptr->production_vec_kW[i] -
262     test_tidal_ptr->dispatch_vec_kW[i] -
263     test_tidal_ptr->storage_vec_kW[i] -
264     test_tidal_ptr->curtailment_vec_kW[i],
265     0,
266     __FILE__,
267     __LINE__
268 );
269 }
270
271 return;
272 } /* testCommit_Tidal() */

```

#### 5.62.2.4 testConstruct\_Tidal()

```

Renewable * testConstruct_Tidal (
    void )

```

A function to construct a [Tidal](#) object and spot check some post-construction attributes.

#### Returns

A [Renewable](#) pointer to a test [Tidal](#) object.

```

38 {
39     TidalInputs tidal_inputs;
40
41     Renewable* test_tidal_ptr = new Tidal(8760, 1, tidal_inputs);
42
43     testTruth(
44         not tidal_inputs.renewable_inputs.production_inputs.print_flag,
45         __FILE__,
46         __LINE__
47     );
48
49     testFloatEquals(
50         test_tidal_ptr->n_points,
51         8760,
52         __FILE__,
53         __LINE__
54     );
55
56     testFloatEquals(
57         test_tidal_ptr->type,
58         RenewableType :: TIDAL,
59         __FILE__,
60         __LINE__
61     );
62
63     testTruth(
64         test_tidal_ptr->type_str == "TIDAL",
65         __FILE__,
66         __LINE__

```

```

67     );
68
69     testFloatEquals(
70         test_tidal_ptr->capital_cost,
71         500237.446725,
72         __FILE__,
73         __LINE__
74     );
75
76     testFloatEquals(
77         test_tidal_ptr->operation_maintenance_cost_kWh,
78         0.069905,
79         __FILE__,
80         __LINE__
81     );
82
83     return test_tidal_ptr;
84 } /* testConstruct_Tidal() */

```

### 5.62.2.5 testEconomics\_Tidal()

```

void testEconomics_Tidal (
    Renewable * test_tidal_ptr )
290 {
291     for (int i = 0; i < 48; i++) {
292         // resource, O&M > 0 whenever tidal is running (i.e., producing)
293         if (test_tidal_ptr->is_running_vec[i]) {
294             testGreaterThan(
295                 test_tidal_ptr->operation_maintenance_cost_vec[i],
296                 0,
297                 __FILE__,
298                 __LINE__
299             );
300         }
301
302         // resource, O&M = 0 whenever tidal is not running (i.e., not producing)
303         else {
304             testFloatEquals(
305                 test_tidal_ptr->operation_maintenance_cost_vec[i],
306                 0,
307                 __FILE__,
308                 __LINE__
309             );
310         }
311     }
312
313     return;
314 } /* testEconomics_Tidal() */

```

### 5.62.2.6 testProductionConstraint\_Tidal()

```

void testProductionConstraint_Tidal (
    Renewable * test_tidal_ptr )

```

Function to test that the production constraint is active and behaving as expected.

#### Parameters

<i>test_tidal_ptr</i>	A <a href="#">Renewable</a> pointer to the test <a href="#">Tidal</a> object.
-----------------------	---

```

136 {
137     testFloatEquals(
138         test_tidal_ptr->computeProductionkW(0, 1, 1e6),
139         0,
140         __FILE__,
141         __LINE__

```

```

142     );
143
144     testFloatEquals(
145         test_tidal_ptr->computeProductionkW(
146             0,
147             1,
148             ((Tidal*)test_tidal_ptr)->design_speed_ms
149         ),
150         test_tidal_ptr->capacity_kW,
151         __FILE__,
152         __LINE__
153     );
154
155     testFloatEquals(
156         test_tidal_ptr->computeProductionkW(0, 1, -1),
157         0,
158         __FILE__,
159         __LINE__
160     );
161
162     return;
163 } /* testProductionConstraint_Tidal() */

```

## 5.63 test/source/Production/Renewable/test\_Wave.cpp File Reference

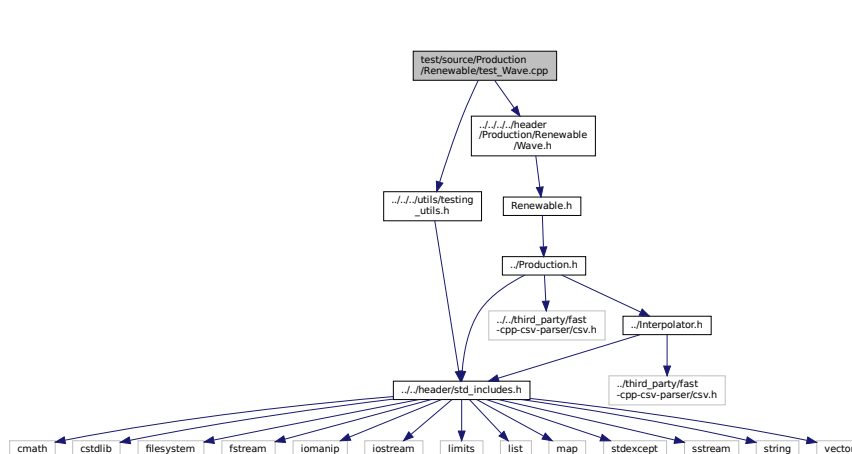
Testing suite for [Wave](#) class.

```

#include "../.../utils/testing_utils.h"
#include "../.../header/Production/Renewable/Wave.h"

```

Include dependency graph for test\_Wave.cpp:



## Functions

- [Renewable](#) \* [testConstruct\\_Wave](#) (void)  
A function to construct a [Wave](#) object and spot check some post-construction attributes.
- [Renewable](#) \* [testConstructLookup\\_Wave](#) (void)  
A function to construct a [Wave](#) object using production lookup.
- void [testBadConstruct\\_Wave](#) (void)  
Function to test the trying to construct a [Wave](#) object given bad inputs is being handled as expected.
- void [testProductionConstraint\\_Wave](#) ([Renewable](#) \*test\_wave\_ptr)  
Function to test that the production constraint is active and behaving as expected.
- void [testCommit\\_Wave](#) ([Renewable](#) \*test\_wave\_ptr)

Function to test if the commit method is working as expected, by checking some post-call attributes of the test [Wave](#) object. Uses a randomized resource input.

- void [testEconomics\\_Wave](#) ([Renewable](#) \*test\_wave\_ptr)
- void [testProductionLookup\\_Wave](#) ([Renewable](#) \*test\_wave\_lookup\_ptr)

Function to test that production lookup (i.e., interpolation) is returning the expected values.

- int [main](#) (int argc, char \*\*argv)

### 5.63.1 Detailed Description

Testing suite for [Wave](#) class.

A suite of tests for the [Wave](#) class.

### 5.63.2 Function Documentation

#### 5.63.2.1 main()

```
int main (
    int argc,
    char ** argv )
436 {
437     #ifdef _WIN32
438         activateVirtualTerminal();
439     #endif /* _WIN32 */
440
441     printGold("\tTesting Production <-- Renewable <-- Wave");
442
443     srand(time(NULL));
444
445
446     Renewable* test_wave_ptr = testConstruct_Wave();
447     Renewable* test_wave_lookup_ptr = testConstructLookup_Wave();
448
449     try {
450         testBadConstruct_Wave();
451
452         testProductionConstraint_Wave(test_wave_ptr);
453
454         testCommit_Wave(test_wave_ptr);
455         testEconomics_Wave(test_wave_ptr);
456
457         testProductionLookup_Wave(test_wave_lookup_ptr);
458     }
459
460
461     catch (...) {
462         delete test_wave_ptr;
463         delete test_wave_lookup_ptr;
464
465         printGold(" ..... ");
466         printRed("FAIL");
467         std::cout << std::endl;
468         throw;
469     }
470
471
472     delete test_wave_ptr;
473     delete test_wave_lookup_ptr;
474
475     printGold(" ..... ");
476     printGreen("PASS");
477     std::cout << std::endl;
478     return 0;
479 }
480
481 } /* main() */
```

### 5.63.2.2 testBadConstruct\_Wave()

```
void testBadConstruct_Wave (
    void )
```

Function to test the trying to construct a [Wave](#) object given bad inputs is being handled as expected.

```
127 {
128     bool error_flag = true;
129
130     try {
131         WaveInputs bad_wave_inputs;
132         bad_wave_inputs.design_significant_wave_height_m = -1;
133
134         Wave bad_wave(8760, 1, bad_wave_inputs);
135
136         error_flag = false;
137     } catch (...) {
138         // Task failed successfully! =P
139     }
140     if (not error_flag) {
141         expectedErrorNotDetected(__FILE__, __LINE__);
142     }
143
144     return;
145 } /* testBadConstruct_Wave() */
```

### 5.63.2.3 testCommit\_Wave()

```
void testCommit_Wave (
    Renewable * test_wave_ptr )
```

Function to test if the commit method is working as expected, by checking some post-call attributes of the test [Wave](#) object. Uses a randomized resource input.

#### Parameters

<i>test_wave_ptr</i>	A <a href="#">Renewable</a> pointer to the test <a href="#">Wave</a> object.
----------------------	--

```
198 {
199     std::vector<double> dt_vec_hrs (48, 1);
200
201     std::vector<double> load_vec_kW = {
202         1, 1, 0, 1, 0, 0, 1, 1, 1, 0, 1, 1,
203         1, 1, 1, 0, 0, 0, 0, 0, 0, 1, 1, 0,
204         1, 1, 1, 1, 1, 0, 1, 1, 1, 1, 0, 1,
205         1, 0, 0, 0, 1, 1, 1, 0, 1, 1, 0, 0
206     };
207
208     double load_kW = 0;
209     double production_kW = 0;
210     double roll = 0;
211     double significant_wave_height_m = 0;
212     double energy_period_s = 0;
213
214     for (int i = 0; i < 48; i++) {
215         roll = (double)rand() / RAND_MAX;
216
217         if (roll <= 0.05) {
218             roll = 0;
219         }
220
221         significant_wave_height_m = roll *
222             ((Wave*)test_wave_ptr)->design_significant_wave_height_m;
223
224         roll = (double)rand() / RAND_MAX;
225
226         if (roll <= 0.05) {
227             roll = 0;
228         }
229
230         energy_period_s = roll * ((Wave*)test_wave_ptr)->design_energy_period_s;
```



```

231
232     roll = (double)rand() / RAND_MAX;
233
234     if (roll >= 0.95) {
235         roll = 1.25;
236     }
237
238     load_vec_kW[i] *= roll * test_wave_ptr->capacity_kW;
239     load_kW = load_vec_kW[i];
240
241     production_kW = test_wave_ptr->computeProductionkW(
242         i,
243         dt_vec_hrs[i],
244         significant_wave_height_m,
245         energy_period_s
246     );
247
248     load_kW = test_wave_ptr->commit(
249         i,
250         dt_vec_hrs[i],
251         production_kW,
252         load_kW
253     );
254
255     // is running (or not) as expected
256     if (production_kW > 0) {
257         testTruth(
258             test_wave_ptr->is_running,
259             __FILE__,
260             __LINE__
261         );
262     }
263
264     else {
265         testTruth(
266             not test_wave_ptr->is_running,
267             __FILE__,
268             __LINE__
269         );
270     }
271
272     // load_kW <= load_vec_kW (i.e., after vs before)
273     testLessThanOrEqualTo(
274         load_kW,
275         load_vec_kW[i],
276         __FILE__,
277         __LINE__
278     );
279
280     // production = dispatch + storage + curtailment
281     testFloatEquals(
282         test_wave_ptr->production_vec_kW[i] -
283         test_wave_ptr->dispatch_vec_kW[i] -
284         test_wave_ptr->storage_vec_kW[i] -
285         test_wave_ptr->curtailment_vec_kW[i],
286         0,
287         __FILE__,
288         __LINE__
289     );
290 }
291
292 return;
293 } /* testCommit_Wave() */

```

#### 5.63.2.4 testConstruct\_Wave()

```

Renewable * testConstruct_Wave (
    void )

```

A function to construct a [Wave](#) object and spot check some post-construction attributes.

## Returns

A [Renewable](#) pointer to a test [Wave](#) object.

```

38 {
39     WaveInputs wave_inputs;
40
41     Renewable* test_wave_ptr = new Wave(8760, 1, wave_inputs);
42
43     testTruth(
44         not wave_inputs.renewable_inputs.production_inputs.print_flag,
45         __FILE__,
46         __LINE__
47     );
48
49     testFloatEquals(
50         test_wave_ptr->n_points,
51         8760,
52         __FILE__,
53         __LINE__
54     );
55
56     testFloatEquals(
57         test_wave_ptr->type,
58         RenewableType :: WAVE,
59         __FILE__,
60         __LINE__
61     );
62
63     testTruth(
64         test_wave_ptr->type_str == "WAVE",
65         __FILE__,
66         __LINE__
67     );
68
69     testFloatEquals(
70         test_wave_ptr->capital_cost,
71         850831.063539,
72         __FILE__,
73         __LINE__
74     );
75
76     testFloatEquals(
77         test_wave_ptr->operation_maintenance_cost_kWh,
78         0.069905,
79         __FILE__,
80         __LINE__
81     );
82
83     return test_wave_ptr;
84 } /* testConstruct_Wave() */

```

### 5.63.2.5 testConstructLookup\_Wave()

```

Renewable * testConstructLookup_Wave (
    void )

```

A function to construct a [Wave](#) object using production lookup.

## Returns

A [Renewable](#) pointer to a test [Wave](#) object.

```

101 {
102     WaveInputs wave_inputs;
103
104     wave_inputs.power_model = WavePowerProductionModel :: WAVE_POWER_LOOKUP;
105     wave_inputs.path_2_normalized_performance_matrix =
106         "data/test/interpolation/wave_energy_converter_normalized_performance_matrix.csv";
107
108     Renewable* test_wave_lookup_ptr = new Wave(8760, 1, wave_inputs);
109
110     return test_wave_lookup_ptr;
111 } /* testConstructLookup_Wave() */

```

### 5.63.2.6 testEconomics\_Wave()

```

void testEconomics_Wave (
    Renewable * test_wave_ptr )
311 {
312     for (int i = 0; i < 48; i++) {
313         // resource, O&M > 0 whenever wave is running (i.e., producing)
314         if (test_wave_ptr->is_running_vec[i]) {
315             testGreaterThan(
316                 test_wave_ptr->operation_maintenance_cost_vec[i],
317                 0,
318                 __FILE__,
319                 __LINE__
320             );
321         }
322
323         // resource, O&M = 0 whenever wave is not running (i.e., not producing)
324         else {
325             testFloatEquals(
326                 test_wave_ptr->operation_maintenance_cost_vec[i],
327                 0,
328                 __FILE__,
329                 __LINE__
330             );
331         }
332     }
333
334     return;
335 } /* testEconomics_Wave() */

```

### 5.63.2.7 testProductionConstraint\_Wave()

```

void testProductionConstraint_Wave (
    Renewable * test_wave_ptr )

```

Function to test that the production constraint is active and behaving as expected.

#### Parameters

<i>test_wave_ptr</i>	A <a href="#">Renewable</a> pointer to the test <a href="#">Wave</a> object.
----------------------	--

```

163 {
164     testFloatEquals(
165         test_wave_ptr->computeProductionkW(0, 1, 0, rand()),
166         0,
167         __FILE__,
168         __LINE__
169     );
170
171     testFloatEquals(
172         test_wave_ptr->computeProductionkW(0, 1, rand(), 0),
173         0,
174         __FILE__,
175         __LINE__
176     );
177
178     return;
179 } /* testProductionConstraint_Wave() */

```

### 5.63.2.8 testProductionLookup\_Wave()

```

void testProductionLookup_Wave (
    Renewable * test_wave_lookup_ptr )

```

Function to test that production lookup (i.e., interpolation) is returning the expected values.

## Parameters

<code>test_wave_lookup_ptr</code>	A <a href="#">Renewable</a> pointer to the test <a href="#">Wave</a> object using production lookup.
-----------------------------------	--

```

354 {
355     std::vector<double> significant_wave_height_vec_m = {
356         0.389211848822208,
357         0.836477431896843,
358         1.52738334015579,
359         1.92640601114508,
360         2.27297317532019,
361         2.87416589636605,
362         3.72275770908175,
363         3.95063175885536,
364         4.68097139867404,
365         4.97775020449812,
366         5.55184219980547,
367         6.06566629451658,
368         6.27927876785062,
369         6.96218133671013,
370         7.51754442460228
371     };
372
373     std::vector<double> energy_period_vec_s = {
374         5.45741899698926,
375         6.00101329139007,
376         7.50567689404182,
377         8.77681262912881,
378         9.45143678206774,
379         10.7767876462885,
380         11.4795760857165,
381         12.9430684577599,
382         13.303544885703,
383         14.5069863517863,
384         15.1487890438045,
385         16.086524049077,
386         17.176609978648,
387         18.4155153740256,
388         19.1704554940162
389     };
390
391     std::vector<std::vector<double>> expected_normalized_performance_matrix = {
392
393 {0.0337204906738533,0.145056406036013,0.334677248806653,0.441674658936075,0.533295755691263,0.68807895676592,0.8996148
394
395 {0.0310681846933292,0.135425896595439,0.324045598153363,0.430214268249038,0.520985043044784,0.673879556322479,0.882058
396
397 {0.0237266281076604,0.108768742207538,0.294617294841705,0.398492020763049,0.486909112828702,0.63457575706117,0.8334608
398
399 {0.0175245009938255,0.0862488504001753,0.269756343931147,0.371693152028768,0.458121859300634,0.601372013927032,0.79240
400
401 {0.0142328739589644,0.0742969694833995,0.256562003243255,0.357470308928265,0.442843729679424,0.583749940636223,0.77061
402
403 {0.0077662203173173,0.0508165832074184,0.230640709501637,0.329528443353471,0.41282867283787,0.549130026772199,0.727811
404
405 {0.00433717405958826,0.0383657337957315,0.21689552996585,0.314711823368423,0.396912710109449,0.530772265145106,0.70511
406
407 {0.000102358416923608,0.0210697053701168,0.188272456115393,0.283857573197153,0.363769179652786,0.492543912767949,0.657
408
409 {0,0.0196038727057393,0.181222235960193,0.276257786480759,0.355605514643888,0.483127792688125,0.646203044346932,0.6855
410
411 {0,0.0157252942367668,0.157685253727545,0.250886090139653,0.328351324840186,0.451692313207986,0.607334650020078,0.6442
412
413 {0,0.0136568246246201,0.145132837191606,0.23735520935175,0.313816498778623,0.43492757979648,0.586605897674033,0.622265
414
415 {0,0.0106345930466366,0.12679255826648,0.217585300741544,0.292579730277991,0.410432703770651,0.556319211544087,0.59010
416
417 {0,0.00712134879261874,0.10547259059088,0.194603435839713,0.267892689267542,0.381958220518761,0.52111194060085,0.55272
418
419 {0,0.00312847342058727,0.0812420026472571,0.168484067035528,0.239835352250276,0.349596376397684,0.481098142839729,0.510
420
421 {0,0.00103256269522045,0.0673448574082101,0.152567953107312,0.222738316872545,0.329876344040866,0.456715311514779,0.48
422     };
423
424     for (size_t i = 0; i < energy_period_vec_s.size(); i++) {
425         for (size_t j = 0; j < significant_wave_height_vec_m.size(); j++) {
426             testFloatEquals(
427                 test_wave_lookup_ptr->computeProductionKW(
428                     0,
429                     1,
430                     significant_wave_height_vec_m[j],
431                     energy_period_vec_s[i]
432                 ),
433                 expected_normalized_performance_matrix[i][j] *
434                 test_wave_lookup_ptr->capacity_kW,
435                 __FILE__,

```

```

421         __LINE__
422     );
423 }
424 }
425
426 return;
427 } /* testProductionLookup_Wave() */

```

## 5.64 test/source/Production/Renewable/test\_Wind.cpp File Reference

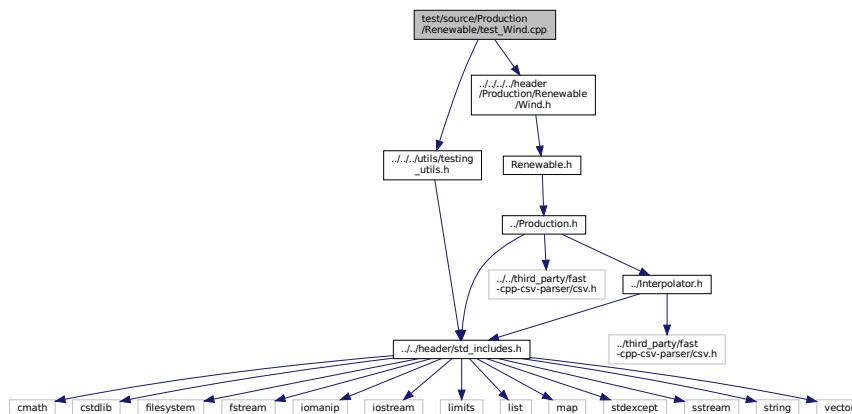
Testing suite for [Wind](#) class.

