

PGMcpp: PRIMED Grid Modelling (in C++)

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# Chapter 1

## Hierarchical Index

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## Chapter 2

# Class Index

### 2.1 Class List

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

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<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> . . .	22
<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> . . . . .	23
<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 . . . . .	40
<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> . . .	53
<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> . . . . .	57
<a href="#">Emissions</a>	A structure which bundles the emitted masses of various emissions chemistries . . . . .	62
<a href="#">Interpolator</a>	A class which contains interpolation data and functionality . . . . .	64
<a href="#">Lilon</a>	A derived class of <a href="#">Storage</a> which models energy storage by way of lithium-ion batteries . . . .	65
<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> . . . . .	84
<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 . . . . .	89
<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) . . . . .	105

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A structure which bundles the necessary inputs for the <b>Solar</b> constructor. Provides default values for every necessary input. Note that this structure encapsulates <b>RenewableInputs</b> . . . . .	148
<b>Storage</b>	
The base class of the <b>Storage</b> hierarchy. This hierarchy contains derived classes which model the storage of energy . . . . .	151
<b>StorageInputs</b>	
A structure which bundles the necessary inputs for the <b>Storage</b> constructor. Provides default values for every necessary input . . . . .	163
<b>Tidal</b>	
A derived class of the <b>Renewable</b> branch of <b>Production</b> which models tidal production . . . . .	165
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A structure which bundles the necessary inputs for the <b>Tidal</b> constructor. Provides default values for every necessary input. Note that this structure encapsulates <b>RenewableInputs</b> . . . . .	177
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A structure which bundles the necessary inputs for the <b>Wave</b> constructor. Provides default values for every necessary input. Note that this structure encapsulates <b>RenewableInputs</b> . . . . .	192
<b>Wind</b>	
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<b>WindInputs</b>	
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---

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## Chapter 4

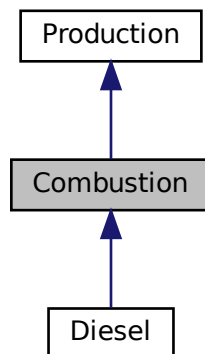
# Class Documentation

### 4.1 Combustion Class Reference

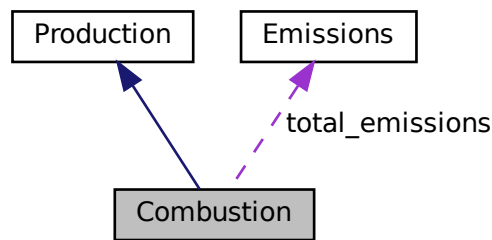
The root of the [Combustion](#) branch of the [Production](#) hierarchy. This branch contains derived classes which model the production of energy by way of combustibles.

```
#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.*
- 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.

- [Emissions total\\_emissions](#)

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

- std::vector< double > [fuel\\_consumption\\_vec\\_L](#)

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

- std::vector< double > [fuel\\_cost\\_vec](#)

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

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

#### 4.1.2.2 Combustion() [2/2]

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

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

#### Parameters

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

```
93 :
94 Production(
95     n_points,
96     n_years,
97     combustion_inputs.production_inputs
98 )
99 {
100     // 1. check inputs
101     this->__checkInputs(combustion_inputs);
102
103     // 2. set attributes
104     this->fuel_cost_L = 0;
105     this->nominal_fuel_escalation_annual =
106         combustion_inputs.nominal_fuel_escalation_annual;
107
108     this->real_fuel_escalation_annual = this->computeRealDiscountAnnual(
109         combustion_inputs.nominal_fuel_escalation_annual,
110         combustion_inputs.production_inputs.nominal_discount_annual
111     );
112
113     this->linear_fuel_slope_LkWh = 0;
114     this->linear_fuel_intercept_LkWh = 0;
115
116     this->CO2_emissions_intensity_kgL = 0;
```



```

117     this->CO_emissions_intensity_kgL = 0;
118     this->NOx_emissions_intensity_kgL = 0;
119     this->SOx_emissions_intensity_kgL = 0;
120     this->CH4_emissions_intensity_kgL = 0;
121     this->PM_emissions_intensity_kgL = 0;
122
123     this->total_fuel_consumed_L = 0;
124
125     this->fuel_consumption_vec_L.resize(this->n_points, 0);
126     this->fuel_cost_vec.resize(this->n_points, 0);
127
128     this->CO2_emissions_vec_kg.resize(this->n_points, 0);
129     this->CO_emissions_vec_kg.resize(this->n_points, 0);
130     this->NOx_emissions_vec_kg.resize(this->n_points, 0);
131     this->SOx_emissions_vec_kg.resize(this->n_points, 0);
132     this->CH4_emissions_vec_kg.resize(this->n_points, 0);
133     this->PM_emissions_vec_kg.resize(this->n_points, 0);
134
135     // 3. construction print
136     if (this->print_flag) {
137         std::cout << "Combustion object constructed at " << this << std::endl;
138     }
139
140     return;
141 } /* Combustion() */

```

#### 4.1.2.3 ~Combustion()

```

Combustion::~Combustion (
    void ) [virtual]

```

Destructor for the [Combustion](#) class.