```

#include "../.../utils/testing_utils.h"
#include "../.../header/Production/Renewable/Wind.h"

```

Include dependency graph for test\_Wind.cpp:



## Functions

- [Renewable \\* testConstruct\\_Wind](#) (void)  
A function to construct a [Wind](#) object and spot check some post-construction attributes.
- void [testBadConstruct\\_Wind](#) (void)  
Function to test the trying to construct a [Wind](#) object given bad inputs is being handled as expected.
- void [testProductionConstraint\\_Wind](#) ([Renewable \\*test\\_wind\\_ptr](#))  
Function to test that the production constraint is active and behaving as expected.
- void [testCommit\\_Wind](#) ([Renewable \\*test\\_wind\\_ptr](#))  
Function to test if the commit method is working as expected, by checking some post-call attributes of the test [Wind](#) object. Uses a randomized resource input.
- void [testEconomics\\_Wind](#) ([Renewable \\*test\\_wind\\_ptr](#))
- int [main](#) (int argc, char \*\*argv)

### 5.64.1 Detailed Description

Testing suite for [Wind](#) class.

A suite of tests for the [Wind](#) class.

## 5.64.2 Function Documentation

### 5.64.2.1 main()

```

int main (
    int argc,
    char ** argv )
323 {
324     #ifdef _WIN32
325         activateVirtualTerminal();
326     #endif /* _WIN32 */
327
328     printGold("\tTesting Production <-- Renewable <-- Wind");
329
330     srand(time(NULL));
331
332
333     Renewable* test_wind_ptr = testConstruct_Wind();
334
335
336     try {
337         testBadConstruct_Wind();
338
339         testProductionConstraint_Wind(test_wind_ptr);
340
341         testCommit_Wind(test_wind_ptr);
342         testEconomics_Wind(test_wind_ptr);
343     }
344
345
346     catch (...) {
347         delete test_wind_ptr;
348
349         printGold(" ..... ");
350         printRed("FAIL");
351         std::cout << std::endl;
352         throw;
353     }
354
355
356     delete test_wind_ptr;
357
358     printGold(" ..... ");
359     printGreen("PASS");
360     std::cout << std::endl;
361     return 0;
362
363 } /* main() */

```

### 5.64.2.2 testBadConstruct\_Wind()

```

void testBadConstruct_Wind (
    void )

```

Function to test the trying to construct a [Wind](#) object given bad inputs is being handled as expected.

```

100 {
101     bool error_flag = true;
102
103     try {
104         WindInputs bad_wind_inputs;
105         bad_wind_inputs.design_speed_ms = -1;
106
107         Wind bad_wind(8760, 1, bad_wind_inputs);
108
109         error_flag = false;
110     } catch (...) {
111         // Task failed successfully! =P
112     }
113     if (not error_flag) {

```

```

114         expectedErrorNotDetected(__FILE__, __LINE__);
115     }
116
117     return;
118 } /* testBadConstruct_Wind() */

```

### 5.64.2.3 testCommit\_Wind()

```

void testCommit_Wind (
    Renewable * test_wind_ptr )

```

Function to test if the commit method is working as expected, by checking some post-call attributes of the test [Wind](#) object. Uses a randomized resource input.

#### Parameters

<i>test_wind_ptr</i>	A <a href="#">Renewable</a> pointer to the test <a href="#">Wind</a> object.
----------------------	--

```

182 {
183     std::vector<double> dt_vec_hrs (48, 1);
184
185     std::vector<double> load_vec_kW = {
186         1, 1, 0, 1, 0, 0, 1, 1, 1, 0, 1, 1,
187         1, 1, 1, 0, 0, 0, 0, 0, 1, 1, 0,
188         1, 1, 1, 1, 1, 0, 1, 1, 1, 1, 0, 1,
189         1, 0, 0, 0, 1, 1, 1, 0, 1, 1, 0, 0
190     };
191
192     double load_kW = 0;
193     double production_kW = 0;
194     double roll = 0;
195     double wind_resource_ms = 0;
196
197     for (int i = 0; i < 48; i++) {
198         roll = (double)rand() / RAND_MAX;
199
200         wind_resource_ms = roll * ((Wind*)test_wind_ptr)->design_speed_ms;
201
202         roll = (double)rand() / RAND_MAX;
203
204         if (roll <= 0.1) {
205             wind_resource_ms = 0;
206         }
207
208         else if (roll >= 0.95) {
209             wind_resource_ms = 3 * ((Wind*)test_wind_ptr)->design_speed_ms;
210         }
211
212         roll = (double)rand() / RAND_MAX;
213
214         if (roll >= 0.95) {
215             roll = 1.25;
216         }
217
218         load_vec_kW[i] *= roll * test_wind_ptr->capacity_kW;
219         load_kW = load_vec_kW[i];
220
221         production_kW = test_wind_ptr->computeProductionkW(
222             i,
223             dt_vec_hrs[i],
224             wind_resource_ms
225         );
226
227         load_kW = test_wind_ptr->commit(
228             i,
229             dt_vec_hrs[i],
230             production_kW,
231             load_kW
232         );
233
234         // is running (or not) as expected
235         if (production_kW > 0) {
236             testTruth(
237                 test_wind_ptr->is_running,

```

```

238         __FILE__,
239         __LINE__
240     );
241 }
242
243 else {
244     testTruth(
245         not test_wind_ptr->is_running,
246         __FILE__,
247         __LINE__
248     );
249 }
250
251 // load_kW <= load_vec_kW (i.e., after vs before)
252 testLessThanOrEqualTo(
253     load_kW,
254     load_vec_kW[i],
255     __FILE__,
256     __LINE__
257 );
258
259 // production = dispatch + storage + curtailment
260 testFloatEquals(
261     test_wind_ptr->production_vec_kW[i] -
262     test_wind_ptr->dispatch_vec_kW[i] -
263     test_wind_ptr->storage_vec_kW[i] -
264     test_wind_ptr->curtailment_vec_kW[i],
265     0,
266     __FILE__,
267     __LINE__
268 );
269 }
270
271 return;
272 } /* testCommit_Wind() */

```

#### 5.64.2.4 testConstruct\_Wind()

```

Renewable * testConstruct_Wind (
    void )

```

A function to construct a [Wind](#) object and spot check some post-construction attributes.

#### Returns

A [Renewable](#) pointer to a test [Wind](#) object.

```

38 {
39     WindInputs wind_inputs;
40
41     Renewable* test_wind_ptr = new Wind(8760, 1, wind_inputs);
42
43     testTruth(
44         not wind_inputs.renewable_inputs.production_inputs.print_flag,
45         __FILE__,
46         __LINE__
47     );
48
49     testFloatEquals(
50         test_wind_ptr->n_points,
51         8760,
52         __FILE__,
53         __LINE__
54     );
55
56     testFloatEquals(
57         test_wind_ptr->type,
58         RenewableType :: WIND,
59         __FILE__,
60         __LINE__
61     );
62
63     testTruth(
64         test_wind_ptr->type_str == "WIND",
65         __FILE__,
66         __LINE__

```



```

67     );
68
69     testFloatEquals(
70         test_wind_ptr->capital_cost,
71         450356.170088,
72         __FILE__,
73         __LINE__
74     );
75
76     testFloatEquals(
77         test_wind_ptr->operation_maintenance_cost_kWh,
78         0.034953,
79         __FILE__,
80         __LINE__
81     );
82
83     return test_wind_ptr;
84 } /* testConstruct_Wind() */

```

### 5.64.2.5 testEconomics\_Wind()

```

void testEconomics_Wind (
    Renewable * test_wind_ptr )
290 {
291     for (int i = 0; i < 48; i++) {
292         // resource, O&M > 0 whenever wind is running (i.e., producing)
293         if (test_wind_ptr->is_running_vec[i]) {
294             testGreaterThan(
295                 test_wind_ptr->operation_maintenance_cost_vec[i],
296                 0,
297                 __FILE__,
298                 __LINE__
299             );
300         }
301
302         // resource, O&M = 0 whenever wind is not running (i.e., not producing)
303         else {
304             testFloatEquals(
305                 test_wind_ptr->operation_maintenance_cost_vec[i],
306                 0,
307                 __FILE__,
308                 __LINE__
309             );
310         }
311     }
312
313     return;
314 } /* testEconomics_Wind() */

```

### 5.64.2.6 testProductionConstraint\_Wind()

```

void testProductionConstraint_Wind (
    Renewable * test_wind_ptr )

```

Function to test that the production constraint is active and behaving as expected.

#### Parameters

<i>test_wind_ptr</i>	A <a href="#">Renewable</a> pointer to the test <a href="#">Wind</a> object.
----------------------	--

```

136 {
137     testFloatEquals(
138         test_wind_ptr->computeProductionkW(0, 1, 1e6),
139         0,
140         __FILE__,
141         __LINE__

```

```

142     );
143
144     testFloatEquals(
145         test_wind_ptr->computeProductionkW(
146             0,
147             1,
148             ((Wind*)test_wind_ptr)->design_speed_ms
149         ),
150         test_wind_ptr->capacity_kW,
151         __FILE__,
152         __LINE__
153     );
154
155     testFloatEquals(
156         test_wind_ptr->computeProductionkW(0, 1, -1),
157         0,
158         __FILE__,
159         __LINE__
160     );
161
162     return;
163 } /* testProductionConstraint_Wind() */

```

## 5.65 test/source/Production/test\_Production.cpp File Reference

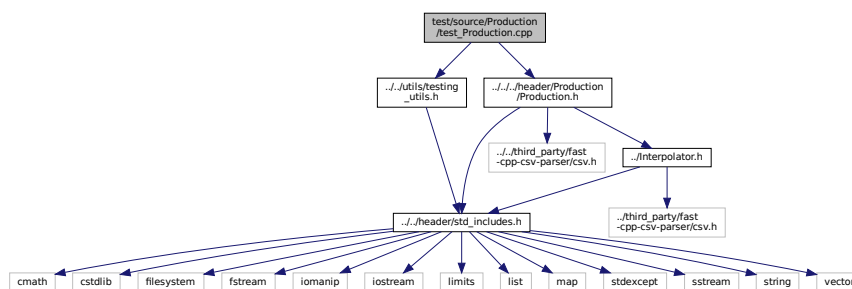
Testing suite for [Production](#) class.

```

#include "../utils/testing_utils.h"
#include "../../../header/Production/Production.h"

```

Include dependency graph for test\_Production.cpp:



## Functions

- [Production](#) \* [testConstruct\\_Production](#) (void)  
A function to construct a [Production](#) object and spot check some post-construction attributes.
- void [testBadConstruct\\_Production](#) (void)  
Function to test the trying to construct a [Production](#) object given bad inputs is being handled as expected.
- int [main](#) (int argc, char \*\*argv)

### 5.65.1 Detailed Description

Testing suite for [Production](#) class.

A suite of tests for the [Production](#) class.

## 5.65.2 Function Documentation

### 5.65.2.1 main()

```

int main (
    int argc,
    char ** argv )
169 {
170     #ifdef _WIN32
171         activateVirtualTerminal();
172     #endif /* _WIN32 */
173
174     printGold("\tTesting Production");
175
176     srand(time(NULL));
177
178
179     Production* test_production_ptr = testConstruct_Production();
180
181
182     try {
183         testBadConstruct_Production();
184     }
185
186
187     catch (...) {
188         delete test_production_ptr;
189
190         printGold(" ..... ");
191         printRed("FAIL");
192         std::cout << std::endl;
193         throw;
194     }
195
196
197     delete test_production_ptr;
198
199     printGold(" ..... ");
200     printGreen("PASS");
201     std::cout << std::endl;
202     return 0;
203
204 } /* main() */

```

### 5.65.2.2 testBadConstruct\_Production()

```

void testBadConstruct_Production (
    void )

```

Function to test the trying to construct a [Production](#) object given bad inputs is being handled as expected.

```

143 {
144     bool error_flag = true;
145
146     try {
147         ProductionInputs production_inputs;
148
149         Production bad_production(0, 1, production_inputs);
150
151         error_flag = false;
152     } catch (...) {
153         // Task failed successfully! =P
154     }
155     if (not error_flag) {
156         expectedErrorNotDetected(__FILE__, __LINE__);
157     }
158
159     return;
160 } /* testBadConstruct_Production() */

```

### 5.65.2.3 testConstruct\_Production()

```
Production * testConstruct_Production (
    void )
```

A function to construct a [Production](#) object and spot check some post-construction attributes.

#### Returns

A pointer to a test [Production](#) object.

```
38 {
39     ProductionInputs production_inputs;
40
41     Production* test_production_ptr = new Production(8760, 1, production_inputs);
42
43     testTruth(
44         not production_inputs.print_flag,
45         __FILE__,
46         __LINE__
47     );
48
49     testFloatEquals(
50         production_inputs.nominal_inflation_annual,
51         0.02,
52         __FILE__,
53         __LINE__
54     );
55
56     testFloatEquals(
57         production_inputs.nominal_discount_annual,
58         0.04,
59         __FILE__,
60         __LINE__
61     );
62
63     testFloatEquals(
64         test_production_ptr->n_points,
65         8760,
66         __FILE__,
67         __LINE__
68     );
69
70     testFloatEquals(
71         test_production_ptr->capacity_kW,
72         100,
73         __FILE__,
74         __LINE__
75     );
76
77     testFloatEquals(
78         test_production_ptr->real_discount_annual,
79         0.0196078431372549,
80         __FILE__,
81         __LINE__
82     );
83
84     testFloatEquals(
85         test_production_ptr->production_vec_kW.size(),
86         8760,
87         __FILE__,
88         __LINE__
89     );
90
91     testFloatEquals(
92         test_production_ptr->dispatch_vec_kW.size(),
93         8760,
94         __FILE__,
95         __LINE__
96     );
97
98     testFloatEquals(
99         test_production_ptr->storage_vec_kW.size(),
100        8760,
101        __FILE__,
102        __LINE__
103    );
104
105    testFloatEquals(
106        test_production_ptr->curtailment_vec_kW.size(),
107        8760,
108        __FILE__,
```

```

109     __LINE__
110 );
111
112 testFloatEquals (
113     test_production_ptr->capital_cost_vec.size(),
114     8760,
115     __FILE__,
116     __LINE__
117 );
118
119 testFloatEquals (
120     test_production_ptr->operation_maintenance_cost_vec.size(),
121     8760,
122     __FILE__,
123     __LINE__
124 );
125
126 return test_production_ptr;
127 } /* testConstruct_Production() */

```

## 5.66 test/source/Storage/test\_Lilon.cpp File Reference

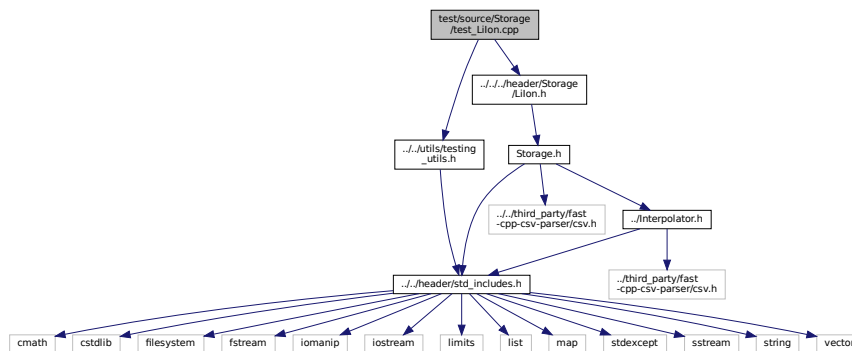
Testing suite for [Lilon](#) class.

```

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

```

Include dependency graph for test\_Lilon.cpp:



## Functions

- [Storage](#) \* [testConstruct\\_Lilon](#) (void)  
A function to construct a [Lilon](#) object and spot check some post-construction attributes.
- void [testBadConstruct\\_Lilon](#) (void)  
Function to test the trying to construct a [Lilon](#) object given bad inputs is being handled as expected.
- void [testCommitCharge\\_Lilon](#) ([Storage](#) \*test\_liion\_ptr)  
A function to test [commitCharge\(\)](#) and ensure that its impact on acceptable and available power is as expected.
- void [testCommitDischarge\\_Lilon](#) ([Storage](#) \*test\_liion\_ptr)  
A function to test [commitDischarge\(\)](#) and ensure that its impact on acceptable and available power is as expected.
- int [main](#) (int argc, char \*\*argv)

### 5.66.1 Detailed Description

Testing suite for [Lilon](#) class.

A suite of tests for the [Lilon](#) class.

## 5.66.2 Function Documentation

### 5.66.2.1 main()

```

int main (
    int argc,
    char ** argv )
286 {
287     #ifdef _WIN32
288         activateVirtualTerminal();
289     #endif /* _WIN32 */
290
291     printGold("\tTesting Storage <-- LiIon");
292
293     srand(time(NULL));
294
295
296     Storage* test_liion_ptr = testConstruct_LiIon();
297
298
299     try {
300         testBadConstruct_LiIon();
301
302         testCommitCharge_LiIon(test_liion_ptr);
303         testCommitDischarge_LiIon(test_liion_ptr);
304     }
305
306
307     catch (...) {
308         delete test_liion_ptr;
309
310         printGold(" ..... ");
311         printRed("FAIL");
312         std::cout << std::endl;
313         throw;
314     }
315
316
317     delete test_liion_ptr;
318
319     printGold(" ..... ");
320     printGreen("PASS");
321     std::cout << std::endl;
322     return 0;
323
324 } /* main() */

```

### 5.66.2.2 testBadConstruct\_LiIon()

```

void testBadConstruct_LiIon (
    void )

```

Function to test the trying to construct a [LiIon](#) object given bad inputs is being handled as expected.

```

129 {
130     bool error_flag = true;
131
132     try {
133         LiIonInputs bad_liion_inputs;
134         bad_liion_inputs.min_SOC = -1;
135
136         LiIon bad_liion(8760, 1, bad_liion_inputs);
137
138         error_flag = false;
139     } catch (...) {
140         // Task failed successfully! =P
141     }
142     if (not error_flag) {
143         expectedErrorNotDetected(__FILE__, __LINE__);
144     }
145
146     return;
147 } /* testBadConstruct_LiIon() */

```

### 5.66.2.3 testCommitCharge\_LiIon()

```
void testCommitCharge_LiIon (
    Storage * test_liion_ptr )
```

A function to test commitCharge() and ensure that its impact on acceptable and available power is as expected.

#### Parameters

<i>test_liion_ptr</i>	A <a href="#">Storage</a> pointer to a test <a href="#">LiIon</a> object.
-----------------------	---

```
165 {
166     double dt_hrs = 1;
167
168     testFloatEquals(
169         test_liion_ptr->getAvailablekW(dt_hrs),
170         100, // hits power capacity constraint
171         __FILE__,
172         __LINE__
173     );
174
175     testFloatEquals(
176         test_liion_ptr->getAcceptablekW(dt_hrs),
177         100, // hits power capacity constraint
178         __FILE__,
179         __LINE__
180     );
181
182     test_liion_ptr->power_kW = 1e6; // as if a massive amount of power is already flowing in
183
184     testFloatEquals(
185         test_liion_ptr->getAvailablekW(dt_hrs),
186         0, // is already hitting power capacity constraint
187         __FILE__,
188         __LINE__
189     );
190
191     testFloatEquals(
192         test_liion_ptr->getAcceptablekW(dt_hrs),
193         0, // is already hitting power capacity constraint
194         __FILE__,
195         __LINE__
196     );
197
198     test_liion_ptr->commitCharge(0, dt_hrs, 100);
199
200     testFloatEquals(
201         test_liion_ptr->power_kW,
202         0,
203         __FILE__,
204         __LINE__
205     );
206
207     return;
208 } /* testCommitCharge_LiIon() */
```

### 5.66.2.4 testCommitDischarge\_LiIon()

```
void testCommitDischarge_LiIon (
    Storage * test_liion_ptr )
```

A function to test commitDischarge() and ensure that its impact on acceptable and available power is as expected.

#### Parameters

<i>test_liion_ptr</i>	A <a href="#">Storage</a> pointer to a test <a href="#">LiIon</a> object.
-----------------------	---

```
226 {
```

```

227     double dt_hrs = 1;
228     double load_kW = 100;
229
230     testFloatEquals(
231         test_liion_ptr->getAvailablekW(dt_hrs),
232         100, // hits power capacity constraint
233         __FILE__,
234         __LINE__
235     );
236
237     testFloatEquals(
238         test_liion_ptr->getAcceptablekW(dt_hrs),
239         100, // hits power capacity constraint
240         __FILE__,
241         __LINE__
242     );
243
244     test_liion_ptr->power_kW = 1e6; // as if a massive amount of power is already flowing out
245
246     testFloatEquals(
247         test_liion_ptr->getAvailablekW(dt_hrs),
248         0, // is already hitting power capacity constraint
249         __FILE__,
250         __LINE__
251     );
252
253     testFloatEquals(
254         test_liion_ptr->getAcceptablekW(dt_hrs),
255         0, // is already hitting power capacity constraint
256         __FILE__,
257         __LINE__
258     );
259
260     load_kW = test_liion_ptr->commitDischarge(0, dt_hrs, 100, load_kW);
261
262     testFloatEquals(
263         load_kW,
264         0,
265         __FILE__,
266         __LINE__
267     );
268
269     testFloatEquals(
270         test_liion_ptr->power_kW,
271         0,
272         __FILE__,
273         __LINE__
274     );
275
276     return;
277 } /* testCommitDischarge_LiIon() */

```

### 5.66.2.5 testConstruct\_LiIon()

```

Storage * testConstruct_LiIon (
    void )

```

A function to construct a [LiIon](#) object and spot check some post-construction attributes.

#### Returns

A [Storage](#) pointer to a test [LiIon](#) object.

```

38 {
39     LiIonInputs liion_inputs;
40
41     Storage* test_liion_ptr = new LiIon(8760, 1, liion_inputs);
42
43     testTruth(
44         test_liion_ptr->type_str == "LIION",
45         __FILE__,
46         __LINE__
47     );
48
49     testFloatEquals(
50         ((LiIon*)test_liion_ptr)->init_SOC,

```



```

51         0.5,
52         __FILE__,
53         __LINE__
54     );
55
56     testFloatEquals(
57         ((LiIon*)test_liion_ptr)->min_SOC,
58         0.15,
59         __FILE__,
60         __LINE__
61     );
62
63     testFloatEquals(
64         ((LiIon*)test_liion_ptr)->hysteresis_SOC,
65         0.5,
66         __FILE__,
67         __LINE__
68     );
69
70     testFloatEquals(
71         ((LiIon*)test_liion_ptr)->max_SOC,
72         0.9,
73         __FILE__,
74         __LINE__
75     );
76
77     testFloatEquals(
78         ((LiIon*)test_liion_ptr)->charging_efficiency,
79         0.9,
80         __FILE__,
81         __LINE__
82     );
83
84     testFloatEquals(
85         ((LiIon*)test_liion_ptr)->discharging_efficiency,
86         0.9,
87         __FILE__,
88         __LINE__
89     );
90
91     testFloatEquals(
92         ((LiIon*)test_liion_ptr)->replace_SOH,
93         0.8,
94         __FILE__,
95         __LINE__
96     );
97
98     testFloatEquals(
99         ((LiIon*)test_liion_ptr)->power_kW,
100        0,
101        __FILE__,
102        __LINE__
103    );
104
105    testFloatEquals(
106        ((LiIon*)test_liion_ptr)->SOH_vec.size(),
107        8760,
108        __FILE__,
109        __LINE__
110    );
111
112    return test_liion_ptr;
113 } /* testConstruct_LiIon() */

```

## 5.67 test/source/Storage/test\_Storage.cpp File Reference

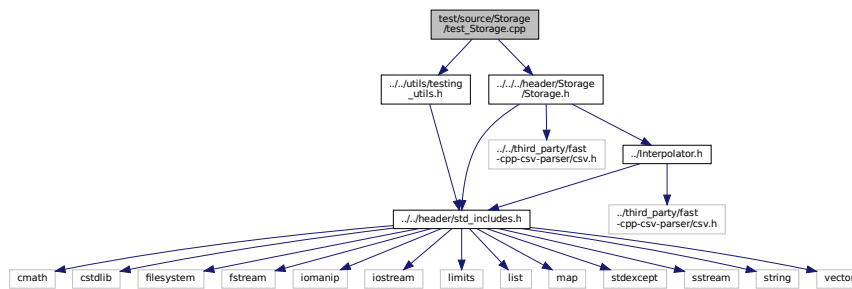
Testing suite for [Storage](#) class.

```

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

```

Include dependency graph for `test_Storage.cpp`:



## Functions

- `Storage * testConstruct_Storage` (void)  
A function to construct a `Storage` object and spot check some post-construction attributes.
- void `testBadConstruct_Storage` (void)  
Function to test the trying to construct a `Storage` object given bad inputs is being handled as expected.
- int `main` (int argc, char \*\*argv)

### 5.67.1 Detailed Description

Testing suite for `Storage` class.

A suite of tests for the `Storage` class.

### 5.67.2 Function Documentation

#### 5.67.2.1 main()

```

int main (
    int argc,
    char ** argv )
{
    136 {
    137     #ifdef _WIN32
    138         activateVirtualTerminal();
    139     #endif /* _WIN32 */
    140
    141     printGold("\tTesting Storage");
    142
    143     srand(time(NULL));
    144
    145     Storage* test_storage_ptr = testConstruct_Storage();
    146
    147     try {
    148         testBadConstruct_Storage();
    149     }
    150
    151     catch (...) {
    152
    153
    154

```

```

155         delete test_storage_ptr;
156
157         printGold(" ..... ");
158         printRed("FAIL");
159         std::cout << std::endl;
160         throw;
161     }
162
163
164     delete test_storage_ptr;
165
166     printGold(" ..... ");
167     printGreen("PASS");
168     std::cout << std::endl;
169     return 0;
170
171 } /* main() */

```

### 5.67.2.2 testBadConstruct\_Storage()

```

void testBadConstruct_Storage (
    void )

```

Function to test the trying to construct a [Storage](#) object given bad inputs is being handled as expected.

```

109 {
110     bool error_flag = true;
111
112     try {
113         StorageInputs bad_storage_inputs;
114         bad_storage_inputs.energy_capacity_kWh = 0;
115
116         Storage bad_storage(8760, 1, bad_storage_inputs);
117
118         error_flag = false;
119     } catch (...) {
120         // Task failed successfully! =P
121     }
122     if (not error_flag) {
123         expectedErrorNotDetected(__FILE__, __LINE__);
124     }
125
126     return;
127 } /* testBadConstruct_Storage() */

```

### 5.67.2.3 testConstruct\_Storage()

```

Storage * testConstruct_Storage (
    void )

```

A function to construct a [Storage](#) object and spot check some post-construction attributes.

#### Returns

A [Renewable](#) pointer to a test [Storage](#) object.

```

38 {
39     StorageInputs storage_inputs;
40
41     Storage* test_storage_ptr = new Storage(8760, 1, storage_inputs);
42
43     testFloatEquals(
44         test_storage_ptr->power_capacity_kW,
45         100,
46         __FILE__,
47         __LINE__
48     );
49

```

```

50     testFloatEquals(
51         test_storage_ptr->energy_capacity_kWh,
52         1000,
53         __FILE__,
54         __LINE__
55     );
56
57     testFloatEquals(
58         test_storage_ptr->charge_vec_kWh.size(),
59         8760,
60         __FILE__,
61         __LINE__
62     );
63
64     testFloatEquals(
65         test_storage_ptr->charging_power_vec_kW.size(),
66         8760,
67         __FILE__,
68         __LINE__
69     );
70
71     testFloatEquals(
72         test_storage_ptr->discharging_power_vec_kW.size(),
73         8760,
74         __FILE__,
75         __LINE__
76     );
77
78     testFloatEquals(
79         test_storage_ptr->capital_cost_vec.size(),
80         8760,
81         __FILE__,
82         __LINE__
83     );
84
85     testFloatEquals(
86         test_storage_ptr->operation_maintenance_cost_vec.size(),
87         8760,
88         __FILE__,
89         __LINE__
90     );
91
92     return test_storage_ptr;
93 } /* testConstruct_Storage() */

```

## 5.68 test/source/test\_Controller.cpp File Reference

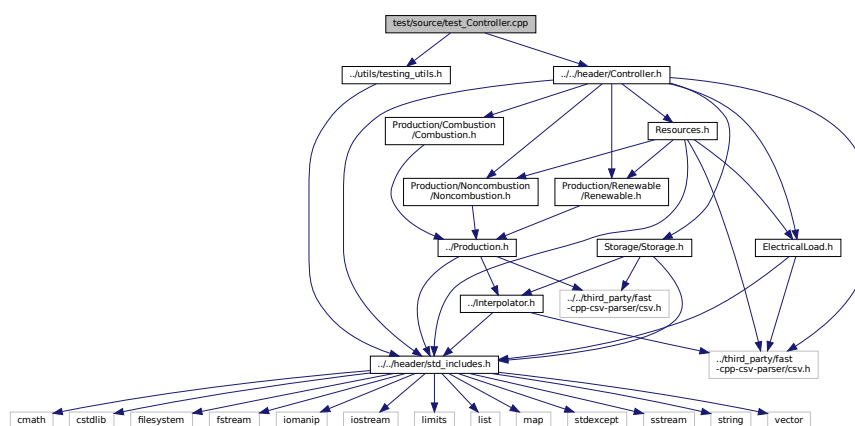
Testing suite for [Controller](#) class.

```

#include "../utils/testing_utils.h"
#include "../../header/Controller.h"

```

Include dependency graph for test\_Controller.cpp:



## Functions

- `Controller * testConstruct_Controller` (void)  
*A function to construct a `Controller` object.*
- `int main` (int argc, char \*\*argv)

### 5.68.1 Detailed Description

Testing suite for `Controller` class.

A suite of tests for the `Controller` class.

### 5.68.2 Function Documentation

#### 5.68.2.1 `main()`

```
int main (
    int argc,
    char ** argv )
50 {
51     #ifdef _WIN32
52         activateVirtualTerminal();
53     #endif /* _WIN32 */
54     printGold("\tTesting Controller");
55
56     srand(time(NULL));
57
58
59
60     Controller* test_controller_ptr = testConstruct_Controller();
61
62
63     try {
64         //...
65     }
66
67
68     catch (...) {
69         delete test_controller_ptr;
70
71         printGold(" ..... ");
72         printRed("FAIL");
73         std::cout << std::endl;
74         throw;
75     }
76
77
78     delete test_controller_ptr;
79
80     printGold(" ..... ");
81     printGreen("PASS");
82     std::cout << std::endl;
83     return 0;
84 } /* main() */
```

### 5.68.2.2 testConstruct\_Controller()

```
Controller * testConstruct_Controller (
    void )
```

A function to construct a [Controller](#) object.

#### Returns

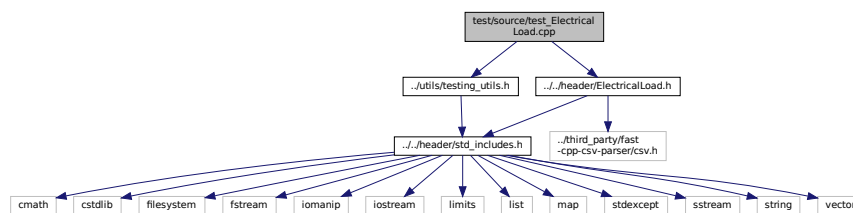
A pointer to a test [Controller](#) object.

```
37 {
38     Controller* test_controller_ptr = new Controller();
39
40     return test_controller_ptr;
41 } /* testConstruct_Controller() */
```

## 5.69 test/source/test\_ElectricalLoad.cpp File Reference

Testing suite for [ElectricalLoad](#) class.

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



## Functions

- [ElectricalLoad](#) \* [testConstruct\\_ElectricalLoad](#) (void)  
A function to construct an [ElectricalLoad](#) object.
- void [testPostConstructionAttributes\\_ElectricalLoad](#) ([ElectricalLoad](#) \*test\_electrical\_load\_ptr)  
A function to check the values of various post-construction attributes.
- void [testDataRead\\_ElectricalLoad](#) ([ElectricalLoad](#) \*test\_electrical\_load\_ptr)  
A function to check the values read into the test [ElectricalLoad](#) object.
- int [main](#) (int argc, char \*\*argv)

### 5.69.1 Detailed Description

Testing suite for [ElectricalLoad](#) class.

A suite of tests for the [ElectricalLoad](#) class.

## 5.69.2 Function Documentation

### 5.69.2.1 main()

```

int main (
    int argc,
    char ** argv )
223 {
224     #ifdef _WIN32
225         activateVirtualTerminal();
226     #endif /* _WIN32 */
227
228     printGold("\tTesting ElectricalLoad");
229
230     srand(time(NULL));
231
232
233     ElectricalLoad* test_electrical_load_ptr = testConstruct_ElectricalLoad();
234
235     try {
236         testPostConstructionAttributes_ElectricalLoad(test_electrical_load_ptr);
237         testDataRead_ElectricalLoad(test_electrical_load_ptr);
238     }
239
240
241     catch (...) {
242         delete test_electrical_load_ptr;
243
244         printGold(" ..... ");
245         printRed("FAIL");
246         std::cout << std::endl;
247         throw;
248     }
249
250
251     delete test_electrical_load_ptr;
252
253     printGold(" ..... ");
254     printGreen("PASS");
255     std::cout << std::endl;
256     return 0;
257 } /* main() */
258

```

### 5.69.2.2 testConstruct\_ElectricalLoad()

```

ElectricalLoad * testConstruct_ElectricalLoad (
    void )

```

A function to construct an [ElectricalLoad](#) object.

#### Returns

A pointer to a test [ElectricalLoad](#) object.

```

37 {
38     std::string path_2_electrical_load_time_series =
39         "data/test/electrical_load/electrical_load_generic_peak-500kW_1yr_dt-1hr.csv";
40
41     ElectricalLoad* test_electrical_load_ptr =
42         new ElectricalLoad(path_2_electrical_load_time_series);
43
44     testTruth(
45         test_electrical_load_ptr->path_2_electrical_load_time_series ==
46         path_2_electrical_load_time_series,
47         __FILE__,
48         __LINE__
49     );
50
51     return test_electrical_load_ptr;
52 } /* testConstruct_ElectricalLoad() */

```

### 5.69.2.3 testDataRead\_ElectricalLoad()

```
void testDataRead_ElectricalLoad (
    ElectricalLoad * test_electrical_load_ptr )
```

A function to check the values read into the test [ElectricalLoad](#) object.

#### Parameters

<code>test_electrical_load_ptr</code>	A pointer to the test <a href="#">ElectricalLoad</a> object.
---------------------------------------	--

```
128 {
129     std::vector<double> expected_dt_vec_hrs (48, 1);
130
131     std::vector<double> expected_time_vec_hrs = {
132         0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11,
133         12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23,
134         24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35,
135         36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47
136     };
137
138     std::vector<double> expected_load_vec_kW = {
139         360.253836463674,
140         355.171277826775,
141         353.776453532298,
142         353.75405737934,
143         346.592867404975,
144         340.132411175118,
145         337.354867340578,
146         340.644115618736,
147         363.639028500678,
148         378.787797779238,
149         372.215798201712,
150         395.093925731298,
151         402.325427142659,
152         386.907725462306,
153         380.709170928091,
154         372.062070914977,
155         372.328646856954,
156         391.841444284136,
157         394.029351759596,
158         383.369407765254,
159         381.093099675206,
160         382.604158946193,
161         390.744843709034,
162         383.13949492437,
163         368.150393976985,
164         364.629744480226,
165         363.572736804082,
166         359.854924202248,
167         355.207590170267,
168         349.094656012401,
169         354.365935871597,
170         343.380608328546,
171         404.673065729266,
172         486.296896820126,
173         480.225974100847,
174         457.318764401085,
175         418.177339948609,
176         414.399018364126,
177         409.678420185754,
178         404.768766016563,
179         401.699589920585,
180         402.44339040654,
181         398.138372541906,
182         396.010498627646,
183         390.165117432277,
184         375.850429417013,
185         365.567100746484,
186         365.429624610923
187     };
188
189     for (int i = 0; i < 48; i++) {
190         testFloatEquals(
191             test_electrical_load_ptr->dt_vec_hrs[i],
192             expected_dt_vec_hrs[i],
193             __FILE__,
194             __LINE__
195         );
196
197         testFloatEquals(
```



```

198         test_electrical_load_ptr->time_vec_hrs[i],
199         expected_time_vec_hrs[i],
200         __FILE__,
201         __LINE__
202     );
203
204     testFloatEquals(
205         test_electrical_load_ptr->load_vec_kW[i],
206         expected_load_vec_kW[i],
207         __FILE__,
208         __LINE__
209     );
210
211 }
212
213 return;
214 } /* testDataRead_ElectricalLoad() */

```

### 5.69.2.4 testPostConstructionAttributes\_ElectricalLoad()

```

void testPostConstructionAttributes_ElectricalLoad (
    ElectricalLoad * test_electrical_load_ptr )

```

A function to check the values of various post-construction attributes.

#### Parameters

<i>test_electrical_load_ptr</i>	A pointer to the test <a href="#">ElectricalLoad</a> object.
---------------------------------	--

```

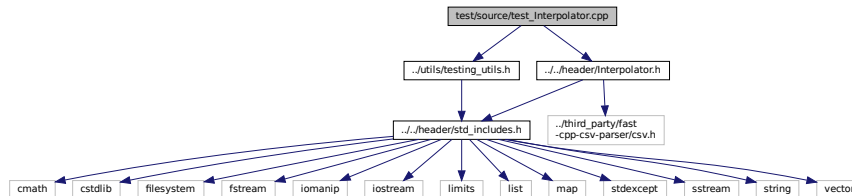
73 {
74     testFloatEquals(
75         test_electrical_load_ptr->n_points,
76         8760,
77         __FILE__,
78         __LINE__
79     );
80
81     testFloatEquals(
82         test_electrical_load_ptr->n_years,
83         0.999886,
84         __FILE__,
85         __LINE__
86     );
87
88     testFloatEquals(
89         test_electrical_load_ptr->min_load_kW,
90         82.1211213927802,
91         __FILE__,
92         __LINE__
93     );
94
95     testFloatEquals(
96         test_electrical_load_ptr->mean_load_kW,
97         258.373472633202,
98         __FILE__,
99         __LINE__
100    );
101
102
103     testFloatEquals(
104         test_electrical_load_ptr->max_load_kW,
105         500,
106         __FILE__,
107         __LINE__
108     );
109
110     return;
111 } /* testPostConstructionAttributes_ElectricalLoad() */

```

## 5.70 test/source/test\_Interpolator.cpp File Reference

Testing suite for [Interpolator](#) class.