```

448 {
449     // 1. destruction print
450     if (this->print_flag) {
451         std::cout << "Combustion object at " << this << " destroyed" << std::endl;
452     }
453
454     return;
455 } /* ~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     // ...
42
43     return;
44 } /* __checkInputs() */

```

#### 4.1.3.2 \_\_writeSummary()

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

Reimplemented in [Diesel](#).

```
87 {return;}
```

#### 4.1.3.3 \_\_writeTimeSeries()

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

Reimplemented in [Diesel](#).

```
92 {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](#).

```
271 {
272     // 1. invoke base class method
273     load_kW = Production::commit(
274         timestep,
275         dt_hrs,
276         production_kW,
277         load_kW
```

```

278     );
279
280
281     if (this->is_running) {
282         // 2. compute and record fuel consumption
283         double fuel_consumed_L = this->getFuelConsumptionL(dt_hrs, production_kW);
284         this->fuel_consumption_vec_L[timestep] = fuel_consumed_L;
285
286         // 3. compute and record emissions
287         Emissions emissions = this->getEmissionskg(fuel_consumed_L);
288         this->CO2_emissions_vec_kg[timestep] = emissions.CO2_kg;
289         this->CO_emissions_vec_kg[timestep] = emissions.CO_kg;
290         this->NOx_emissions_vec_kg[timestep] = emissions.NOx_kg;
291         this->SOx_emissions_vec_kg[timestep] = emissions.SOx_kg;
292         this->CH4_emissions_vec_kg[timestep] = emissions.CH4_kg;
293         this->PM_emissions_vec_kg[timestep] = emissions.PM_kg;
294
295         // 4. incur fuel costs
296         this->fuel_cost_vec[timestep] = fuel_consumed_L * this->fuel_cost_L;
297     }
298
299     return load_kW;
300 } /* 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 <i>time_vec_hrs</i> attribute of the <a href="#">ElectricalLoad</a> .
-------------------------	----------------------------------------------------------------------------------------

Reimplemented from [Production](#).

```

215 {
216     // 1. account for fuel costs in net present cost
217     double t_hrs = 0;
218     double real_fuel_escalation_scalar = 0;
219
220     for (int i = 0; i < this->n_points; i++) {
221         t_hrs = time_vec_hrs_ptr->at(i);
222
223         real_fuel_escalation_scalar = 1.0 / pow(
224             1 + this->real_fuel_escalation_annual,
225             t_hrs / 8760
226         );
227
228         this->net_present_cost += real_fuel_escalation_scalar * this->fuel_cost_vec[i];
229     }
230
231     // 2. invoke base class method
232     Production::computeEconomics(time_vec_hrs_ptr);
233
234     return;
235 } /* computeEconomics() */

```

#### 4.1.3.6 computeFuelAndEmissions()

```

void Combustion::computeFuelAndEmissions (
    void )

```

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

```

183 {
184     for (int i = 0; i < n_points; i++) {
185         this->total_fuel_consumed_L += this->fuel_consumption_vec_L[i];
186
187         this->total_emissions.CO2_kg += this->CO2_emissions_vec_kg[i];
188         this->total_emissions.CO_kg += this->CO_emissions_vec_kg[i];
189         this->total_emissions.NOx_kg += this->NOx_emissions_vec_kg[i];
190         this->total_emissions.SOx_kg += this->SOx_emissions_vec_kg[i];
191         this->total_emissions.CH4_kg += this->CH4_emissions_vec_kg[i];
192         this->total_emissions.PM_kg += this->PM_emissions_vec_kg[i];
193     }
194
195     return;
196 } /* 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.

```

348                                     {
349     Emissions emissions;
350
351     emissions.CO2_kg = this->CO2_emissions_intensity_kgL * fuel_consumed_L;
352     emissions.CO_kg = this->CO_emissions_intensity_kgL * fuel_consumed_L;
353     emissions.NOx_kg = this->NOx_emissions_intensity_kgL * fuel_consumed_L;
354     emissions.SOx_kg = this->SOx_emissions_intensity_kgL * fuel_consumed_L;
355     emissions.CH4_kg = this->CH4_emissions_intensity_kgL * fuel_consumed_L;
356     emissions.PM_kg = this->PM_emissions_intensity_kgL * fuel_consumed_L;
357
358     return emissions;
359 } /* 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].

```

322 {
323     double fuel_consumed_L = (
324         this->linear_fuel_slope_LkWh * production_kW +
325         this->linear_fuel_intercept_LkWh * this->capacity_kW
326     ) * dt_hrs;
327
328     return fuel_consumed_L;
329 } /* 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](#).

```

159 {
160     // 1. reset attributes
161     //...
162
163     // 2. invoke base class method
164     Production::handleReplacement(timestep);
165
166     return;
167 } /* __handleReplacement() */

```

**4.1.3.10 requestProductionkW()**

```

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

```

Reimplemented in [Diesel](#).

```

135 {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.

```

395 {
396     // 1. handle sentinel
397     if (max_lines < 0) {
398         max_lines = this->n_points;
399     }
400
401     // 2. create subdirectories
402     write_path += "Production/";
403     if (not std::filesystem::is_directory(write_path)) {
404         std::filesystem::create_directory(write_path);
405     }
406
407     write_path += "Combustion/";
408     if (not std::filesystem::is_directory(write_path)) {
409         std::filesystem::create_directory(write_path);
410     }
411
412     write_path += this->type_str;
413     write_path += "_";
414     write_path += std::to_string(int(ceil(this->capacity_kW)));
415     write_path += "kW_idx";
416     write_path += std::to_string(combustion_index);
417     write_path += "/";
418     std::filesystem::create_directory(write_path);
419
420     // 3. write summary
421     this->__writeSummary(write_path);
422
423     // 4. write time series
424     if (max_lines > this->n_points) {
425         max_lines = this->n_points;
426     }
427
428     if (max_lines > 0) {
429         this->__writeTimeSeries(write_path, time_vec_hrs_ptr, max_lines);
430     }
431
432     return;
433 } /* 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 linear\_fuel\_intercept\_LkWh

```
double Combustion::linear_fuel_intercept_LkWh
```

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

#### 4.1.4.11 linear\_fuel\_slope\_LkWh

```
double Combustion::linear_fuel_slope_LkWh
```

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

#### 4.1.4.12 nominal\_fuel\_escalation\_annual

```
double Combustion::nominal_fuel_escalation_annual
```

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

#### 4.1.4.13 NOx\_emissions\_intensity\_kgL

```
double Combustion::NOx_emissions_intensity_kgL
```

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

#### 4.1.4.14 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.



#### 4.1.4.15 PM\_emissions\_intensity\_kgL

```
double Combustion::PM_emissions_intensity_kgL
```

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

#### 4.1.4.16 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.

#### 4.1.4.17 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.

#### 4.1.4.18 SOx\_emissions\_intensity\_kgL

```
double Combustion::SOx_emissions_intensity_kgL
```

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

#### 4.1.4.19 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.

#### 4.1.4.20 total\_emissions

```
Emissions Combustion::total_emissions
```

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

#### 4.1.4.21 total\_fuel\_consumed\_L

```
double Combustion::total_fuel_consumed_L
```

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

#### 4.1.4.22 type

```
CombustionType Combustion::type
```

The type (CombustionType) of the asset.

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

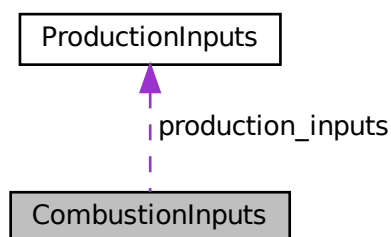
- header/Production/Combustion/[Combustion.h](#)
- source/Production/Combustion/[Combustion.cpp](#)

## 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.
- double `nominal_fuel_escalation_annual` = 0.05  
The nominal, annual fuel escalation rate to use in computing model economics.

### 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 nominal\_fuel\_escalation\_annual

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

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

#### 4.2.2.2 production\_inputs

```
ProductionInputs CombustionInputs::production_inputs
```

An encapsulated [ProductionInputs](#) instance.