```
#include "../utils/testing_utils.h"
#include "../../header/Interpolator.h"
Include dependency graph for test_Interpolator.cpp:
```



### Functions

- [Interpolator](#) \* [testConstruct\\_Interpolator](#) (void)  
A function to construct an [Interpolator](#) object.
- void [testDataRead1D\\_Interpolator](#) ([Interpolator](#) \*test\_interpolator\_ptr, int data\_key\_1D, std::string path\_2↔\_data\_1D)  
A function to check the 1D data values read into the [Interpolator](#) object.
- void [testBadIndexing1D\\_Interpolator](#) ([Interpolator](#) \*test\_interpolator\_ptr, int data\_key\_bad)  
A function to check if bad key errors are being handled properly.
- void [testInvalidInterpolation1D\\_Interpolator](#) ([Interpolator](#) \*test\_interpolator\_ptr, int data\_key\_1D)  
Function to check if attempting to interpolate outside the given 1D data domain is handled properly.
- void [testInterpolation1D\\_Interpolator](#) ([Interpolator](#) \*test\_interpolator\_ptr, int data\_key\_1D)  
Function to check that the [Interpolator](#) object is returning the expected 1D interpolation values.
- void [testDataRead2D\\_Interpolator](#) ([Interpolator](#) \*test\_interpolator\_ptr, int data\_key\_2D, std::string path\_2↔\_data\_2D)  
A function to check the 2D data values read into the [Interpolator](#) object.
- void [testInvalidInterpolation2D\\_Interpolator](#) ([Interpolator](#) \*test\_interpolator\_ptr, int data\_key\_2D)  
Function to check if attempting to interpolate outside the given 2D data domain is handled properly.
- void [testInterpolation2D\\_Interpolator](#) ([Interpolator](#) \*test\_interpolator\_ptr, int data\_key\_2D)  
Function to check that the [Interpolator](#) object is returning the expected 2D interpolation values.
- int [main](#) (int argc, char \*\*argv)

### 5.70.1 Detailed Description

Testing suite for [Interpolator](#) class.

A suite of tests for the [Interpolator](#) class.

### 5.70.2 Function Documentation

## 5.70.2.1 main()

```

int main (
    int argc,
    char ** argv )
700 {
701     #ifdef _WIN32
702         activateVirtualTerminal();
703     #endif /* _WIN32 */
704     printGold("\n\tTesting Interpolator");
705     srand(time(NULL));
706
707     Interpolator* test_interpolator_ptr = testConstruct_Interpolator();
708
709     try {
710         int data_key_1D = 1;
711         std::string path_2_data_1D =
712             "data/test/interpolation/diesel_fuel_curve.csv";
713
714         testDataRead1D_Interpolator(test_interpolator_ptr, data_key_1D, path_2_data_1D);
715         testBadIndexing1D_Interpolator(test_interpolator_ptr, -99);
716         testInvalidInterpolation1D_Interpolator(test_interpolator_ptr, data_key_1D);
717         testInterpolation1D_Interpolator(test_interpolator_ptr, data_key_1D);
718
719         int data_key_2D = 2;
720         std::string path_2_data_2D =
721             "data/test/interpolation/wave_energy_converter_normalized_performance_matrix.csv";
722
723         testDataRead2D_Interpolator(test_interpolator_ptr, data_key_2D, path_2_data_2D);
724         testInvalidInterpolation2D_Interpolator(test_interpolator_ptr, data_key_2D);
725         testInterpolation2D_Interpolator(test_interpolator_ptr, data_key_2D);
726     }
727
728     catch (...) {
729         delete test_interpolator_ptr;
730
731         printGold(" ..... ");
732         printRed("FAIL");
733         std::cout << std::endl;
734         throw;
735     }
736
737     delete test_interpolator_ptr;
738
739     printGold(" ..... ");
740     printGreen("PASS");
741     std::cout << std::endl;
742     return 0;
743 } /* main() */

```

## 5.70.2.2 testBadIndexing1D\_Interpolator()

```

void testBadIndexing1D_Interpolator (
    Interpolator * test_interpolator_ptr,
    int data_key_bad )

```

A function to check if bad key errors are being handled properly.

## Parameters

<i>test_interpolator_ptr</i>	A pointer to the test <a href="#">Interpolator</a> object.
<i>data_key_bad</i>	A key used to index into the <a href="#">Interpolator</a> object.

```

187 {

```

```

188     bool error_flag = true;
189
190     try {
191         test_interpolator_ptr->interp1D(data_key_bad, 0);
192         error_flag = false;
193     } catch (...) {
194         // Task failed successfully! =P
195     }
196     if (not error_flag) {
197         expectedErrorNotDetected(__FILE__, __LINE__);
198     }
199
200     return;
201 } /* testBadIndexing1D_Interpolator() */

```

### 5.70.2.3 testConstruct\_Interpolator()

```

Interpolator * testConstruct_Interpolator (
    void )

```

A function to construct an [Interpolator](#) object.

#### Returns

A pointer to a test [Interpolator](#) object.

```

37 {
38     Interpolator* test_interpolator_ptr = new Interpolator();
39
40     return test_interpolator_ptr;
41 } /* testConstruct_Interpolator() */

```

### 5.70.2.4 testDataRead1D\_Interpolator()

```

void testDataRead1D_Interpolator (
    Interpolator * test_interpolator_ptr,
    int data_key,
    std::string path_2_data_1D )

```

A function to check the 1D data values read into the [Interpolator](#) object.

#### Parameters

<i>test_interpolator_ptr</i>	A pointer to the test <a href="#">Interpolator</a> object.
<i>data_key_1D</i>	A key used to index into the <a href="#">Interpolator</a> object.
<i>path_2_data_1D</i>	A path (either relative or absolute) to the interpolation data.

```

70 {
71     test_interpolator_ptr->addData1D(data_key_1D, path_2_data_1D);
72
73     testTruth(
74         test_interpolator_ptr->path_map_1D[data_key_1D] == path_2_data_1D,
75         __FILE__,
76         __LINE__
77     );
78
79     testFloatEquals(
80         test_interpolator_ptr->interp_map_1D[data_key_1D].n_points,
81         16,
82         __FILE__,

```

```

83     __LINE__
84 );
85
86 testFloatEquals(
87     test_interpolator_ptr->interp_map_1D[data_key_1D].x_vec.size(),
88     16,
89     __FILE__,
90     __LINE__
91 );
92
93 std::vector<double> expected_x_vec = {
94     0,
95     0.3,
96     0.35,
97     0.4,
98     0.45,
99     0.5,
100    0.55,
101    0.6,
102    0.65,
103    0.7,
104    0.75,
105    0.8,
106    0.85,
107    0.9,
108    0.95,
109    1
110 };
111
112 std::vector<double> expected_y_vec = {
113     4.68079520372916,
114     11.1278522361839,
115     12.4787834830748,
116     13.7808847600209,
117     15.0417468303382,
118     16.277263,
119     17.4612831516442,
120     18.6279054806525,
121     19.7698039220515,
122     20.8893499214868,
123     21.955378,
124     23.0690535155297,
125     24.1323614374927,
126     25.1797231192866,
127     26.2122451458747,
128     27.254952
129 };
130
131 for (int i = 0; i < test_interpolator_ptr->interp_map_1D[data_key_1D].n_points; i++) {
132     testFloatEquals(
133         test_interpolator_ptr->interp_map_1D[data_key_1D].x_vec[i],
134         expected_x_vec[i],
135         __FILE__,
136         __LINE__
137     );
138
139     testFloatEquals(
140         test_interpolator_ptr->interp_map_1D[data_key_1D].y_vec[i],
141         expected_y_vec[i],
142         __FILE__,
143         __LINE__
144     );
145 }
146
147 testFloatEquals(
148     test_interpolator_ptr->interp_map_1D[data_key_1D].min_x,
149     expected_x_vec[0],
150     __FILE__,
151     __LINE__
152 );
153
154 testFloatEquals(
155     test_interpolator_ptr->interp_map_1D[data_key_1D].max_x,
156     expected_x_vec[expected_x_vec.size() - 1],
157     __FILE__,
158     __LINE__
159 );
160
161 return;
162 } /* testDataRead1D_Interpolator() */

```

### 5.70.2.5 testDataRead2D\_Interpolator()

```
void testDataRead2D_Interpolator (
    Interpolator * test_interpolator_ptr,
    int data_key,
    std::string path_2_data_2D )
```

A function to check the 2D data values read into the [Interpolator](#) object.

#### Parameters

<i>test_interpolator_ptr</i>	A pointer to the test <a href="#">Interpolator</a> object.
<i>data_key_2D</i>	A key used to index into the <a href="#">Interpolator</a> object.
<i>path_2_data_2D</i>	A path (either relative or absolute) to the interpolation data.

```
377 {
378     test_interpolator_ptr->addData2D(data_key_2D, path_2_data_2D);
379
380     testTruth(
381         test_interpolator_ptr->path_map_2D[data_key_2D] == path_2_data_2D,
382         __FILE__,
383         __LINE__
384     );
385
386     testFloatEquals(
387         test_interpolator_ptr->interp_map_2D[data_key_2D].n_rows,
388         16,
389         __FILE__,
390         __LINE__
391     );
392
393     testFloatEquals(
394         test_interpolator_ptr->interp_map_2D[data_key_2D].n_cols,
395         16,
396         __FILE__,
397         __LINE__
398     );
399
400     testFloatEquals(
401         test_interpolator_ptr->interp_map_2D[data_key_2D].x_vec.size(),
402         16,
403         __FILE__,
404         __LINE__
405     );
406
407     testFloatEquals(
408         test_interpolator_ptr->interp_map_2D[data_key_2D].y_vec.size(),
409         16,
410         __FILE__,
411         __LINE__
412     );
413
414     testFloatEquals(
415         test_interpolator_ptr->interp_map_2D[data_key_2D].z_matrix.size(),
416         16,
417         __FILE__,
418         __LINE__
419     );
420
421     testFloatEquals(
422         test_interpolator_ptr->interp_map_2D[data_key_2D].z_matrix[0].size(),
423         16,
424         __FILE__,
425         __LINE__
426     );
427
428     std::vector<double> expected_x_vec = {
429         0.25, 0.75, 1.25, 1.75, 2.25, 2.75, 3.25, 3.75, 4.25, 4.75, 5.25, 5.75, 6.25, 6.75, 7.25, 7.75
430     };
431
432     std::vector<double> expected_y_vec = {
433         5,
434         6,
435         7,
436         8,
437         9,
438         10,
439         11,
```

```

440         12,
441         13,
442         14,
443         15,
444         16,
445         17,
446         18,
447         19,
448         20
449     };
450
451     for (int i = 0; i < test_interpolator_ptr->interp_map_2D[data_key_2D].n_cols; i++) {
452         testFloatEquals(
453             test_interpolator_ptr->interp_map_2D[data_key_2D].x_vec[i],
454             expected_x_vec[i],
455             __FILE__,
456             __LINE__
457         );
458     }
459
460     for (int i = 0; i < test_interpolator_ptr->interp_map_2D[data_key_2D].n_rows; i++) {
461         testFloatEquals(
462             test_interpolator_ptr->interp_map_2D[data_key_2D].y_vec[i],
463             expected_y_vec[i],
464             __FILE__,
465             __LINE__
466         );
467     }
468
469     testFloatEquals(
470         test_interpolator_ptr->interp_map_2D[data_key_2D].min_x,
471         expected_x_vec[0],
472         __FILE__,
473         __LINE__
474     );
475
476     testFloatEquals(
477         test_interpolator_ptr->interp_map_2D[data_key_2D].max_x,
478         expected_x_vec[expected_x_vec.size() - 1],
479         __FILE__,
480         __LINE__
481     );
482
483     testFloatEquals(
484         test_interpolator_ptr->interp_map_2D[data_key_2D].min_y,
485         expected_y_vec[0],
486         __FILE__,
487         __LINE__
488     );
489
490     testFloatEquals(
491         test_interpolator_ptr->interp_map_2D[data_key_2D].max_y,
492         expected_y_vec[expected_y_vec.size() - 1],
493         __FILE__,
494         __LINE__
495     );
496
497     std::vector<std::vector<double>> expected_z_matrix = {
498         {0, 0.129128125, 0.268078125, 0.404253125, 0.537653125, 0.668278125, 0.796128125, 0.921203125,
499         1, 1, 0, 0, 0, 0, 0},
500         {0, 0.11160375, 0.24944375, 0.38395375, 0.51513375, 0.64298375, 0.76750375, 0.88869375, 1, 1, 1,
501         1, 1, 1, 1},
502         {0, 0.094079375, 0.230809375, 0.363654375, 0.492614375, 0.617689375, 0.738879375, 0.856184375,
503         0.969604375, 1, 1, 1, 1, 1, 1, 1},
504         {0, 0.076555, 0.212175, 0.343355, 0.470095, 0.592395, 0.710255, 0.823675, 0.932655, 1, 1, 1, 1,
505         1, 1, 1},
506         {0, 0.059030625, 0.193540625, 0.323055625, 0.447575625, 0.567100625, 0.681630625, 0.791165625,
507         0.895705625, 0.995250625, 1, 1, 1, 1, 1, 1},
508         {0, 0.04150625, 0.17490625, 0.30275625, 0.42505625, 0.54180625, 0.65300625, 0.75865625,
509         0.85875625, 0.95330625, 1, 1, 1, 1, 1, 1},
510         {0, 0.023981875, 0.156271875, 0.282456875, 0.402536875, 0.516511875, 0.624381875, 0.726146875,
511         0.821806875, 0.911361875, 0.994811875, 1, 1, 1, 1, 1},
512         {0, 0.0064575, 0.1376375, 0.2621575, 0.3800175, 0.4912175, 0.5957575, 0.6936375, 0.7848575,
513         0.8694175, 0.9473175, 1, 1, 1, 1, 1},
514         {0, 0, 0.119003125, 0.241858125, 0.357498125, 0.465923125, 0.567133125, 0.661128125,
515         0.747908125, 0.827473125, 0.899823125, 0.964958125, 1, 1, 1, 1},
516         {0, 0, 0.10036875, 0.22155875, 0.33497875, 0.44062875, 0.53850875, 0.62861875, 0.71095875,
517         0.78552875, 0.85232875, 0.91135875, 0.96261875, 1, 1, 1},
518         {0, 0, 0.081734375, 0.201259375, 0.312459375, 0.415334375, 0.509884375, 0.596109375,
519         0.674009375, 0.743584375, 0.804834375, 0.857759375, 0.902359375, 0.938634375, 0.966584375,
520         0.986209375},
521         {0, 0, 0.0631, 0.18096, 0.28994, 0.39004, 0.48126, 0.5636, 0.63706, 0.70164, 0.75734, 0.80416,
522         0.8421, 0.87116, 0.89134, 0.90264},
523         {0, 0, 0.044465625, 0.160660625, 0.267420625, 0.364745625, 0.452635625, 0.531090625,
524         0.600110625, 0.659695625, 0.709845625, 0.750560625, 0.781840625, 0.8036856249999999, 0.816095625,
525         0.819070625},
526         {0, 0, 0.02583125, 0.14036125, 0.24490125, 0.33945125, 0.42401125, 0.49858125, 0.56316125,

```

```

0.61775125, 0.66235125, 0.69696125, 0.72158125, 0.73621125, 0.74085125, 0.73550125},
512     {0, 0, 0.007196875, 0.120061875, 0.222381875, 0.314156875, 0.395386875, 0.466071875,
0.526211875, 0.575806875, 0.614856875, 0.643361875, 0.661321875, 0.668736875, 0.665606875,
0.651931875},
513     {0, 0, 0, 0.0997625, 0.1998625, 0.2888625, 0.3667625, 0.4335625, 0.4892625, 0.5338625,
0.5673625, 0.5897625, 0.6010625, 0.6012625, 0.5903625, 0.5683625}
514 };
515
516 for (int i = 0; i < test_interpolator_ptr->interp_map_2D[data_key_2D].n_rows; i++) {
517     for (int j = 0; j < test_interpolator_ptr->interp_map_2D[data_key_2D].n_cols; j++) {
518         testFloatEquals(
519             test_interpolator_ptr->interp_map_2D[data_key_2D].z_matrix[i][j],
520             expected_z_matrix[i][j],
521             __FILE__,
522             __LINE__
523         );
524     }
525 }
526
527 return;
528 } /* testDataRead2D_Interpolator() */

```

### 5.70.2.6 testInterpolation1D\_Interpolator()

```

void testInterpolation1D_Interpolator (
    Interpolator * test_interpolator_ptr,
    int data_key_1D )

```

Function to check that the [Interpolator](#) object is returning the expected 1D interpolation values.

#### Parameters

<i>test_interpolator_ptr</i>	A pointer to the test <a href="#">Interpolator</a> object.
<i>data_key_1D</i>	A key used to index into the <a href="#">Interpolator</a> object.

```

297 {
298     std::vector<double> interp_x_vec = {
299         0,
300         0.170812859791767,
301         0.322739274162545,
302         0.369750203682042,
303         0.443532869135929,
304         0.471567864244626,
305         0.536513734479662,
306         0.586125806988674,
307         0.601101175455075,
308         0.658356862575221,
309         0.70576929893201,
310         0.784069734739331,
311         0.805765927542453,
312         0.884747873186048,
313         0.930870496062112,
314         0.979415217694769,
315         1
316     };
317
318     std::vector<double> expected_interp_y_vec = {
319         4.68079520372916,
320         8.35159603357656,
321         11.7422361561399,
322         12.9931187917615,
323         14.8786636301325,
324         15.5746957307243,
325         17.1419229487141,
326         18.3041866133728,
327         18.6530540913696,
328         19.9569217633299,
329         21.012354614584,
330         22.7142305879957,
331         23.1916726441968,
332         24.8602332554707,
333         25.8172124624032,
334         26.8256741279932,
335         27.254952

```



```

336     };
337
338     for (size_t i = 0; i < interp_x_vec.size(); i++) {
339         testFloatEquals(
340             test_interpolator_ptr->interp1D(data_key_1D, interp_x_vec[i]),
341             expected_interp_y_vec[i],
342             __FILE__,
343             __LINE__
344         );
345     }
346
347     return;
348 } /* testInterpolation1D_Interpolator() */

```

### 5.70.2.7 testInterpolation2D\_Interpolator()

```

void testInterpolation2D_Interpolator (
    Interpolator * test_interpolator_ptr,
    int data_key_2D )

```

Function to check that the [Interpolator](#) object is returning the expected 2D interpolation values.

#### Parameters

<i>test_interpolator_ptr</i>	A pointer to the test <a href="#">Interpolator</a> object.
<i>data_key_2D</i>	A key used to index into the <a href="#">Interpolator</a> object.

```

624 {
625     std::vector<double> interp_x_vec = {
626         0.389211848822208,
627         0.836477431896843,
628         1.52738334015579,
629         1.92640601114508,
630         2.27297317532019,
631         2.87416589636605,
632         3.72275770908175,
633         3.95063175885536,
634         4.68097139867404,
635         4.97775020449812,
636         5.55184219980547,
637         6.06566629451658,
638         6.27927876785062,
639         6.96218133671013,
640         7.51754442460228
641     };
642
643     std::vector<double> interp_y_vec = {
644         5.45741899698926,
645         6.00101329139007,
646         7.50567689404182,
647         8.77681262912881,
648         9.45143678206774,
649         10.7767876462885,
650         11.4795760857165,
651         12.9430684577599,
652         13.303544885703,
653         14.5069863517863,
654         15.1487890438045,
655         16.086524049077,
656         17.176609978648,
657         18.4155153740256,
658         19.1704554940162
659     };
660
661     std::vector<std::vector<double>> expected_interp_z_matrix = {
662
663         {0.0337204906738533,0.145056406036013,0.334677248806653,0.441674658936075,0.533295755691263,0.68807895676592,0.8996148
664
665         {0.0310681846933292,0.135425896595439,0.324045598153363,0.430214268249038,0.520985043044784,0.673879556322479,0.882058
666
667         {0.0237266281076604,0.108768742207538,0.294617294841705,0.398492020763049,0.486909112828702,0.63457575706117,0.8334608
668
669         {0.0175245009938255,0.0862488504001753,0.269756343931147,0.371693152028768,0.458121859300634,0.601372013927032,0.79240

```

```

666 {0.0142328739589644,0.0742969694833995,0.256562003243255,0.357470308928265,0.442843729679424,0.583749940636223,0.770611
667 {0.0077662203173173,0.0508165832074184,0.230640709501637,0.329528443353471,0.41282867283787,0.549130026772199,0.727811
668 {0.00433717405958826,0.0383657337957315,0.21689552996585,0.314711823368423,0.396912710109449,0.530772265145106,0.705111
669 {0.000102358416923608,0.0210697053701168,0.188272456115393,0.283857573197153,0.363769179652786,0.492543912767949,0.6578
670 {0,0.0196038727057393,0.181222235960193,0.276257786480759,0.355605514643888,0.483127792688125,0.646203044346932,0.6855
671 {0,0.0157252942367668,0.157685253727545,0.250886090139653,0.328351324840186,0.451692313207986,0.607334650020078,0.6442
672 {0,0.0136568246246201,0.145132837191606,0.23735520935175,0.313816498778623,0.43492757979648,0.586605897674033,0.622265
673 {0,0.0106345930466366,0.12679255826648,0.217585300741544,0.292579730277991,0.410432703770651,0.556319211544087,0.59010
674 {0,0.00712134879261874,0.10547259059088,0.194603435839713,0.267892689267542,0.381958220518761,0.52111194060085,0.55272
675 {0,0.00312847342058727,0.0812420026472571,0.168484067035528,0.239835352250276,0.349596376397684,0.481098142839729,0.51
676 {0,0.00103256269522045,0.0673448574082101,0.152567953107312,0.222738316872545,0.329876344040866,0.456715311514779,0.48
677 };
678
679 for (size_t i = 0; i < interp_y_vec.size(); i++) {
680     for (size_t j = 0; j < interp_x_vec.size(); j++) {
681         testFloatEquals(
682             test_interpolator_ptr->interp2D(data_key_2D, interp_x_vec[j], interp_y_vec[i]),
683             expected_interp_z_matrix[i][j],
684             __FILE__,
685             __LINE__
686         );
687     }
688 }
689
690 return;
691 } /* testInterpolation2D_Interpolator() */

```

### 5.70.2.8 testInvalidInterpolation1D\_Interpolator()

```

void testInvalidInterpolation1D_Interpolator (
    Interpolator * test_interpolator_ptr,
    int data_key_1D )

```

Function to check if attempting to interpolate outside the given 1D data domain is handled properly.

#### Parameters

<i>test_interpolator_ptr</i>	A pointer to the test <a href="#">Interpolator</a> object.
<i>data_key_1D</i>	A key used to index into the <a href="#">Interpolator</a> object.