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

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

## 4.3 Controller Class Reference

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

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

### Public Member Functions

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

## Public Attributes

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

## Private Member Functions

- `void __computeNetLoad (ElectricalLoad *, std::vector< Renewable * > *, Resources *)`  
Helper method to compute and populate the net load vector.
- `void __constructCombustionMap (std::vector< Combustion * > *)`  
Helper method to construct a *Combustion* map, for use in determining.
- `void __applyLoadFollowingControl_CHARGING (int, ElectricalLoad *, std::vector< Combustion * > *, std::vector< Renewable * > *, std::vector< Storage * > *)`  
Helper method to apply load following control action for given timestep of the *Model* run when net load  $\leq 0$ .
- `void __applyLoadFollowingControl_DISCHARGING (int, ElectricalLoad *, std::vector< Combustion * > *, std::vector< Renewable * > *, std::vector< Storage * > *)`  
Helper method to apply load following control action for given timestep of the *Model* run when net load  $> 0$ .
- `void __applyCycleChargingControl_CHARGING (int, ElectricalLoad *, std::vector< Combustion * > *, std::vector< Renewable * > *, std::vector< Storage * > *)`  
Helper method to apply cycle charging control action for given timestep of the *Model* run when net load  $\leq 0$ . Simply defaults to load following control.
- `void __applyCycleChargingControl_DISCHARGING (int, ElectricalLoad *, std::vector< Combustion * > *, std::vector< Renewable * > *, std::vector< Storage * > *)`  
Helper method to apply cycle charging control action for given timestep of the *Model* run when net load  $> 0$ . Defaults to load following control if no depleted storage assets.
- `void __handleStorageCharging (int, double, std::list< Storage * >, std::vector< Combustion * > *, 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< 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)`  
Helper method to handle the optimal dispatch of *Combustion* assets. Dispatches for 1.2x the received net load, so as to ensure a "20% spinning reserve". Dispatches a minimum number of *Combustion* assets, which then share the load proportional to their rated capacities.
- `double __handleStorageDischarging (int, double, double, std::list< Storage * >)`  
Helper method to handle the discharging of the given *Storage* assets.

### 4.3.1 Detailed Description

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

## 4.3.2 Constructor & Destructor Documentation

### 4.3.2.1 Controller()

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

Constructor for the [Controller](#) class.

```
999 {
1000     return;
1001 } /* Controller() */
```

### 4.3.2.2 ~Controller()

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

Destructor for the [Controller](#) class.

```
1228 {
1229     this->clear();
1230
1231     return;
1232 } /* ~Controller() */
```

## 4.3.3 Member Function Documentation

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

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

Helper method to apply cycle charging control action for given timestep of the [Model](#) run when net load  $\leq 0$ . 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>combustion_ptr_vec_ptr</i>	A pointer to the <a href="#">Combustion</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> .

```

402 {
403     // 1. default to load following
404     this->__applyLoadFollowingControl_CHARGING(
405         timestep,
406         electrical_load_ptr,
407         combustion_ptr_vec_ptr,
408         renewable_ptr_vec_ptr,
409         storage_ptr_vec_ptr
410     );
411
412     return;
413 } /* __applyCycleChargingControl_CHARGING() */

```

#### 4.3.3.2 \_\_applyCycleChargingControl\_DISCHARGING()

```

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

```

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

##### Parameters

<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>combustion_ptr_vec_ptr</i>	A pointer to the <a href="#">Combustion</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

```

452 {
453     // 1. get dt_hrs, net load
454     double dt_hrs = electrical_load_ptr->dt_vec_hrs[timestep];
455     double net_load_kW = this->net_load_vec_kW[timestep];
456
457     // 2. partition Storage assets into depleted and non-depleted
458     std::list<Storage*> depleted_storage_ptr_list;
459     std::list<Storage*> nondepleted_storage_ptr_list;
460
461     Storage* storage_ptr;
462     for (size_t i = 0; i < storage_ptr_vec_ptr->size(); i++) {
463         storage_ptr = storage_ptr_vec_ptr->at(i);
464
465         if (storage_ptr->is_depleted) {
466             depleted_storage_ptr_list.push_back(storage_ptr);
467         }
468         else {
469             nondepleted_storage_ptr_list.push_back(storage_ptr);
470         }
471     }
472
473     // 3. discharge non-depleted storage assets
474     net_load_kW = this->__handleStorageDischarging(
475         timestep,
476         dt_hrs,
477         net_load_kW,
478         nondepleted_storage_ptr_list
479     );
480
481     // 4. request optimal production from all Combustion assets
482     // default to load following if no depleted storage
483     if (depleted_storage_ptr_list.empty()) {

```

```

485         net_load_kW = this->__handleCombustionDispatch(
486             timestep,
487             dt_hrs,
488             net_load_kW,
489             combustion_ptr_vec_ptr,
490             false // is_cycle_charging
491         );
492     }
493
494     else {
495         net_load_kW = this->__handleCombustionDispatch(
496             timestep,
497             dt_hrs,
498             net_load_kW,
499             combustion_ptr_vec_ptr,
500             true // is_cycle_charging
501         );
502     }
503
504     // 5. attempt to charge depleted Storage assets using any and all available
505     // charge priority is Combustion, then Renewable
506     this->__handleStorageCharging(
507         timestep,
508         dt_hrs,
509         depleted_storage_ptr_list,
510         combustion_ptr_vec_ptr,
511         renewable_ptr_vec_ptr
512     );
513
514     // 6. record any missed load
515     if (net_load_kW > 1e-6) {
516         this->missed_load_vec_kW[timestep] = net_load_kW;
517     }
518
519     return;
520 }
521 /* __applyCycleChargingControl_DISCHARGING() */

```

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

```

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