```

227 {
228     bool error_flag = true;
229
230     try {
231         test_interpolator_ptr->interp1D(data_key_1D, -1);
232         error_flag = false;
233     } catch (...) {
234         // Task failed successfully! =P
235     }
236     if (not error_flag) {
237         expectedErrorNotDetected(__FILE__, __LINE__);
238     }
239
240     try {
241         test_interpolator_ptr->interp1D(data_key_1D, 2);
242         error_flag = false;
243     } catch (...) {
244         // Task failed successfully! =P
245     }
246     if (not error_flag) {
247         expectedErrorNotDetected(__FILE__, __LINE__);
248     }
249 }

```

```

250     try {
251         test_interpolator_ptr->interp1D(data_key_1D, 0 - FLOAT_TOLERANCE);
252         error_flag = false;
253     } catch (...) {
254         // Task failed successfully! =P
255     }
256     if (not error_flag) {
257         expectedErrorNotDetected(__FILE__, __LINE__);
258     }
259
260     try {
261         test_interpolator_ptr->interp1D(data_key_1D, 1 + FLOAT_TOLERANCE);
262         error_flag = false;
263     } catch (...) {
264         // Task failed successfully! =P
265     }
266     if (not error_flag) {
267         expectedErrorNotDetected(__FILE__, __LINE__);
268     }
269
270     return;
271 } /* testInvalidInterpolation1D_Interpolator() */

```

### 5.70.2.9 testInvalidInterpolation2D\_Interpolator()

```

void testInvalidInterpolation2D_Interpolator (
    Interpolator * test_interpolator_ptr,
    int data_key_2D )

```

Function to check if attempting to interpolate outside the given 2D data domain is handled properly.

#### Parameters

<i>test_interpolator_ptr</i>	A pointer to the test <a href="#">Interpolator</a> object.
<i>data_key_2D</i>	A key used to index into the <a href="#">Interpolator</a> object.

```

554 {
555     bool error_flag = true;
556
557     try {
558         test_interpolator_ptr->interp2D(data_key_2D, -1, 6);
559         error_flag = false;
560     } catch (...) {
561         // Task failed successfully! =P
562     }
563     if (not error_flag) {
564         expectedErrorNotDetected(__FILE__, __LINE__);
565     }
566
567     try {
568         test_interpolator_ptr->interp2D(data_key_2D, 99, 6);
569         error_flag = false;
570     } catch (...) {
571         // Task failed successfully! =P
572     }
573     if (not error_flag) {
574         expectedErrorNotDetected(__FILE__, __LINE__);
575     }
576
577     try {
578         test_interpolator_ptr->interp2D(data_key_2D, 0.75, -1);
579         error_flag = false;
580     } catch (...) {
581         // Task failed successfully! =P
582     }
583     if (not error_flag) {
584         expectedErrorNotDetected(__FILE__, __LINE__);
585     }
586
587     try {
588         test_interpolator_ptr->interp2D(data_key_2D, 0.75, 99);
589         error_flag = false;
590     } catch (...) {
591         // Task failed successfully! =P

```

```

592     }
593     if (not error_flag) {
594         expectedErrorNotDetected(__FILE__, __LINE__);
595     }
596
597     return;
598 } /* testInvalidInterpolation2D_Interpolator() */

```

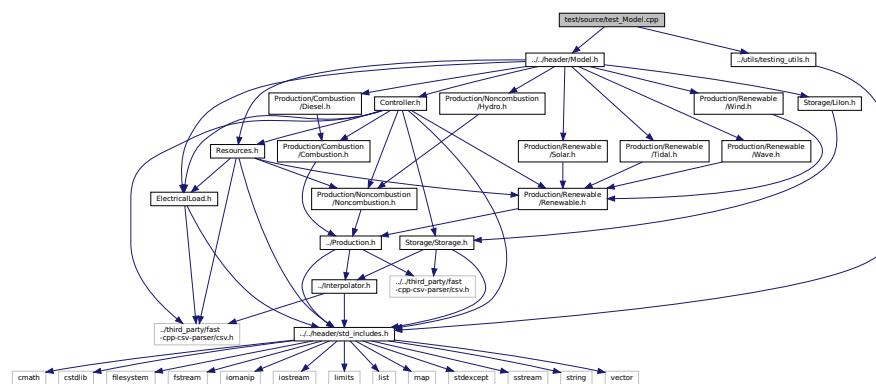
## 5.71 test/source/test\_Model.cpp File Reference

Testing suite for [Model](#) class.

```
#include "../utils/testing_utils.h"
```

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

Include dependency graph for test\_Model.cpp:



## Functions

- [Model](#) \* [testConstruct\\_Model](#) ([ModelInputs](#) test\_model\_inputs)
- void [testBadConstruct\\_Model](#) (void)
 

Function to check if passing bad [ModelInputs](#) to the [Model](#) constructor is handled appropriately.
- void [testPostConstructionAttributes\\_Model](#) ([Model](#) \*test\_model\_ptr)
 

A function to check the values of various post-construction attributes.
- void [testElectricalLoadData\\_Model](#) ([Model](#) \*test\_model\_ptr)
 

Function to check the values read into the [ElectricalLoad](#) component of the test [Model](#) object.
- void [testAddSolarResource\\_Model](#) ([Model](#) \*test\_model\_ptr, std::string path\_2\_solar\_resource\_data, int solar\_resource\_key)
 

Function to test adding a solar resource and then check the values read into the [Resources](#) component of the test [Model](#) object.
- void [testAddTidalResource\\_Model](#) ([Model](#) \*test\_model\_ptr, std::string path\_2\_tidal\_resource\_data, int tidal\_resource\_key)
 

Function to test adding a tidal resource and then check the values read into the [Resources](#) component of the test [Model](#) object.
- void [testAddWaveResource\\_Model](#) ([Model](#) \*test\_model\_ptr, std::string path\_2\_wave\_resource\_data, int wave\_resource\_key)
 

Function to test adding a wave resource and then check the values read into the [Resources](#) component of the test [Model](#) object.
- void [testAddWindResource\\_Model](#) ([Model](#) \*test\_model\_ptr, std::string path\_2\_wind\_resource\_data, int wind\_resource\_key)

- Function to test adding a wind resource and then check the values read into the [Resources](#) component of the test [Model](#) object.*
- void [testAddHydroResource\\_Model](#) ([Model](#) \*test\_model\_ptr, std::string path\_2\_hydro\_resource\_data, int hydro\_resource\_key)
- Function to test adding a hydro resource and then check the values read into the [Resources](#) component of the test [Model](#) object.*
- void [testAddHydro\\_Model](#) ([Model](#) \*test\_model\_ptr, int hydro\_resource\_key)
- Function to test adding a hydroelectric asset to the test [Model](#) object, and then spot check some post-add attributes.*
- void [testAddDiesel\\_Model](#) ([Model](#) \*test\_model\_ptr)
- Function to test adding a suite of diesel generators to the test [Model](#) object, and then spot check some post-add attributes.*
- void [testAddSolar\\_Model](#) ([Model](#) \*test\_model\_ptr, int solar\_resource\_key)
- Function to test adding a solar PV array to the test [Model](#) object and then spot check some post-add attributes.*
- void [testAddTidal\\_Model](#) ([Model](#) \*test\_model\_ptr, int tidal\_resource\_key)
- Function to test adding a tidal turbine to the test [Model](#) object and then spot check some post-add attributes.*
- void [testAddWave\\_Model](#) ([Model](#) \*test\_model\_ptr, int wave\_resource\_key)
- Function to test adding a wave energy converter to the test [Model](#) object and then spot check some post-add attributes.*
- void [testAddWind\\_Model](#) ([Model](#) \*test\_model\_ptr, int wind\_resource\_key)
- Function to test adding a wind turbine to the test [Model](#) object and then spot check some post-add attributes.*
- void [testAddLilon\\_Model](#) ([Model](#) \*test\_model\_ptr)
- Function to test adding a lithium ion battery energy storage system to the test [Model](#) object and then spot check some post-add attributes.*
- void [testLoadBalance\\_Model](#) ([Model](#) \*test\_model\_ptr)
- Function to check that the post-run load data is as expected. That is, the added renewable, production, and storage assets are handled by the [Controller](#) as expected.*
- void [testEconomics\\_Model](#) ([Model](#) \*test\_model\_ptr)
- Function to check that the modelled economic metrics are > 0.*
- void [testFuelConsumptionEmissions\\_Model](#) ([Model](#) \*test\_model\_ptr)
- Function to check that the modelled fuel consumption and emissions are > 0.*
- int [main](#) (int argc, char \*\*argv)

### 5.71.1 Detailed Description

Testing suite for [Model](#) class.

A suite of tests for the [Model](#) class.

### 5.71.2 Function Documentation

## 5.71.2.1 main()

```

int main (
    int argc,
    char ** argv )

1403 {
1404     #ifdef _WIN32
1405         activateVirtualTerminal();
1406     #endif /* _WIN32 */
1407
1408     printGold("\tTesting Model");
1409
1410     srand(time(NULL));
1411
1412
1413     std::string path_2_electrical_load_time_series =
1414         "data/test/electrical_load/electrical_load_generic_peak-500kW_1yr_dt-1hr.csv";
1415
1416     ModelInputs test_model_inputs;
1417     test_model_inputs.path_2_electrical_load_time_series =
1418         path_2_electrical_load_time_series;
1419
1420     Model* test_model_ptr = testConstruct_Model(test_model_inputs);
1421
1422
1423     try {
1424         testBadConstruct_Model();
1425         testPostConstructionAttributes_Model(test_model_ptr);
1426         testElectricalLoadData_Model(test_model_ptr);
1427
1428
1429         int solar_resource_key = 0;
1430         std::string path_2_solar_resource_data =
1431             "data/test/resources/solar_GHI_peak-1kWm2_1yr_dt-1hr.csv";
1432
1433         testAddSolarResource_Model(
1434             test_model_ptr,
1435             path_2_solar_resource_data,
1436             solar_resource_key
1437         );
1438
1439
1440         int tidal_resource_key = 1;
1441         std::string path_2_tidal_resource_data =
1442             "data/test/resources/tidal_speed_peak-3ms_1yr_dt-1hr.csv";
1443
1444         testAddTidalResource_Model(
1445             test_model_ptr,
1446             path_2_tidal_resource_data,
1447             tidal_resource_key
1448         );
1449
1450
1451         int wave_resource_key = 2;
1452         std::string path_2_wave_resource_data =
1453             "data/test/resources/waves_H_s_peak-8m_T_e_peak-15s_1yr_dt-1hr.csv";
1454
1455         testAddWaveResource_Model(
1456             test_model_ptr,
1457             path_2_wave_resource_data,
1458             wave_resource_key
1459         );
1460
1461
1462         int wind_resource_key = 3;
1463         std::string path_2_wind_resource_data =
1464             "data/test/resources/wind_speed_peak-25ms_1yr_dt-1hr.csv";
1465
1466         testAddWindResource_Model(
1467             test_model_ptr,
1468             path_2_wind_resource_data,
1469             wind_resource_key
1470         );
1471
1472
1473         int hydro_resource_key = 4;
1474         std::string path_2_hydro_resource_data =
1475             "data/test/resources/hydro_inflow_peak-20000m3hr_1yr_dt-1hr.csv";
1476
1477         testAddHydroResource_Model(
1478             test_model_ptr,
1479             path_2_hydro_resource_data,
1480             hydro_resource_key
1481         );
1482

```

```

1483
1484     testAddHydro_Model(test_model_ptr, hydro_resource_key);
1485     testAddDiesel_Model(test_model_ptr);
1486     testAddSolar_Model(test_model_ptr, solar_resource_key);
1487     testAddTidal_Model(test_model_ptr, tidal_resource_key);
1488     testAddWave_Model(test_model_ptr, wave_resource_key);
1489     testAddWind_Model(test_model_ptr, wind_resource_key);
1490
1491
1492     test_model_ptr->run();
1493     test_model_ptr->writeResults("test/test_results/");
1494
1495
1496     testLoadBalance_Model(test_model_ptr);
1497     testEconomics_Model(test_model_ptr);
1498     testFuelConsumptionEmissions_Model(test_model_ptr);
1499 }
1500
1501
1502 catch (...) {
1503     delete test_model_ptr;
1504
1505     printGold(" ..... ");
1506     printRed("FAIL");
1507     std::cout << std::endl;
1508     throw;
1509 }
1510
1511
1512 delete test_model_ptr;
1513
1514 printGold(" ..... ");
1515 printGreen("PASS");
1516 std::cout << std::endl;
1517 return 0;
1518 } /* main() */

```

### 5.71.2.2 testAddDiesel\_Model()

```

void testAddDiesel_Model (
    Model * test_model_ptr )

```

Function to test adding a suite of diesel generators to the test [Model](#) object, and then spot check some post-add attributes.

#### Parameters

<i>test_model_ptr</i>	A pointer to the test <a href="#">Model</a> object.
-----------------------	---

```

893 {
894     DieselInputs diesel_inputs;
895     diesel_inputs.combustion_inputs.production_inputs.capacity_kW = 100;
896     diesel_inputs.combustion_inputs.production_inputs.is_sunk = true;
897
898     test_model_ptr->addDiesel(diesel_inputs);
899
900     testFloatEquals(
901         test_model_ptr->combustion_ptr_vec.size(),
902         1,
903         __FILE__,
904         __LINE__
905     );
906
907     testFloatEquals(
908         test_model_ptr->combustion_ptr_vec[0]->type,
909         CombustionType :: DIESEL,
910         __FILE__,
911         __LINE__
912     );
913
914     diesel_inputs.combustion_inputs.production_inputs.capacity_kW = 150;
915
916     test_model_ptr->addDiesel(diesel_inputs);
917
918     diesel_inputs.combustion_inputs.production_inputs.capacity_kW = 250;

```

```

919
920     test_model_ptr->addDiesel(diesel_inputs);
921
922     testFloatEquals(
923         test_model_ptr->combustion_ptr_vec.size(),
924         3,
925         __FILE__,
926         __LINE__
927     );
928
929     std::vector<int> expected_diesel_capacity_vec_kW = {100, 150, 250};
930
931     for (int i = 0; i < 3; i++) {
932         testFloatEquals(
933             test_model_ptr->combustion_ptr_vec[i]->capacity_kW,
934             expected_diesel_capacity_vec_kW[i],
935             __FILE__,
936             __LINE__
937         );
938     }
939
940     diesel_inputs.combustion_inputs.production_inputs.capacity_kW = 100;
941
942     for (int i = 0; i < 2 * ((double)rand() / RAND_MAX); i++) {
943         test_model_ptr->addDiesel(diesel_inputs);
944     }
945
946     return;
947 } /* testAddDiesel_Model() */

```

### 5.71.2.3 testAddHydro\_Model()

```

void testAddHydro_Model (
    Model * test_model_ptr,
    int hydro_resource_key )

```

Function to test adding a hydroelectric asset to the test [Model](#) object, and then spot check some post-add attributes.

#### Parameters

<i>test_model_ptr</i>	A pointer to the test <a href="#">Model</a> object.
<i>hydro_resource_key</i>	A key used to index into the <a href="#">Resources</a> component of the test <a href="#">Model</a> object.

```

843 {
844     HydroInputs hydro_inputs;
845     hydro_inputs.noncombustion_inputs.production_inputs.capacity_kW = 300;
846     hydro_inputs.reservoir_capacity_m3 = 100000;
847     hydro_inputs.init_reservoir_state = 0.5;
848     hydro_inputs.noncombustion_inputs.production_inputs.is_sunk = true;
849     hydro_inputs.resource_key = hydro_resource_key;
850
851     test_model_ptr->addHydro(hydro_inputs);
852
853     testFloatEquals(
854         test_model_ptr->noncombustion_ptr_vec.size(),
855         1,
856         __FILE__,
857         __LINE__
858     );
859
860     testFloatEquals(
861         test_model_ptr->noncombustion_ptr_vec[0]->type,
862         NoncombustionType :: HYDRO,
863         __FILE__,
864         __LINE__
865     );
866
867     testFloatEquals(
868         test_model_ptr->noncombustion_ptr_vec[0]->resource_key,
869         hydro_resource_key,
870         __FILE__,
871         __LINE__
872     );

```



```

873
874     return;
875 } /* testAddHydro_Model() */

```

#### 5.71.2.4 testAddHydroResource\_Model()

```

void testAddHydroResource_Model (
    Model * test_model_ptr,
    std::string path_2_hydro_resource_data,
    int hydro_resource_key )

```

Function to test adding a hydro resource and then check the values read into the [Resources](#) component of the test [Model](#) object.

##### Parameters

<i>test_model_ptr</i>	A pointer to the test <a href="#">Model</a> object.
<i>path_2_hydro_resource_data</i>	A path (either relative or absolute) to the hydro resource data.
<i>hydro_resource_key</i>	A key used to index into the <a href="#">Resources</a> component of the test <a href="#">Model</a> object.

```

748 {
749     test_model_ptr->addResource(
750         NoncombustionType :: HYDRO,
751         path_2_hydro_resource_data,
752         hydro_resource_key
753     );
754
755     std::vector<double> expected_hydro_resource_vec_ms = {
756         2167.91531556942,
757         2046.58261560569,
758         2007.85941123153,
759         2000.11477247929,
760         1917.50527264453,
761         1963.97311577093,
762         1908.46985899809,
763         1886.5267112678,
764         1965.26388854254,
765         1953.64692935289,
766         2084.01504296306,
767         2272.46796101188,
768         2520.29645627096,
769         2715.203242423,
770         2720.36633563203,
771         3130.83228077221,
772         3289.59741021591,
773         3981.45195965772,
774         5295.45929491303,
775         7084.47124360523,
776         7709.20557708454,
777         7436.85238642936,
778         7235.49173429668,
779         6710.14695517339,
780         6015.71085806577,
781         5279.97001316337,
782         4877.24870889801,
783         4421.60569340303,
784         3919.49483690424,
785         3498.70270322341,
786         3274.10813058883,
787         3147.61233529349,
788         2904.94693324343,
789         2805.55738101,
790         2418.32535637171,
791         2398.96375630723,
792         2260.85100182222,
793         2157.58912702878,
794         2019.47637254377,
795         1913.63295220712,
796         1863.29279076589,
797         1748.41395678279,
798         1695.49224555317,
799         1599.97501375715,

```

```

800         1559.96103873397,
801         1505.74855473274,
802         1438.62833664765,
803         1384.41585476901
804     };
805
806     for (size_t i = 0; i < expected_hydro_resource_vec_ms.size(); i++) {
807         testFloatEquals(
808             test_model_ptr->resources.resource_map_1D[hydro_resource_key][i],
809             expected_hydro_resource_vec_ms[i],
810             __FILE__,
811             __LINE__
812         );
813     }
814
815     return;
816 } /* testAddHydroResource_Model() */

```

### 5.71.2.5 testAddLiIon\_Model()

```

void testAddLiIon_Model (
    Model * test_model_ptr )

```

Function to test adding a lithium ion battery energy storage system to the test [Model](#) object and then spot check some post-add attributes.

#### Parameters

<i>test_model_ptr</i>	A pointer to the test <a href="#">Model</a> object.
-----------------------	---

```

1157 {
1158     LiIonInputs liion_inputs;
1159
1160     test_model_ptr->addLiIon(liion_inputs);
1161
1162     testFloatEquals(
1163         test_model_ptr->storage_ptr_vec.size(),
1164         1,
1165         __FILE__,
1166         __LINE__
1167     );
1168
1169     testFloatEquals(
1170         test_model_ptr->storage_ptr_vec[0]->type,
1171         StorageType :: LIION,
1172         __FILE__,
1173         __LINE__
1174     );
1175
1176     return;
1177 } /* testAddLiIon_Model() */

```

### 5.71.2.6 testAddSolar\_Model()

```

void testAddSolar_Model (
    Model * test_model_ptr,
    int solar_resource_key )

```

Function to test adding a solar PV array to the test [Model](#) object and then spot check some post-add attributes.

#### Parameters

<i>test_model_ptr</i>	A pointer to the test <a href="#">Model</a> object.
<i>solar_resource_key</i>	A key used to index into the <a href="#">Resources</a> component of the test <a href="#">Model</a> object.

```

974 {
975     SolarInputs solar_inputs;
976     solar_inputs.resource_key = solar_resource_key;
977
978     test_model_ptr->addSolar(solar_inputs);
979
980     testFloatEquals(
981         test_model_ptr->renewable_ptr_vec.size(),
982         1,
983         __FILE__,
984         __LINE__
985     );
986
987     testFloatEquals(
988         test_model_ptr->renewable_ptr_vec[0]->type,
989         RenewableType :: SOLAR,
990         __FILE__,
991         __LINE__
992     );
993
994     return;
995 } /* testAddSolar_Model() */

```

### 5.71.2.7 testAddSolarResource\_Model()

```

void testAddSolarResource_Model (
    Model * test_model_ptr,
    std::string path_2_solar_resource_data,
    int solar_resource_key )

```

Function to test adding a solar resource and then check the values read into the [Resources](#) component of the test [Model](#) object.

#### Parameters

<i>test_model_ptr</i>	A pointer to the test <a href="#">Model</a> object.
<i>path_2_solar_resource_data</i>	A path (either relative or absolute) to the solar resource data.
<i>solar_resource_key</i>	A key used to index into the <a href="#">Resources</a> component of the test <a href="#">Model</a> object.

```

290 {
291     test_model_ptr->addResource(
292         RenewableType :: SOLAR,
293         path_2_solar_resource_data,
294         solar_resource_key
295     );
296
297     std::vector<double> expected_solar_resource_vec_kWm2 = {
298         0,
299         0,
300         0,
301         0,
302         0,
303         0,
304         8.51702662684015E-05,
305         0.000348341567045,
306         0.00213793728593,
307         0.004099863613322,
308         0.000997135230553,
309         0.009534527624657,
310         0.022927996790616,
311         0.0136071715294,
312         0.002535134127751,
313         0.005206897515821,
314         0.005627658648597,
315         0.000701186722215,
316         0.00017119827089,
317         0,
318         0,
319         0,
320         0,
321         0,
322         0,

```

```

323         0,
324         0,
325         0,
326         0,
327         0,
328         0,
329         0.000141055102242,
330         0.00084525014743,
331         0.024893647822702,
332         0.091245556190749,
333         0.158722176731637,
334         0.152859680515876,
335         0.149922903895116,
336         0.13049996570866,
337         0.03081254222795,
338         0.001218928911125,
339         0.000206092647423,
340         0,
341         0,
342         0,
343         0,
344         0,
345         0
346     };
347
348     for (size_t i = 0; i < expected_solar_resource_vec_kWm2.size(); i++) {
349         testFloatEquals(
350             test_model_ptr->resources.resource_map_1D[solar_resource_key][i],
351             expected_solar_resource_vec_kWm2[i],
352             __FILE__,
353             __LINE__
354         );
355     }
356
357     return;
358 } /* testAddSolarResource_Model() */

```

### 5.71.2.8 testAddTidal\_Model()

```

void testAddTidal_Model (
    Model * test_model_ptr,
    int tidal_resource_key )

```

Function to test adding a tidal turbine to the test [Model](#) object and then spot check some post-add attributes.

#### Parameters

<i>test_model_ptr</i>	A pointer to the test <a href="#">Model</a> object.
<i>tidal_resource_key</i>	A key used to index into the <a href="#">Resources</a> component of the test <a href="#">Model</a> object.

```

1022 {
1023     TidalInputs tidal_inputs;
1024     tidal_inputs.resource_key = tidal_resource_key;
1025
1026     test_model_ptr->addTidal(tidal_inputs);
1027
1028     testFloatEquals(
1029         test_model_ptr->renewable_ptr_vec.size(),
1030         2,
1031         __FILE__,
1032         __LINE__
1033     );
1034
1035     testFloatEquals(
1036         test_model_ptr->renewable_ptr_vec[1]->type,
1037         RenewableType :: TIDAL,
1038         __FILE__,
1039         __LINE__
1040     );
1041
1042     return;
1043 } /* testAddTidal_Model() */

```

## 5.71.2.9 testAddTidalResource\_Model()

```
void testAddTidalResource_Model (
    Model * test_model_ptr,
    std::string path_2_tidal_resource_data,
    int tidal_resource_key )
```

Function to test adding a tidal resource and then check the values read into the [Resources](#) component of the test [Model](#) object.

## Parameters

<i>test_model_ptr</i>	A pointer to the test <a href="#">Model</a> object.
<i>path_2_tidal_resource_data</i>	A path (either relative or absolute) to the tidal resource data.
<i>tidal_resource_key</i>	A key used to index into the <a href="#">Resources</a> component of the test <a href="#">Model</a> object.

```
390 {
391     test_model_ptr->addResource(
392         RenewableType :: TIDAL,
393         path_2_tidal_resource_data,
394         tidal_resource_key
395     );
396
397     std::vector<double> expected_tidal_resource_vec_ms = {
398         0.347439913040533,
399         0.770545522195602,
400         0.731352084836198,
401         0.293389814389542,
402         0.209959110813115,
403         0.610609623896497,
404         1.78067162013604,
405         2.53522775118089,
406         2.75966627832024,
407         2.52101111143895,
408         2.05389330201031,
409         1.3461515862445,
410         0.28909254878384,
411         0.897754086048563,
412         1.71406453837407,
413         1.85047408742869,
414         1.71507908595979,
415         1.33540349705416,
416         0.434586143463003,
417         0.500623815700637,
418         1.37172172646733,
419         1.68294125491228,
420         1.56101300975417,
421         1.04925834219412,
422         0.211395463930223,
423         1.03720048903385,
424         1.85059536356448,
425         1.85203242794517,
426         1.4091471616277,
427         0.767776539039899,
428         0.251464906990961,
429         1.47018469375652,
430         2.36260493698197,
431         2.46653750048625,
432         2.12851908739291,
433         1.62783753197988,
434         0.734594890957439,
435         0.441886297300355,
436         1.6574418350918,
437         2.0684558286637,
438         1.87717416992136,
439         1.58871262337931,
440         1.03451227609235,
441         0.193371305159817,
442         0.976400122458815,
443         1.6583227369707,
444         1.76690616570953,
445         1.54801328553115
446     };
```

```

447
448     for (size_t i = 0; i < expected_tidal_resource_vec_ms.size(); i++) {
449         testFloatEquals(
450             test_model_ptr->resources.resource_map_1D[tidal_resource_key][i],
451             expected_tidal_resource_vec_ms[i],
452             __FILE__,
453             __LINE__
454         );
455     }
456
457     return;
458 } /* testAddTidalResource_Model() */

```

#### 5.71.2.10 testAddWave\_Model()

```

void testAddWave_Model (
    Model * test_model_ptr,
    int wave_resource_key )

```

Function to test adding a wave energy converter to the test [Model](#) object and then spot check some post-add attributes.

##### Parameters

<i>test_model_ptr</i>	A pointer to the test <a href="#">Model</a> object.
<i>wave_resource_key</i>	A key used to index into the <a href="#">Resources</a> component of the test <a href="#">Model</a> object.

```

1070 {
1071     WaveInputs wave_inputs;
1072     wave_inputs.resource_key = wave_resource_key;
1073
1074     test_model_ptr->addWave(wave_inputs);
1075
1076     testFloatEquals(
1077         test_model_ptr->renewable_ptr_vec.size(),
1078         3,
1079         __FILE__,
1080         __LINE__
1081     );
1082
1083     testFloatEquals(
1084         test_model_ptr->renewable_ptr_vec[2]->type,
1085         RenewableType :: WAVE,
1086         __FILE__,
1087         __LINE__
1088     );
1089
1090     return;
1091 } /* testAddWave_Model() */

```

#### 5.71.2.11 testAddWaveResource\_Model()

```

void testAddWaveResource_Model (
    Model * test_model_ptr,
    std::string path_2_wave_resource_data,
    int wave_resource_key )

```

Function to test adding a wave resource and then check the values read into the [Resources](#) component of the test [Model](#) object.

## Parameters

<i>test_model_ptr</i>	A pointer to the test <a href="#">Model</a> object.
<i>path_2_wave_resource_data</i>	A path (either relative or absolute) to the wave resource data.
<i>wave_resource_key</i>	A key used to index into the <a href="#">Resources</a> component of the test <a href="#">Model</a> object.

```

490 {
491     test_model_ptr->addResource (
492         RenewableType :: WAVE,
493         path_2_wave_resource_data,
494         wave_resource_key
495     );
496
497     std::vector<double> expected_significant_wave_height_vec_m = {
498         4.26175222125028,
499         4.25020976167872,
500         4.25656524330349,
501         4.27193854786718,
502         4.28744955711233,
503         4.29421815278154,
504         4.2839937266082,
505         4.25716982457976,
506         4.22419391611483,
507         4.19588925217606,
508         4.17338788587412,
509         4.14672746914214,
510         4.10560041173665,
511         4.05074966447193,
512         3.9953696962433,
513         3.95316976150866,
514         3.92771018142378,
515         3.91129562488595,
516         3.89558312094911,
517         3.87861093931749,
518         3.86538307240754,
519         3.86108961027929,
520         3.86459448853189,
521         3.86796474016882,
522         3.86357412779993,
523         3.85554872014731,
524         3.86044266668675,
525         3.89445961915999,
526         3.95554798115731,
527         4.02265508610476,
528         4.07419587011404,
529         4.10314247143958,
530         4.11738045085928,
531         4.12554995596708,
532         4.12923992001675,
533         4.1229292327442,
534         4.10123955307441,
535         4.06748827895363,
536         4.0336230651344,
537         4.01134236393876,
538         4.00136570034559,
539         3.99368787690411,
540         3.97820924247644,
541         3.95369335178055,
542         3.92742545608532,
543         3.90683362771686,
544         3.89331520944006,
545         3.88256045801583
546     };
547
548     std::vector<double> expected_energy_period_vec_s = {
549         10.4456008226821,
550         10.4614151137651,
551         10.4462827795433,
552         10.4127692097884,
553         10.3734397942723,
554         10.3408599227669,
555         10.32637292093,
556         10.3245412676322,
557         10.310409818185,
558         10.2589529840966,
559         10.1728100603103,
560         10.0862908658929,
561         10.03480243813,
562         10.023673635806,
563         10.0243418565116,
564         10.0063487117653,
565         9.96050302286607,
566         9.9011999635568,
567         9.84451822125472,

```

```

568         9.79726875879626,
569         9.75614594835158,
570         9.7173447961368,
571         9.68342904390577,
572         9.66380508567062,
573         9.6674009575699,
574         9.68927134575103,
575         9.70979984863046,
576         9.70967357906908,
577         9.68983025704562,
578         9.6722855524805,
579         9.67973599910003,
580         9.71977125328293,
581         9.78450442291421,
582         9.86532355233449,
583         9.96158937600019,
584         10.0807018356507,
585         10.2291022504937,
586         10.39458528356,
587         10.5464393581004,
588         10.6553277500484,
589         10.7245553190084,
590         10.7893127285064,
591         10.8846512240849,
592         11.0148158739075,
593         11.1544325654719,
594         11.2772785848343,
595         11.3744362756187,
596         11.4533643503183
597     };
598
599     for (size_t i = 0; i < expected_energy_period_vec_s.size(); i++) {
600         testFloatEquals(
601             test_model_ptr->resources.resource_map_2D[wave_resource_key][i][0],
602             expected_significant_wave_height_vec_m[i],
603             __FILE__,
604             __LINE__
605         );
606
607         testFloatEquals(
608             test_model_ptr->resources.resource_map_2D[wave_resource_key][i][1],
609             expected_energy_period_vec_s[i],
610             __FILE__,
611             __LINE__
612         );
613     }
614
615     return;
616 } /* testAddWaveResource_Model() */

```

### 5.71.2.12 testAddWind\_Model()

```

void testAddWind_Model (
    Model * test_model_ptr,
    int wind_resource_key )

```

Function to test adding a wind turbine to the test [Model](#) object and then spot check some post-add attributes.

#### Parameters

<i>test_model_ptr</i>	A pointer to the test <a href="#">Model</a> object.
<i>wind_resource_key</i>	A key used to index into the <a href="#">Resources</a> component of the test <a href="#">Model</a> object.

```

1118 {
1119     WindInputs wind_inputs;
1120     wind_inputs.resource_key = wind_resource_key;
1121
1122     test_model_ptr->addWind(wind_inputs);
1123
1124     testFloatEquals(
1125         test_model_ptr->renewable_ptr_vec.size(),
1126         4,
1127         __FILE__,

```



```

1128     __LINE__
1129 );
1130
1131 testFloatEquals(
1132     test_model_ptr->renewable_ptr_vec[3]->type,
1133     RenewableType :: WIND,
1134     __FILE__,
1135     __LINE__
1136 );
1137
1138 return;
1139 } /* testAddWind_Model() */

```

### 5.71.2.13 testAddWindResource\_Model()

```

void testAddWindResource_Model (
    Model * test_model_ptr,
    std::string path_2_wind_resource_data,
    int wind_resource_key )

```

Function to test adding a wind resource and then check the values read into the [Resources](#) component of the test [Model](#) object.

#### Parameters

<i>test_model_ptr</i>	A pointer to the test <a href="#">Model</a> object.
<i>path_2_wind_resource_data</i>	A path (either relative or absolute) to the wind resource data.
<i>wind_resource_key</i>	A key used to index into the <a href="#">Resources</a> component of the test <a href="#">Model</a> object.

```

648 {
649     test_model_ptr->addResource(
650         RenewableType :: WIND,
651         path_2_wind_resource_data,
652         wind_resource_key
653     );
654
655     std::vector<double> expected_wind_resource_vec_ms = {
656         6.88566688469997,
657         5.02177105466549,
658         3.74211715899568,
659         5.67169579985362,
660         4.90670669971858,
661         4.29586955031368,
662         7.41155377205065,
663         10.2243290476943,
664         13.1258696725555,
665         13.7016198628274,
666         16.2481482330233,
667         16.5096744355418,
668         13.4354482206162,
669         14.0129230731609,
670         14.5554549260515,
671         13.4454539065912,
672         13.3447169512094,
673         11.7372615098554,
674         12.7200070078013,
675         10.6421127908149,
676         6.09869498990661,
677         5.66355596602321,
678         4.97316966910831,
679         3.48937138360567,
680         2.15917470979169,
681         1.29061103587027,
682         3.43475751425219,
683         4.11706326260927,
684         4.28905275747408,
685         5.75850263196241,
686         8.98293663055264,
687         11.7069822941315,
688         12.4031987075858,
689         15.4096570910089,
690         16.6210843829552,

```

```

691         13.3421219142573,
692         15.2112831900548,
693         18.350864533037,
694         15.8751799822971,
695         15.3921198799796,
696         15.9729192868434,
697         12.4728950178772,
698         10.177050481096,
699         10.7342247355551,
700         8.98846695631389,
701         4.14671169124739,
702         3.17256452697149,
703         3.40036336968628
704     };
705
706     for (size_t i = 0; i < expected_wind_resource_vec_ms.size(); i++) {
707         testFloatEquals(
708             test_model_ptr->resources.resource_map_1D[wind_resource_key][i],
709             expected_wind_resource_vec_ms[i],
710             __FILE__,
711             __LINE__
712         );
713     }
714
715     return;
716 } /* testAddWindResource_Model() */

```

#### 5.71.2.14 testBadConstruct\_Model()

```

void testBadConstruct_Model (
    void )

```

Function to check if passing bad [ModelInputs](#) to the [Model](#) constructor is handled appropriately.

```

66 {
67     bool error_flag = true;
68
69     try {
70         ModelInputs bad_model_inputs; // path_2_electrical_load_time_series left empty
71
72         Model bad_model(bad_model_inputs);
73
74         error_flag = false;
75     } catch (...) {
76         // Task failed successfully! =P
77     }
78     if (not error_flag) {
79         expectedErrorNotDetected(__FILE__, __LINE__);
80     }
81
82     try {
83         ModelInputs bad_model_inputs;
84         bad_model_inputs.path_2_electrical_load_time_series =
85             "data/test/electrical_load/bad_path_";
86         bad_model_inputs.path_2_electrical_load_time_series += std::to_string(rand());
87         bad_model_inputs.path_2_electrical_load_time_series += ".csv";
88
89         Model bad_model(bad_model_inputs);
90
91         error_flag = false;
92     } catch (...) {
93         // Task failed successfully! =P
94     }
95     if (not error_flag) {
96         expectedErrorNotDetected(__FILE__, __LINE__);
97     }
98
99     return;
100 }

```

## 5.71.2.15 testConstruct\_Model()

```

Model* testConstruct_Model (
    ModelInputs test_model_inputs )
39 {
40     Model* test_model_ptr = new Model(test_model_inputs);
41
42     testTruth(
43         test_model_ptr->electrical_load.path_2_electrical_load_time_series ==
44         test_model_inputs.path_2_electrical_load_time_series,
45         __FILE__,
46         __LINE__
47     );
48
49     return test_model_ptr;
50 } /* testConstruct_Model() */

```

## 5.71.2.16 testEconomics\_Model()

```

void testEconomics_Model (
    Model * test_model_ptr )

```

Function to check that the modelled economic metrics are  $> 0$ .

## Parameters

<i>test_model_ptr</i>	A pointer to the test <a href="#">Model</a> object.
-----------------------	---

```

1310 {
1311     testGreaterThan(
1312         test_model_ptr->net_present_cost,
1313         0,
1314         __FILE__,
1315         __LINE__
1316     );
1317
1318     testGreaterThan(
1319         test_model_ptr->levellized_cost_of_energy_kWh,
1320         0,
1321         __FILE__,
1322         __LINE__
1323     );
1324
1325     return;
1326 } /* testEconomics_Model() */

```

## 5.71.2.17 testElectricalLoadData\_Model()

```

void testElectricalLoadData_Model (
    Model * test_model_ptr )

```

Function to check the values read into the [ElectricalLoad](#) component of the test [Model](#) object.

## Parameters

<i>test_model_ptr</i>	A pointer to the test <a href="#">Model</a> object.
-----------------------	---

```

173 {
174     std::vector<double> expected_dt_vec_hrs (48, 1);
175

```

```

176     std::vector<double> expected_time_vec_hrs = {
177         0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11,
178         12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23,
179         24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35,
180         36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47
181     };
182
183     std::vector<double> expected_load_vec_kW = {
184         360.253836463674,
185         355.171277826775,
186         353.776453532298,
187         353.75405737934,
188         346.592867404975,
189         340.132411175118,
190         337.354867340578,
191         340.644115618736,
192         363.639028500678,
193         378.787797779238,
194         372.215798201712,
195         395.093925731298,
196         402.325427142659,
197         386.907725462306,
198         380.709170928091,
199         372.062070914977,
200         372.328646856954,
201         391.841444284136,
202         394.029351759596,
203         383.369407765254,
204         381.093099675206,
205         382.604158946193,
206         390.744843709034,
207         383.13949492437,
208         368.150393976985,
209         364.629744480226,
210         363.572736804082,
211         359.854924202248,
212         355.207590170267,
213         349.094656012401,
214         354.365935871597,
215         343.380608328546,
216         404.673065729266,
217         486.296896820126,
218         480.225974100847,
219         457.318764401085,
220         418.177339948609,
221         414.399018364126,
222         409.678420185754,
223         404.768766016563,
224         401.699589920585,
225         402.44339040654,
226         398.138372541906,
227         396.010498627646,
228         390.165117432277,
229         375.850429417013,
230         365.567100746484,
231         365.429624610923
232     };
233
234     for (int i = 0; i < 48; i++) {
235         testFloatEquals(
236             test_model_ptr->electrical_load.dt_vec_hrs[i],
237             expected_dt_vec_hrs[i],
238             __FILE__,
239             __LINE__
240         );
241
242         testFloatEquals(
243             test_model_ptr->electrical_load.time_vec_hrs[i],
244             expected_time_vec_hrs[i],
245             __FILE__,
246             __LINE__
247         );
248
249         testFloatEquals(
250             test_model_ptr->electrical_load.load_vec_kW[i],
251             expected_load_vec_kW[i],
252             __FILE__,
253             __LINE__
254         );
255     }
256
257     return;
258 } /* testElectricalLoadData_Model() */

```

### 5.71.2.18 testFuelConsumptionEmissions\_Model()