```

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

##### 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>combustion_ptr_vec_ptr</i>	A pointer to the <a href="#">Combustion</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> .

```

245 {
246     // 1. get dt_hrs, set net load
247     double dt_hrs = electrical_load_ptr->dt_vec_hrs[timestep];
248     double net_load_kW = 0;
249
250     // 2. request zero production from all Combustion assets
251     this->__handleCombustionDispatch(
252         timestep,
253         dt_hrs,
254         net_load_kW,
255         combustion_ptr_vec_ptr,
256         false // is_cycle_charging
257     );

```

```

258
259 // 3. attempt to charge all Storage assets using any and all available curtailment
260 // charge priority is Combustion, then Renewable
261 this->__handleStorageCharging(
262     timestep,
263     dt_hrs,
264     storage_ptr_vec_ptr,
265     combustion_ptr_vec_ptr,
266     renewable_ptr_vec_ptr
267 );
268
269 return;
270 } /* __applyLoadFollowingControl_CHARGING() */

```

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

```

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

```

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

##### Parameters

<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>combustion_ptr_vec_ptr</i>	A pointer to the <a href="#">Combustion</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

```

308 {
309 // 1. get dt_hrs, net load
310 double dt_hrs = electrical_load_ptr->dt_vec_hrs[timestep];
311 double net_load_kW = this->net_load_vec_kW[timestep];
312
313 // 2. partition Storage assets into depleted and non-depleted
314 std::list<Storage*> depleted_storage_ptr_list;
315 std::list<Storage*> nondepleted_storage_ptr_list;
316
317 Storage* storage_ptr;
318 for (size_t i = 0; i < storage_ptr_vec_ptr->size(); i++) {
319     storage_ptr = storage_ptr_vec_ptr->at(i);
320
321     if (storage_ptr->is_depleted) {
322         depleted_storage_ptr_list.push_back(storage_ptr);
323     }
324     else {
325         nondepleted_storage_ptr_list.push_back(storage_ptr);
326     }
327 }
328
329 // 3. discharge non-depleted storage assets
330 net_load_kW = this->__handleStorageDischarging(
331     timestep,
332     dt_hrs,
333     net_load_kW,
334     nondepleted_storage_ptr_list
335 );
336
337 // 4. request optimal production from all Combustion assets
338 net_load_kW = this->__handleCombustionDispatch(
339     timestep,

```



```

341         dt_hrs,
342         net_load_kW,
343         combustion_ptr_vec_ptr,
344         false // is_cycle_charging
345     );
346
347     // 5. attempt to charge depleted Storage assets using any and all available
348     // charge priority is Combustion, then Renewable
349     this->__handleStorageCharging(
350         timestep,
351         dt_hrs,
352         depleted_storage_ptr_list,
353         combustion_ptr_vec_ptr,
354         renewable_ptr_vec_ptr
355     );
356
357     // 6. record any missed load
358     if (net_load_kW > 1e-6) {
359         this->missed_load_vec_kW[timestep] = net_load_kW;
360     }
361 }
362
363 return;
364 } /* __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
95     this->net_load_vec_kW[i] = net_load_kW;
96 }
97
98 return;
99 } /* __computeNetLoad() */

```

#### 4.3.3.6 \_\_constructCombustionMap()

```

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

```

Helper method to construct a [Combustion](#) map, for use in determining.

##### Parameters

<i>combustion_ptr_vec_ptr</i>	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 // 4. test print
182 /*
183 std::cout << std::endl;
184
185 std::cout << "\t\t";
186 for (size_t i = 0; i < combustion_ptr_vec_ptr->size(); i++) {
187     std::cout << combustion_ptr_vec_ptr->at(i)->capacity_kW << "\t";
188 }
189 std::cout << std::endl;
190
191 std::map<double, std::vector<bool>::iterator iter;
192 for (
193     iter = this->combustion_map.begin();
194     iter != this->combustion_map.end();
195     iter++
196 ) {
197     std::cout << iter->first << ":\t{\t";
198
199     for (size_t i = 0; i < iter->second.size(); i++) {
200         std::cout << iter->second[i] << "\t";
201     }
202     std::cout << "}" << std::endl;
203 }
204 */
205
206 return;
207 } /* __constructCombustionTable() */

```

#### 4.3.3.7 \_\_getRenewableProduction()

```

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

```

Helper method to compute the production from the given [Renewable](#) asset at the given point in time.

##### Parameters

<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.

```

758 {
759     double production_kW = 0;
760
761     switch (renewable_ptr->type) {
762         case (RenewableType :: SOLAR): {
763             production_kW = renewable_ptr->computeProductionkW(

```

```

764         timestep,
765         dt_hrs,
766         resources_ptr->resource_map_1D[renewable_ptr->resource_key][timestep]
767     );
768
769     break;
770 }
771
772 case (RenewableType :: TIDAL): {
773     production_kW = renewable_ptr->computeProductionkW(
774         timestep,
775         dt_hrs,
776         resources_ptr->resource_map_1D[renewable_ptr->resource_key][timestep]
777     );
778
779     break;
780 }
781
782 case (RenewableType :: WAVE): {
783     production_kW = renewable_ptr->computeProductionkW(
784         timestep,
785         dt_hrs,
786         resources_ptr->resource_map_2D[renewable_ptr->resource_key][timestep][0],
787         resources_ptr->resource_map_2D[renewable_ptr->resource_key][timestep][1]
788     );
789
790     break;
791 }
792
793 case (RenewableType :: WIND): {
794     production_kW = renewable_ptr->computeProductionkW(
795         timestep,
796         dt_hrs,
797         resources_ptr->resource_map_1D[renewable_ptr->resource_key][timestep]
798     );
799
800     break;
801 }
802
803 default: {
804     std::string error_str = "ERROR: Controller::__getRenewableProduction(): ";
805     error_str += "renewable type ";
806     error_str += std::to_string(renewable_ptr->type);
807     error_str += " not recognized";
808
809     #ifdef _WIN32
810         std::cout << error_str << std::endl;
811     #endif
812
813     throw std::runtime_error(error_str);
814
815     break;
816 }
817 }
818
819 return production_kW;
820 } /* __getRenewableProduction() */

```

#### 4.3.3.8 \_\_handleCombustionDispatch()

```

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

```

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

bool is\_cycle\_charging )

## Parameters

<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.

```

862 {
863     // 1. get minimal Combustion dispatch
864     double target_production_kW = 1.2 * net_load_kW;
865     double total_capacity_kW = 0;
866
867     std::map<double, std::vector<bool>>::iterator iter = this->combustion_map.begin();
868     while (iter != std::prev(this->combustion_map.end(), 1)) {
869         if (target_production_kW <= total_capacity_kW) {
870             break;
871         }
872         iter++;
873         total_capacity_kW = iter->first;
874     }
875
876     // 2. share load proportionally (by rated capacity) over active diesels
877     Combustion* combustion_ptr;
878     double production_kW = 0;
879     double request_kW = 0;
880     double _net_load_kW = net_load_kW;
881
882     for (size_t i = 0; i < this->combustion_map[total_capacity_kW].size(); i++) {
883         combustion_ptr = combustion_ptr_vec_ptr->at(i);
884
885         if (total_capacity_kW > 0) {
886             request_kW =
887                 int(this->combustion_map[total_capacity_kW][i]) *
888                 net_load_kW *
889                 (combustion_ptr->capacity_kW / total_capacity_kW);
890         }
891         else {
892             request_kW = 0;
893         }
894
895         if (is_cycle_charging and request_kW > 0) {
896             if (request_kW < 0.85 * combustion_ptr->capacity_kW) {
897                 request_kW = 0.85 * combustion_ptr->capacity_kW;
898             }
899         }
900
901         production_kW = combustion_ptr->requestProductionkW(
902             timestep,
903             dt_hrs,
904             request_kW
905         );
906
907         _net_load_kW = combustion_ptr->commit(
908             timestep,
909             dt_hrs,
910             production_kW,
911             _net_load_kW
912         );
913     }
914
915     return _net_load_kW;
916 }
917
918 } /* __handleCombustionDispatch() */

```

## 4.3.3.9 \_\_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< 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>renewable_ptr_vec_ptr</i>	A pointer to the <a href="#">Renewable</a> pointer vector of the <a href="#">Model</a> .

```

559 {
560     double acceptable_kW = 0;
561     double curtailment_kW = 0;
562
563     Storage* storage_ptr;
564     Combustion* combustion_ptr;
565     Renewable* renewable_ptr;
566
567     std::list<Storage*>::iterator iter;
568     for (
569         iter = storage_ptr_list.begin();
570         iter != storage_ptr_list.end();
571         iter++
572     ){
573         storage_ptr = (*iter);
574
575         // 1. attempt to charge from Combustion curtailment first
576         for (size_t i = 0; i < combustion_ptr_vec_ptr->size(); i++) {
577             combustion_ptr = combustion_ptr_vec_ptr->at(i);
578             curtailment_kW = combustion_ptr->curtailment_vec_kW[timestep];
579
580             if (curtailment_kW <= 0) {
581                 continue;
582             }
583
584             acceptable_kW = storage_ptr->getAcceptablekW(dt_hrs);
585
586             if (acceptable_kW > curtailment_kW) {
587                 acceptable_kW = curtailment_kW;
588             }
589
590             combustion_ptr->curtailment_vec_kW[timestep] -= acceptable_kW;
591             combustion_ptr->storage_vec_kW[timestep] += acceptable_kW;
592             storage_ptr->power_kW += acceptable_kW;
593         }
594
595         // 2. attempt to charge from Renewable curtailment second
596         for (size_t i = 0; i < renewable_ptr_vec_ptr->size(); i++) {
597             renewable_ptr = renewable_ptr_vec_ptr->at(i);
598             curtailment_kW = renewable_ptr->curtailment_vec_kW[timestep];
599
600             if (curtailment_kW <= 0) {
601                 continue;
602             }
603
604             acceptable_kW = storage_ptr->getAcceptablekW(dt_hrs);
605
606             if (acceptable_kW > curtailment_kW) {
607                 acceptable_kW = curtailment_kW;
608             }
609
610             renewable_ptr->curtailment_vec_kW[timestep] -= acceptable_kW;
611             renewable_ptr->storage_vec_kW[timestep] += acceptable_kW;
612             storage_ptr->power_kW += acceptable_kW;
613         }
614
615         // 3. commit charge
616         storage_ptr->commitCharge(
617             timestep,
618             dt_hrs,
619             storage_ptr->power_kW
620         );
621     }
622 }

```