```
void testFuelConsumptionEmissions_Model (
    Model * test_model_ptr )
```

Function to check that the modelled fuel consumption and emissions are  $> 0$ .

#### Parameters

<code>test_model_ptr</code>	A pointer to the test <a href="#">Model</a> object.
-----------------------------	---

```
1343 {
1344     testGreaterThan(
1345         test_model_ptr->total_fuel_consumed_L,
1346         0,
1347         __FILE__,
1348         __LINE__
1349     );
1350
1351     testGreaterThan(
1352         test_model_ptr->total_emissions.CO2_kg,
1353         0,
1354         __FILE__,
1355         __LINE__
1356     );
1357
1358     testGreaterThan(
1359         test_model_ptr->total_emissions.CO_kg,
1360         0,
1361         __FILE__,
1362         __LINE__
1363     );
1364
1365     testGreaterThan(
1366         test_model_ptr->total_emissions.NOx_kg,
1367         0,
1368         __FILE__,
1369         __LINE__
1370     );
1371
1372     testGreaterThan(
1373         test_model_ptr->total_emissions.SOx_kg,
1374         0,
1375         __FILE__,
1376         __LINE__
1377     );
1378
1379     testGreaterThan(
1380         test_model_ptr->total_emissions.CH4_kg,
1381         0,
1382         __FILE__,
1383         __LINE__
1384     );
1385
1386     testGreaterThan(
1387         test_model_ptr->total_emissions.PM_kg,
1388         0,
1389         __FILE__,
1390         __LINE__
1391     );
1392
1393     return;
1394 } /* testFuelConsumptionEmissions_Model() */
```

### 5.71.2.19 testLoadBalance\_Model()

```
void testLoadBalance_Model (
    Model * test_model_ptr )
```

Function to check that the post-run load data is as expected. That is, the added renewable, production, and storage assets are handled by the [Controller](#) as expected.

## Parameters

<code>test_model_ptr</code>	A pointer to the test <a href="#">Model</a> object.
-----------------------------	---

```

1196 {
1197     double net_load_kW = 0;
1198
1199     Combustion* combustion_ptr;
1200     Noncombustion* noncombustion_ptr;
1201     Renewable* renewable_ptr;
1202     Storage* storage_ptr;
1203
1204     for (int i = 0; i < test_model_ptr->electrical_load.n_points; i++) {
1205         net_load_kW = test_model_ptr->controller.net_load_vec_kW[i];
1206
1207         testLessThanOrEqualTo(
1208             test_model_ptr->controller.net_load_vec_kW[i],
1209             test_model_ptr->electrical_load.max_load_kW,
1210             __FILE__,
1211             __LINE__
1212         );
1213
1214         for (size_t j = 0; j < test_model_ptr->combustion_ptr_vec.size(); j++) {
1215             combustion_ptr = test_model_ptr->combustion_ptr_vec[j];
1216
1217             testFloatEquals(
1218                 combustion_ptr->production_vec_kW[i] -
1219                 combustion_ptr->dispatch_vec_kW[i] -
1220                 combustion_ptr->curtailment_vec_kW[i] -
1221                 combustion_ptr->storage_vec_kW[i],
1222                 0,
1223                 __FILE__,
1224                 __LINE__
1225             );
1226
1227             net_load_kW -= combustion_ptr->production_vec_kW[i];
1228         }
1229
1230         for (size_t j = 0; j < test_model_ptr->noncombustion_ptr_vec.size(); j++) {
1231             noncombustion_ptr = test_model_ptr->noncombustion_ptr_vec[j];
1232
1233             testFloatEquals(
1234                 noncombustion_ptr->production_vec_kW[i] -
1235                 noncombustion_ptr->dispatch_vec_kW[i] -
1236                 noncombustion_ptr->curtailment_vec_kW[i] -
1237                 noncombustion_ptr->storage_vec_kW[i],
1238                 0,
1239                 __FILE__,
1240                 __LINE__
1241             );
1242
1243             net_load_kW -= noncombustion_ptr->production_vec_kW[i];
1244         }
1245
1246         for (size_t j = 0; j < test_model_ptr->renewable_ptr_vec.size(); j++) {
1247             renewable_ptr = test_model_ptr->renewable_ptr_vec[j];
1248
1249             testFloatEquals(
1250                 renewable_ptr->production_vec_kW[i] -
1251                 renewable_ptr->dispatch_vec_kW[i] -
1252                 renewable_ptr->curtailment_vec_kW[i] -
1253                 renewable_ptr->storage_vec_kW[i],
1254                 0,
1255                 __FILE__,
1256                 __LINE__
1257             );
1258
1259             net_load_kW -= renewable_ptr->production_vec_kW[i];
1260         }
1261
1262         for (size_t j = 0; j < test_model_ptr->storage_ptr_vec.size(); j++) {
1263             storage_ptr = test_model_ptr->storage_ptr_vec[j];
1264
1265             testTruth(
1266                 not (
1267                     storage_ptr->charging_power_vec_kW[i] > 0 and
1268                     storage_ptr->discharging_power_vec_kW[i] > 0
1269                 ),
1270                 __FILE__,
1271                 __LINE__
1272             );
1273
1274             net_load_kW -= storage_ptr->discharging_power_vec_kW[i];
1275         }
1276
1277         testLessThanOrEqualTo(

```

```

1278         net_load_kW,
1279         0,
1280         __FILE__,
1281         __LINE__
1282     );
1283 }
1284
1285 testFloatEquals(
1286     test_model_ptr->total_dispatch_discharge_kWh,
1287     2263351.62026685,
1288     __FILE__,
1289     __LINE__
1290 );
1291
1292 return;
1293 } /* testLoadBalance_Model() */

```

### 5.71.2.20 testPostConstructionAttributes\_Model()

```

void testPostConstructionAttributes_Model (
    Model * test_model_ptr )

```

A function to check the values of various post-construction attributes.

#### Parameters

<i>test_model_ptr</i>	A pointer to the test <a href="#">Model</a> object.
-----------------------	---

```

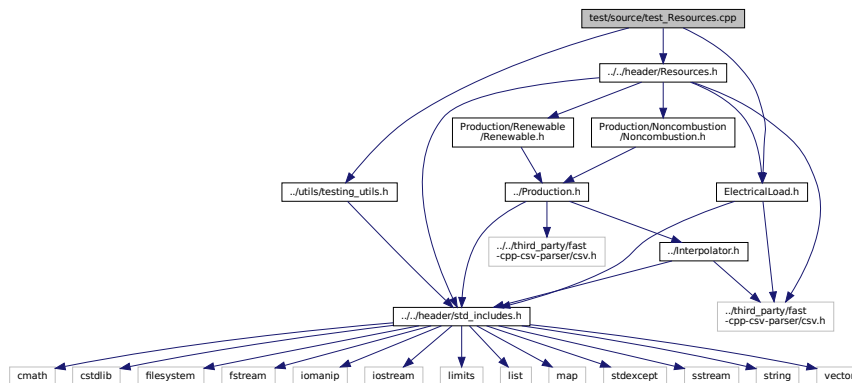
117 {
118     testFloatEquals(
119         test_model_ptr->electrical_load.n_points,
120         8760,
121         __FILE__,
122         __LINE__
123     );
124
125     testFloatEquals(
126         test_model_ptr->electrical_load.n_years,
127         0.999886,
128         __FILE__,
129         __LINE__
130     );
131
132     testFloatEquals(
133         test_model_ptr->electrical_load.min_load_kW,
134         82.1211213927802,
135         __FILE__,
136         __LINE__
137     );
138
139     testFloatEquals(
140         test_model_ptr->electrical_load.mean_load_kW,
141         258.373472633202,
142         __FILE__,
143         __LINE__
144     );
145
146     testFloatEquals(
147         test_model_ptr->electrical_load.max_load_kW,
148         500,
149         __FILE__,
150         __LINE__
151     );
152
153     return;
154 } /* testPostConstructionAttributes_Model() */

```

## 5.72 test/source/test\_Resources.cpp File Reference

Testing suite for [Resources](#) class.

```
#include "../utils/testing_utils.h"
#include "../../header/Resources.h"
#include "../../header/ElectricalLoad.h"
Include dependency graph for test_Resources.cpp:
```



## Functions

- [Resources](#) \* [testConstruct\\_Resources](#) (void)  
A function to construct a [Resources](#) object and spot check some post-construction attributes.
- void [testAddSolarResource\\_Resources](#) ([Resources](#) \*test\_resources\_ptr, [ElectricalLoad](#) \*test\_electrical\_load\_ptr, std::string path\_2\_solar\_resource\_data, int solar\_resource\_key)  
Function to test adding a solar resource and then check the values read into the test [Resources](#) object.
- void [testBadAdd\\_Resources](#) ([Resources](#) \*test\_resources\_ptr, [ElectricalLoad](#) \*test\_electrical\_load\_ptr, std::string path\_2\_solar\_resource\_data, int solar\_resource\_key)  
Function to test that trying to add bad resource data is being handled as expected.
- void [testAddTidalResource\\_Resources](#) ([Resources](#) \*test\_resources\_ptr, [ElectricalLoad](#) \*test\_electrical\_load\_ptr, std::string path\_2\_tidal\_resource\_data, int tidal\_resource\_key)  
Function to test adding a tidal resource and then check the values read into the test [Resources](#) object.
- void [testAddWaveResource\\_Resources](#) ([Resources](#) \*test\_resources\_ptr, [ElectricalLoad](#) \*test\_electrical\_load\_ptr, std::string path\_2\_wave\_resource\_data, int wave\_resource\_key)  
Function to test adding a wave resource and then check the values read into the test [Resources](#) object.
- void [testAddWindResource\\_Resources](#) ([Resources](#) \*test\_resources\_ptr, [ElectricalLoad](#) \*test\_electrical\_load\_ptr, std::string path\_2\_wind\_resource\_data, int wind\_resource\_key)  
Function to test adding a wind resource and then check the values read into the test [Resources](#) object.
- void [testAddHydroResource\\_Resources](#) ([Resources](#) \*test\_resources\_ptr, [ElectricalLoad](#) \*test\_electrical\_load\_ptr, std::string path\_2\_hydro\_resource\_data, int hydro\_resource\_key)  
Function to test adding a hydro resource and then check the values read into the test [Resources](#) object.
- int [main](#) (int argc, char \*\*argv)

### 5.72.1 Detailed Description

Testing suite for [Resources](#) class.

A suite of tests for the [Resources](#) class.



## 5.72.2 Function Documentation

### 5.72.2.1 main()

```

int main (
    int argc,
    char ** argv )
758 {
759     #ifdef _WIN32
760         activateVirtualTerminal();
761     #endif /* _WIN32 */
762
763     printGold("\tTesting Resources");
764
765     srand(time(NULL));
766
767
768     std::string path_2_electrical_load_time_series =
769         "data/test/electrical_load/electrical_load_generic_peak-500kW_1yr_dt-1hr.csv";
770
771     ElectricalLoad* test_electrical_load_ptr =
772         new ElectricalLoad(path_2_electrical_load_time_series);
773
774     Resources* test_resources_ptr = testConstruct_Resources();
775
776
777     try {
778         int solar_resource_key = 0;
779         std::string path_2_solar_resource_data =
780             "data/test/resources/solar_GHI_peak-1kWm2_1yr_dt-1hr.csv";
781
782         testAddSolarResource_Resources(
783             test_resources_ptr,
784             test_electrical_load_ptr,
785             path_2_solar_resource_data,
786             solar_resource_key
787         );
788
789         testBadAdd_Resources(
790             test_resources_ptr,
791             test_electrical_load_ptr,
792             path_2_solar_resource_data,
793             solar_resource_key
794         );
795
796
797         int tidal_resource_key = 1;
798         std::string path_2_tidal_resource_data =
799             "data/test/resources/tidal_speed_peak-3ms_1yr_dt-1hr.csv";
800
801         testAddTidalResource_Resources(
802             test_resources_ptr,
803             test_electrical_load_ptr,
804             path_2_tidal_resource_data,
805             tidal_resource_key
806         );
807
808
809         int wave_resource_key = 2;
810         std::string path_2_wave_resource_data =
811             "data/test/resources/waves_H_s_peak-8m_T_e_peak-15s_1yr_dt-1hr.csv";
812
813         testAddWaveResource_Resources(
814             test_resources_ptr,
815             test_electrical_load_ptr,
816             path_2_wave_resource_data,
817             wave_resource_key
818         );
819
820
821         int wind_resource_key = 3;
822         std::string path_2_wind_resource_data =
823             "data/test/resources/wind_speed_peak-25ms_1yr_dt-1hr.csv";
824
825         testAddWindResource_Resources(
826             test_resources_ptr,
827             test_electrical_load_ptr,
828             path_2_wind_resource_data,

```

```

829         wind_resource_key
830     );
831
832
833     int hydro_resource_key = 4;
834     std::string path_2_hydro_resource_data =
835         "data/test/resources/hydro_inflow_peak-20000m3hr_1yr_dt-1hr.csv";
836
837     testAddHydroResource_Resources(
838         test_resources_ptr,
839         test_electrical_load_ptr,
840         path_2_hydro_resource_data,
841         hydro_resource_key
842     );
843 }
844
845
846 catch (...) {
847     delete test_electrical_load_ptr;
848     delete test_resources_ptr;
849
850     printGold(" ..... ");
851     printRed("FAIL");
852     std::cout << std::endl;
853     throw;
854 }
855
856
857 delete test_electrical_load_ptr;
858 delete test_resources_ptr;
859
860 printGold(" ..... ");
861 printGreen("PASS");
862 std::cout << std::endl;
863 return 0;
864 } /* main() */

```

### 5.72.2.2 testAddHydroResource\_Resources()

```

void testAddHydroResource_Resources (
    Resources * test_resources_ptr,
    ElectricalLoad * test_electrical_load_ptr,
    std::string path_2_hydro_resource_data,
    int hydro_resource_key )

```

Function to test adding a hydro resource and then check the values read into the test [Resources](#) object.

#### Parameters

<i>test_resources_ptr</i>	A pointer to the test <a href="#">Resources</a> object.
<i>test_electrical_load_ptr</i>	A pointer to the test <a href="#">ElectricalLoad</a> object.
<i>path_2_hydro_resource_data</i>	A path (either relative or absolute) to the hydro resource data.
<i>hydro_resource_key</i>	A key used to index into the <a href="#">Resources</a> component of the test <a href="#">Resources</a> object.

```

680 {
681     test_resources_ptr->addResource(
682         NoncombustionType::HYDRO,
683         path_2_hydro_resource_data,
684         hydro_resource_key,
685         test_electrical_load_ptr
686     );
687
688     std::vector<double> expected_hydro_resource_vec_m3hr = {
689         2167.91531556942,
690         2046.58261560569,
691         2007.85941123153,
692         2000.11477247929,
693         1917.50527264453,
694         1963.97311577093,
695         1908.46985899809,
696         1886.5267112678,

```

```

697         1965.26388854254,
698         1953.64692935289,
699         2084.01504296306,
700         2272.46796101188,
701         2520.29645627096,
702         2715.203242423,
703         2720.36633563203,
704         3130.83228077221,
705         3289.59741021591,
706         3981.45195965772,
707         5295.45929491303,
708         7084.47124360523,
709         7709.20557708454,
710         7436.85238642936,
711         7235.49173429668,
712         6710.14695517339,
713         6015.71085806577,
714         5279.97001316337,
715         4877.24870889801,
716         4421.60569340303,
717         3919.49483690424,
718         3498.70270322341,
719         3274.10813058883,
720         3147.61233529349,
721         2904.94693324343,
722         2805.55738101,
723         2418.32535637171,
724         2398.96375630723,
725         2260.85100182222,
726         2157.58912702878,
727         2019.47637254377,
728         1913.63295220712,
729         1863.29279076589,
730         1748.41395678279,
731         1695.49224555317,
732         1599.97501375715,
733         1559.96103873397,
734         1505.74855473274,
735         1438.62833664765,
736         1384.41585476901
737     };
738
739     for (size_t i = 0; i < expected_hydro_resource_vec_m3hr.size(); i++) {
740         testFloatEquals(
741             test_resources_ptr->resource_map_1D[hydro_resource_key][i],
742             expected_hydro_resource_vec_m3hr[i],
743             __FILE__,
744             __LINE__
745         );
746     }
747
748     return;
749 } /* testAddHydroResource_Resources() */

```

### 5.72.2.3 testAddSolarResource\_Resources()

```

void testAddSolarResource_Resources (
    Resources * test_resources_ptr,
    ElectricalLoad * test_electrical_load_ptr,
    std::string path_2_solar_resource_data,
    int solar_resource_key )

```

Function to test adding a solar resource and then check the values read into the test [Resources](#) object.

#### Parameters

<i>test_resources_ptr</i>	A pointer to the test <a href="#">Resources</a> object.
<i>test_electrical_load_ptr</i>	A pointer to the test <a href="#">ElectricalLoad</a> object.
<i>path_2_solar_resource_data</i>	A path (either relative or absolute) to the solar resource data.
<i>solar_resource_key</i>	A key used to index into the <a href="#">Resources</a> component of the test <a href="#">Resources</a> object.

```

107 {
108     test_resources_ptr->addResource(
109         RenewableType::SOLAR,
110         path_2_solar_resource_data,
111         solar_resource_key,
112         test_electrical_load_ptr
113     );
114
115     std::vector<double> expected_solar_resource_vec_kWm2 = {
116         0,
117         0,
118         0,
119         0,
120         0,
121         0,
122         8.51702662684015E-05,
123         0.000348341567045,
124         0.00213793728593,
125         0.004099863613322,
126         0.000997135230553,
127         0.009534527624657,
128         0.022927996790616,
129         0.0136071715294,
130         0.002535134127751,
131         0.005206897515821,
132         0.005627658648597,
133         0.000701186722215,
134         0.00017119827089,
135         0,
136         0,
137         0,
138         0,
139         0,
140         0,
141         0,
142         0,
143         0,
144         0,
145         0,
146         0,
147         0.000141055102242,
148         0.00084525014743,
149         0.024893647822702,
150         0.091245556190749,
151         0.158722176731637,
152         0.152859680515876,
153         0.149922903895116,
154         0.13049996570866,
155         0.03081254222795,
156         0.001218928911125,
157         0.000206092647423,
158         0,
159         0,
160         0,
161         0,
162         0,
163         0
164     };
165
166     for (size_t i = 0; i < expected_solar_resource_vec_kWm2.size(); i++) {
167         testFloatEquals(
168             test_resources_ptr->resource_map_1D[solar_resource_key][i],
169             expected_solar_resource_vec_kWm2[i],
170             __FILE__,
171             __LINE__
172         );
173     }
174
175     return;
176 } /* testAddSolarResource_Resources() */

```

#### 5.72.2.4 testAddTidalResource\_Resources()

```

void testAddTidalResource_Resources (
    Resources * test_resources_ptr,
    ElectricalLoad * test_electrical_load_ptr,
    std::string path_2_tidal_resource_data,
    int tidal_resource_key )

```

Function to test adding a tidal resource and then check the values read into the test [Resources](#) object.

## Parameters

<i>test_resources_ptr</i>	A pointer to the test <a href="#">Resources</a> object.
<i>test_electrical_load_ptr</i>	A pointer to the test <a href="#">ElectricalLoad</a> object.
<i>path_2_tidal_resource_data</i>	A path (either relative or absolute) to the tidal resource data.
<i>tidal_resource_key</i>	A key used to index into the <a href="#">Resources</a> component of the test <a href="#">Resources</a> object.