```

623     return;
624 } /* __handleStorageCharging() */

```

#### 4.3.3.10 \_\_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< 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>renewable_ptr_vec_ptr</i>	A pointer to the <a href="#">Renewable</a> pointer vector of the <a href="#">Model</a> .

```

662 {
663     double acceptable_kW = 0;
664     double curtailment_kW = 0;
665
666     Storage* storage_ptr;
667     Combustion* combustion_ptr;
668     Renewable* renewable_ptr;
669
670     for (size_t j = 0; j < storage_ptr_vec_ptr->size(); j++) {
671         storage_ptr = storage_ptr_vec_ptr->at(j);
672
673         // 1. attempt to charge from Combustion curtailment first
674         for (size_t i = 0; i < combustion_ptr_vec_ptr->size(); i++) {
675             combustion_ptr = combustion_ptr_vec_ptr->at(i);
676             curtailment_kW = combustion_ptr->curtailment_vec_kW[timestep];
677
678             if (curtailment_kW <= 0) {
679                 continue;
680             }
681
682             acceptable_kW = storage_ptr->getAcceptablekW(dt_hrs);
683
684             if (acceptable_kW > curtailment_kW) {
685                 acceptable_kW = curtailment_kW;
686             }
687
688             combustion_ptr->curtailment_vec_kW[timestep] -= acceptable_kW;
689             combustion_ptr->storage_vec_kW[timestep] += acceptable_kW;
690             storage_ptr->power_kW += acceptable_kW;
691         }
692
693         // 2. attempt to charge from Renewable curtailment second
694         for (size_t i = 0; i < renewable_ptr_vec_ptr->size(); i++) {
695             renewable_ptr = renewable_ptr_vec_ptr->at(i);
696             curtailment_kW = renewable_ptr->curtailment_vec_kW[timestep];
697
698             if (curtailment_kW <= 0) {
699                 continue;
700             }
701
702             acceptable_kW = storage_ptr->getAcceptablekW(dt_hrs);
703
704             if (acceptable_kW > curtailment_kW) {
705                 acceptable_kW = curtailment_kW;
706             }
707
708             renewable_ptr->curtailment_vec_kW[timestep] -= acceptable_kW;

```

```

709         renewable_ptr->storage_vec_kW[timestep] += acceptable_kW;
710         storage_ptr->power_kW += acceptable_kW;
711     }
712
713     // 3. commit charge
714     storage_ptr->commitCharge(
715         timestep,
716         dt_hrs,
717         storage_ptr->power_kW
718     );
719 }
720
721 return;
722 } /* __handleStorageCharging() */

```

#### 4.3.3.11 \_\_handleStorageDischarging()

```

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

```

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

##### Parameters

<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.

```

952 {
953     double discharging_kW = 0;
954
955     Storage* storage_ptr;
956
957     std::list<Storage*>::iterator iter;
958     for (
959         iter = storage_ptr_list.begin();
960         iter != storage_ptr_list.end();
961         iter++
962     ){
963         storage_ptr = (*iter);
964
965         discharging_kW = storage_ptr->getAvailablekW(dt_hrs);
966
967         if (discharging_kW > net_load_kW) {
968             discharging_kW = net_load_kW;
969         }
970
971         net_load_kW = storage_ptr->commitDischarge(
972             timestep,
973             dt_hrs,
974             discharging_kW,
975             net_load_kW
976         );
977     }
978
979     return net_load_kW;
980 } /* __handleStorageDischarging() */

```



## 4.3.3.12 applyDispatchControl()

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

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

## Parameters

<i>electrical_load_ptr</i>	A pointer to the <a href="#">ElectricalLoad</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>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> .