```

307 {
308     test_resources_ptr->addResource(
309         RenewableType::TIDAL,
310         path_2_tidal_resource_data,
311         tidal_resource_key,
312         test_electrical_load_ptr
313     );
314
315     std::vector<double> expected_tidal_resource_vec_ms = {
316         0.347439913040533,
317         0.770545522195602,
318         0.731352084836198,
319         0.293389814389542,
320         0.209959110813115,
321         0.610609623896497,
322         1.78067162013604,
323         2.53522775118089,
324         2.75966627832024,
325         2.52101111143895,
326         2.05389330201031,
327         1.3461515862445,
328         0.28909254878384,
329         0.897754086048563,
330         1.71406453837407,
331         1.85047408742869,
332         1.71507908595979,
333         1.33540349705416,
334         0.434586143463003,
335         0.500623815700637,
336         1.37172172646733,
337         1.68294125491228,
338         1.56101300975417,
339         1.04925834219412,
340         0.211395463930223,
341         1.03720048903385,
342         1.85059536356448,
343         1.85203242794517,
344         1.4091471616277,
345         0.767776539039899,
346         0.251464906990961,
347         1.47018469375652,
348         2.36260493698197,
349         2.46653750048625,
350         2.12851908739291,
351         1.62783753197988,
352         0.734594890957439,
353         0.441886297300355,
354         1.6574418350918,
355         2.0684558286637,
356         1.87717416992136,
357         1.58871262337931,
358         1.03451227609235,
359         0.193371305159817,
360         0.976400122458815,
361         1.6583227369707,
362         1.76690616570953,
363         1.54801328553115
364     };
365
366     for (size_t i = 0; i < expected_tidal_resource_vec_ms.size(); i++) {
367         testFloatEquals(
368             test_resources_ptr->resource_map_1D[tidal_resource_key][i],
369             expected_tidal_resource_vec_ms[i],
370             __FILE__,
371             __LINE__
372         );
373     }
374
375     return;
376 } /* testAddTidalResource_Resources() */

```

## 5.72.2.5 testAddWaveResource\_Resources()

```
void testAddWaveResource_Resources (
    Resources * test_resources_ptr,
    ElectricalLoad * test_electrical_load_ptr,
    std::string path_2_wave_resource_data,
    int wave_resource_key )
```

Function to test adding a wave resource and then check the values read into the test [Resources](#) object.

## Parameters

<i>test_resources_ptr</i>	A pointer to the test <a href="#">Resources</a> object.
<i>test_electrical_load_ptr</i>	A pointer to the test <a href="#">ElectricalLoad</a> object.
<i>path_2_wave_resource_data</i>	A path (either relative or absolute) to the wave resource data.
<i>wave_resource_key</i>	A key used to index into the <a href="#">Resources</a> component of the test <a href="#">Resources</a> object.

```
412 {
413     test_resources_ptr->addResource(
414         RenewableType::WAVE,
415         path_2_wave_resource_data,
416         wave_resource_key,
417         test_electrical_load_ptr
418     );
419
420     std::vector<double> expected_significant_wave_height_vec_m = {
421         4.26175222125028,
422         4.25020976167872,
423         4.25656524330349,
424         4.27193854786718,
425         4.28744955711233,
426         4.29421815278154,
427         4.2839937266082,
428         4.25716982457976,
429         4.22419391611483,
430         4.19588925217606,
431         4.17338788587412,
432         4.14672746914214,
433         4.10560041173665,
434         4.05074966447193,
435         3.9953696962433,
436         3.95316976150866,
437         3.92771018142378,
438         3.91129562488595,
439         3.89558312094911,
440         3.87861093931749,
441         3.86538307240754,
442         3.86108961027929,
443         3.86459448853189,
444         3.86796474016882,
445         3.86357412779993,
446         3.85554872014731,
447         3.86044266668675,
448         3.89445961915999,
449         3.95554798115731,
450         4.02265508610476,
451         4.07419587011404,
452         4.10314247143958,
453         4.11738045085928,
454         4.12554995596708,
455         4.12923992001675,
456         4.1229292327442,
457         4.10123955307441,
458         4.06748827895363,
459         4.0336230651344,
460         4.01134236393876,
461         4.00136570034559,
462         3.99368787690411,
463         3.97820924247644,
464         3.95369335178055,
465         3.92742545608532,
466         3.90683362771686,
467         3.89331520944006,
468         3.88256045801583
469     };
470
471     std::vector<double> expected_energy_period_vec_s = {
```

```

472         10.4456008226821,
473         10.4614151137651,
474         10.4462827795433,
475         10.4127692097884,
476         10.3734397942723,
477         10.3408599227669,
478         10.32637292093,
479         10.3245412676322,
480         10.310409818185,
481         10.2589529840966,
482         10.1728100603103,
483         10.0862908658929,
484         10.03480243813,
485         10.023673635806,
486         10.0243418565116,
487         10.0063487117653,
488         9.96050302286607,
489         9.9011999635568,
490         9.84451822125472,
491         9.79726875879626,
492         9.75614594835158,
493         9.7173447961368,
494         9.68342904390577,
495         9.66380508567062,
496         9.6674009575699,
497         9.68927134575103,
498         9.70979984863046,
499         9.70967357906908,
500         9.68983025704562,
501         9.6722855524805,
502         9.67973599910003,
503         9.71977125328293,
504         9.78450442291421,
505         9.86532355233449,
506         9.96158937600019,
507         10.0807018356507,
508         10.2291022504937,
509         10.39458528356,
510         10.5464393581004,
511         10.6553277500484,
512         10.7245553190084,
513         10.7893127285064,
514         10.8846512240849,
515         11.0148158739075,
516         11.1544325654719,
517         11.2772785848343,
518         11.3744362756187,
519         11.4533643503183
520     };
521
522     for (size_t i = 0; i < expected_significant_wave_height_vec_m.size(); i++) {
523         testFloatEquals(
524             test_resources_ptr->resource_map_2D[wave_resource_key][i][0],
525             expected_significant_wave_height_vec_m[i],
526             __FILE__,
527             __LINE__
528         );
529
530         testFloatEquals(
531             test_resources_ptr->resource_map_2D[wave_resource_key][i][1],
532             expected_energy_period_vec_s[i],
533             __FILE__,
534             __LINE__
535         );
536     }
537
538     return;
539 } /* testAddWaveResource_Resources() */

```

### 5.72.2.6 testAddWindResource\_Resources()

```

void testAddWindResource_Resources (
    Resources * test_resources_ptr,
    ElectricalLoad * test_electrical_load_ptr,
    std::string path_2_wind_resource_data,
    int wind_resource_key )

```

Function to test adding a wind resource and then check the values read into the test [Resources](#) object.



## Parameters

<i>test_resources_ptr</i>	A pointer to the test <a href="#">Resources</a> object.
<i>test_electrical_load_ptr</i>	A pointer to the test <a href="#">ElectricalLoad</a> object.
<i>path_2_wind_resource_data</i>	A path (either relative or absolute) to the wind resource data.
<i>wind_resource_key</i>	A key used to index into the <a href="#">Resources</a> component of the test <a href="#">Resources</a> object.

```

575 {
576     test_resources_ptr->addResource(
577         RenewableType::WIND,
578         path_2_wind_resource_data,
579         wind_resource_key,
580         test_electrical_load_ptr
581     );
582
583     std::vector<double> expected_wind_resource_vec_ms = {
584         6.8856688469997,
585         5.02177105466549,
586         3.74211715899568,
587         5.67169579985362,
588         4.90670669971858,
589         4.29586955031368,
590         7.41155377205065,
591         10.2243290476943,
592         13.1258696725555,
593         13.7016198628274,
594         16.2481482330233,
595         16.5096744355418,
596         13.4354482206162,
597         14.0129230731609,
598         14.5554549260515,
599         13.4454539065912,
600         13.3447169512094,
601         11.7372615098554,
602         12.7200070078013,
603         10.6421127908149,
604         6.09869498990661,
605         5.66355596602321,
606         4.97316966910831,
607         3.48937138360567,
608         2.15917470979169,
609         1.29061103587027,
610         3.43475751425219,
611         4.11706326260927,
612         4.28905275747408,
613         5.75850263196241,
614         8.98293663055264,
615         11.7069822941315,
616         12.4031987075858,
617         15.4096570910089,
618         16.6210843829552,
619         13.3421219142573,
620         15.2112831900548,
621         18.350864533037,
622         15.8751799822971,
623         15.3921198799796,
624         15.9729192868434,
625         12.4728950178772,
626         10.177050481096,
627         10.7342247355551,
628         8.98846695631389,
629         4.14671169124739,
630         3.17256452697149,
631         3.40036336968628
632     };
633
634     for (size_t i = 0; i < expected_wind_resource_vec_ms.size(); i++) {
635         testFloatEquals(
636             test_resources_ptr->resource_map_1D[wind_resource_key][i],
637             expected_wind_resource_vec_ms[i],
638             __FILE__,
639             __LINE__
640         );
641     }
642
643     return;
644 } /* testAddWindResource_Resources() */

```

### 5.72.2.7 testBadAdd\_Resources()

```
void testBadAdd_Resources (
    Resources * test_resources_ptr,
    ElectricalLoad * test_electrical_load_ptr,
    std::string path_2_solar_resource_data,
    int solar_resource_key )
```

Function to test that trying to add bad resource data is being handled as expected.

#### Parameters

<i>test_resources_ptr</i>	A pointer to the test <a href="#">Resources</a> object.
<i>test_electrical_load_ptr</i>	A pointer to the test <a href="#">ElectricalLoad</a> object.
<i>path_2_solar_resource_data</i>	A path (either relative or absolute) to the given solar resource data.
<i>solar_resource_key</i>	A key for indexing into the test <a href="#">Resources</a> object.

```
211 {
212     bool error_flag = true;
213
214     try {
215         test_resources_ptr->addResource(
216             RenewableType::SOLAR,
217             path_2_solar_resource_data,
218             solar_resource_key,
219             test_electrical_load_ptr
220         );
221
222         error_flag = false;
223     } catch (...) {
224         // Task failed successfully! =P
225     }
226     if (not error_flag) {
227         expectedErrorNotDetected(__FILE__, __LINE__);
228     }
229
230
231     try {
232         std::string path_2_solar_resource_data_BAD_TIMES =
233             "data/test/resources/solar_GHI_peak-1kWm2_1yr_dt-1hr_BAD_TIMES.csv";
234
235         test_resources_ptr->addResource(
236             RenewableType::SOLAR,
237             path_2_solar_resource_data_BAD_TIMES,
238             -1,
239             test_electrical_load_ptr
240         );
241
242         error_flag = false;
243     } catch (...) {
244         // Task failed successfully! =P
245     }
246     if (not error_flag) {
247         expectedErrorNotDetected(__FILE__, __LINE__);
248     }
249
250
251     try {
252         std::string path_2_solar_resource_data_BAD_LENGTH =
253             "data/test/resources/solar_GHI_peak-1kWm2_1yr_dt-1hr_BAD_LENGTH.csv";
254
255         test_resources_ptr->addResource(
256             RenewableType::SOLAR,
257             path_2_solar_resource_data_BAD_LENGTH,
258             -2,
259             test_electrical_load_ptr
260         );
261
262         error_flag = false;
263     } catch (...) {
264         // Task failed successfully! =P
265     }
266     if (not error_flag) {
267         expectedErrorNotDetected(__FILE__, __LINE__);
268     }
269
270     return;
```

```
271 }    /* testBadAdd_Resources() */
```

### 5.72.2.8 testConstruct\_Resources()

```
Resources * testConstruct_Resources (
    void )
```

A function to construct a [Resources](#) object and spot check some post-construction attributes.

#### Returns

A pointer to a test [Resources](#) object.

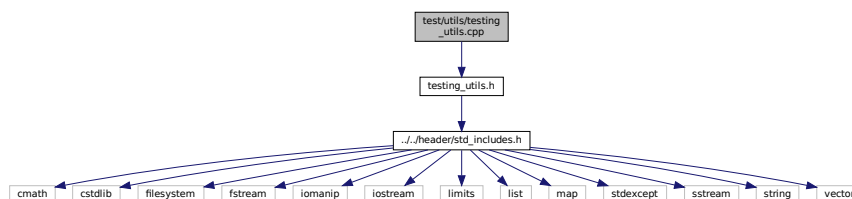
```
39 {
40     Resources* test_resources_ptr = new Resources();
41
42     testFloatEquals(
43         test_resources_ptr->resource_map_1D.size(),
44         0,
45         __FILE__,
46         __LINE__
47     );
48
49     testFloatEquals(
50         test_resources_ptr->path_map_1D.size(),
51         0,
52         __FILE__,
53         __LINE__
54     );
55
56     testFloatEquals(
57         test_resources_ptr->resource_map_2D.size(),
58         0,
59         __FILE__,
60         __LINE__
61     );
62
63     testFloatEquals(
64         test_resources_ptr->path_map_2D.size(),
65         0,
66         __FILE__,
67         __LINE__
68     );
69
70     return test_resources_ptr;
71 }    /* testConstruct_Resources() */
```

## 5.73 test/utls/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  $x \geq y$ .
- 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  $x \leq y$ .
- void `testTruth` (bool statement, std::string file, int line)  
Tests if the given statement is true.
- void `expectedErrorNotDetected` (std::string file, int line)  
A utility function to print out a meaningful error message whenever an expected error fails to be thrown/caught/detected.

### 5.73.1 Detailed Description

Header file for various PGMcpp testing utilities.

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

### 5.73.2 Function Documentation

#### 5.73.2.1 `expectedErrorNotDetected()`

```
void expectedErrorNotDetected (
    std::string file,
    int line )
```

A utility function to print out a meaningful error message whenever an expected error fails to be thrown/caught/detected.

#### Parameters

<i>file</i>	The file in which the test is applied (you should be able to just pass in " <code>__FILE__</code> ").
<i>line</i>	The line of the file in which the test is applied (you should be able to just pass in " <code>__LINE__</code> ").

```
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() */
```

### 5.73.2.2 printGold()

```
void printGold (
    std::string input_str )
```

A function that sends gold text to std::cout.

#### Parameters

<i>input_str</i>	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() */
```

### 5.73.2.3 printGreen()

```
void printGreen (
    std::string input_str )
```

A function that sends green text to std::cout.

#### Parameters

<i>input_str</i>	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() */
```

### 5.73.2.4 printRed()

```
void printRed (
    std::string input_str )
```

A function that sends red text to std::cout.

## Parameters

<i>input_str</i>	The text of the string to be sent to <code>std::cout</code> .
------------------	---

```

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

```

## 5.73.2.5 testFloatEquals()

```

void testFloatEquals (
    double x,
    double y,
    std::string file,
    int line )

```

Tests for the equality of two floating point numbers *x* and *y* (to within `FLOAT_TOLERANCE`).

## Parameters

<i>x</i>	The first of two numbers to test.
<i>y</i>	The second of two numbers to test.
<i>file</i>	The file in which the test is applied (you should be able to just pass in " <code>__FILE__</code> ").
<i>line</i>	The line of the file in which the test is applied (you should be able to just pass in " <code>__LINE__</code> ").

```

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() */

```

## 5.73.2.6 testGreaterThan()

```

void testGreaterThan (
    double x,
    double y,
    std::string file,
    int line )

```

Tests if  $x > y$ .

## Parameters

<i>x</i>	The first of two numbers to test.
<i>y</i>	The second of two numbers to test.
<i>file</i>	The file in which the test is applied (you should be able to just pass in "__FILE__").
<i>line</i>	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() */

```

## 5.73.2.7 testGreaterThanOrEqualTo()

```

void testGreaterThanOrEqualTo (
    double x,
    double y,
    std::string file,
    int line )

```

Tests if  $x \geq y$ .

## Parameters

<i>x</i>	The first of two numbers to test.
<i>y</i>	The second of two numbers to test.
<i>file</i>	The file in which the test is applied (you should be able to just pass in "__FILE__").
<i>line</i>	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() */

```

### 5.73.2.8 testLessThan()

```

void testLessThan (
    double x,
    double y,
    std::string file,
    int line )

```

Tests if  $x < y$ .

#### Parameters

<i>x</i>	The first of two numbers to test.
<i>y</i>	The second of two numbers to test.
<i>file</i>	The file in which the test is applied (you should be able to just pass in "__FILE__").
<i>line</i>	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() */

```

### 5.73.2.9 testLessThanOrEqualTo()

```

void testLessThanOrEqualTo (
    double x,
    double y,
    std::string file,
    int line )

```

Tests if  $x \leq y$ .

#### Parameters

<i>x</i>	The first of two numbers to test.
<i>y</i>	The second of two numbers to test.
<i>file</i>	The file in which the test is applied (you should be able to just pass in "__FILE__").
<i>line</i>	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() */

```

### 5.73.2.10 testTruth()

```

void testTruth (
    bool statement,
    std::string file,
    int line )

```

Tests if the given statement is true.

#### Parameters

<i>statement</i>	The statement whose truth is to be tested ("1 == 0", for example).
<i>file</i>	The file in which the test is applied (you should be able to just pass in "__FILE__").
<i>line</i>	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() */

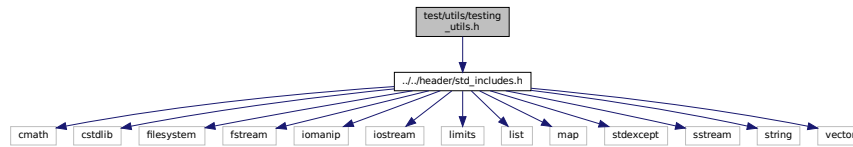
```

## 5.74 test/utills/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  $x \geq y$ .*
- void [testLessThan](#) (double, double, std::string, int)  
*Tests if  $x < y$ .*
- void [testLessThanOrEqualTo](#) (double, double, std::string, int)  
*Tests if  $x \leq y$ .*
- void [testTruth](#) (bool, std::string, int)  
*Tests if the given statement is true.*
- void [expectedErrorNotDetected](#) (std::string, int)  
*A utility function to print out a meaningful error message whenever an expected error fails to be thrown/caught/detected.*

### 5.74.1 Detailed Description

Header file for various PGMcpp testing utilities.

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

## 5.74.2 Macro Definition Documentation

### 5.74.2.1 FLOAT\_TOLERANCE

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

A tolerance for application to floating point equality tests.

## 5.74.3 Function Documentation

### 5.74.3.1 expectedErrorNotDetected()

```
void expectedErrorNotDetected (
    std::string file,
    int line )
```

A utility function to print out a meaningful error message whenever an expected error fails to be thrown/caught/detected.

#### Parameters

<i>file</i>	The file in which the test is applied (you should be able to just pass in "__FILE__").
<i>line</i>	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() */
```

### 5.74.3.2 printGold()

```
void printGold (
    std::string input_str )
```

A function that sends gold text to std::cout.

#### Parameters

<i>input_str</i>	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() */

```

### 5.74.3.3 printGreen()

```

void printGreen (
    std::string input_str )

```

A function that sends green text to std::cout.

#### Parameters

<i>input_str</i>	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() */

```

### 5.74.3.4 printRed()

```

void printRed (
    std::string input_str )

```

A function that sends red text to std::cout.

#### Parameters

<i>input_str</i>	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() */

```

### 5.74.3.5 testFloatEquals()

```

void testFloatEquals (
    double x,
    double y,
    std::string file,
    int line )

```

Tests for the equality of two floating point numbers *x* and *y* (to within FLOAT\_TOLERANCE).

#### Parameters

<i>x</i>	The first of two numbers to test.
----------	-----------------------------------

## Parameters

<i>y</i>	The second of two numbers to test.
<i>file</i>	The file in which the test is applied (you should be able to just pass in "__FILE__").
<i>line</i>	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() */

```

## 5.74.3.6 testGreaterThan()

```

void testGreaterThan (
    double x,
    double y,
    std::string file,
    int line )

```

Tests if  $x > y$ .

## Parameters

<i>x</i>	The first of two numbers to test.
<i>y</i>	The second of two numbers to test.
<i>file</i>	The file in which the test is applied (you should be able to just pass in "__FILE__").
<i>line</i>	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() */

```

### 5.74.3.7 testGreaterThanOrEqualTo()

```

void testGreaterThanOrEqualTo (
    double x,
    double y,
    std::string file,
    int line )

```

Tests if  $x \geq y$ .

#### Parameters

<i>x</i>	The first of two numbers to test.
<i>y</i>	The second of two numbers to test.
<i>file</i>	The file in which the test is applied (you should be able to just pass in "__FILE__").
<i>line</i>	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() */

```

### 5.74.3.8 testLessThan()

```

void testLessThan (
    double x,
    double y,
    std::string file,
    int line )

```

Tests if  $x < y$ .

#### Parameters

<i>x</i>	The first of two numbers to test.
<i>y</i>	The second of two numbers to test.
<i>file</i>	The file in which the test is applied (you should be able to just pass in "__FILE__").
<i>line</i>	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() */

```

### 5.74.3.9 testLessThanOrEqualTo()

```

void testLessThanOrEqualTo (
    double x,
    double y,
    std::string file,
    int line )

```

Tests if  $x \leq y$ .

#### Parameters

<i>x</i>	The first of two numbers to test.
<i>y</i>	The second of two numbers to test.
<i>file</i>	The file in which the test is applied (you should be able to just pass in "__FILE__").
<i>line</i>	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() */

```

### 5.74.3.10 testTruth()

```

void testTruth (

```

```
bool statement,  
std::string file,  
int line )
```

Tests if the given statement is true.

#### Parameters

<i>statement</i>	The statement whose truth is to be tested ("1 == 0", for example).
<i>file</i>	The file in which the test is applied (you should be able to just pass in "__FILE__").
<i>line</i>	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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