```
1123 {
1124     for (int i = 0; i < electrical_load_ptr->n_points; i++) {
1125         switch (this->control_mode) {
1126             case (ControlMode :: LOAD_FOLLOWING): {
1127                 if (this->net_load_vec_kW[i] <= 0) {
1128                     this->__applyLoadFollowingControl_CHARGING(
1129                         i,
1130                         electrical_load_ptr,
1131                         combustion_ptr_vec_ptr,
1132                         renewable_ptr_vec_ptr,
1133                         storage_ptr_vec_ptr
1134                     );
1135                 }
1136             }
1137             else {
1138                 this->__applyLoadFollowingControl_DISCHARGING(
1139                     i,
1140                     electrical_load_ptr,
1141                     combustion_ptr_vec_ptr,
1142                     renewable_ptr_vec_ptr,
1143                     storage_ptr_vec_ptr
1144                 );
1145             }
1146             break;
1147         }
1148     }
1149     case (ControlMode :: CYCLE_CHARGING): {
1150         if (this->net_load_vec_kW[i] <= 0) {
1151             this->__applyCycleChargingControl_CHARGING(
1152                 i,
1153                 electrical_load_ptr,
1154                 combustion_ptr_vec_ptr,
1155                 renewable_ptr_vec_ptr,
1156                 storage_ptr_vec_ptr
1157             );
1158         }
1159     }
1160     else {
1161         this->__applyCycleChargingControl_DISCHARGING(
1162             i,
1163             electrical_load_ptr,
1164             combustion_ptr_vec_ptr,
1165             renewable_ptr_vec_ptr,
1166             storage_ptr_vec_ptr
1167         );
1168     }
1169     break;
1170 }
1171 }
1172 }
1173 }
1174 default: {
1175     std::string error_str = "ERROR: Controller :: applyDispatchControl(): ";
1176     error_str += "control mode ";
1177     error_str += std::to_string(this->control_mode);
1178     error_str += " not recognized";
1179 }
1180 #ifdef _WIN32
1181     std::cout << error_str << std::endl;
1182 #endif
```

```

1183
1184             throw std::runtime_error(error_str);
1185
1186             break;
1187         }
1188     }
1189 }
1190
1191 return;
1192 } /* applyDispatchControl() */

```

#### 4.3.3.13 clear()

```

void Controller::clear (
    void )

```

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

```

1207 {
1208     this->net_load_vec_kW.clear();
1209     this->missed_load_vec_kW.clear();
1210     this->combustion_map.clear();
1211
1212     return;
1213 } /* clear() */

```

#### 4.3.3.14 init()

```

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

```

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

##### Parameters

<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> .

```

1082 {
1083     // 1. compute net load
1084     this->__computeNetLoad(electrical_load_ptr, renewable_ptr_vec_ptr, resources_ptr);
1085
1086     // 2. construct Combustion table
1087     this->__constructCombustionMap(combustion_ptr_vec_ptr);
1088
1089     return;
1090 } /* init() */

```

#### 4.3.3.15 setControlMode()

```

void Controller::setControlMode (
    ControlMode control_mode )

```

## Parameters

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

```

1016 {
1017     this->control_mode = control_mode;
1018
1019     switch(control_mode) {
1020         case (ControlMode :: LOAD_FOLLOWING): {
1021             this->control_string = "LOAD_FOLLOWING";
1022
1023             break;
1024         }
1025
1026         case (ControlMode :: CYCLE_CHARGING): {
1027             this->control_string = "CYCLE_CHARGING";
1028
1029             break;
1030         }
1031
1032         default: {
1033             std::string error_str = "ERROR: Controller :: setControlMode(): ";
1034             error_str += "control mode ";
1035             error_str += std::to_string(control_mode);
1036             error_str += " not recognized";
1037
1038             #ifdef _WIN32
1039                 std::cout << error_str << std::endl;
1040             #endif
1041
1042             throw std::runtime_error(error_str);
1043
1044             break;
1045         }
1046     }
1047
1048     return;
1049 } /* 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:

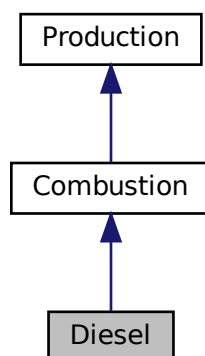
- header/[Controller.h](#)
- source/[Controller.cpp](#)

## 4.4 Diesel Class Reference

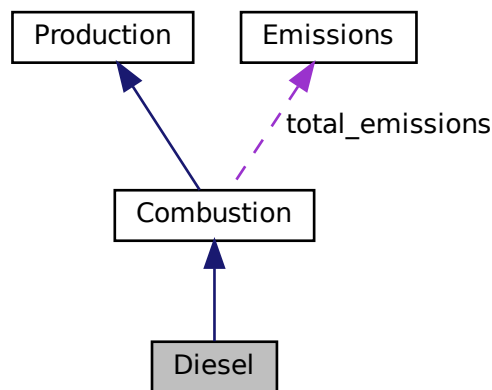
A derived class of the [Combustion](#) branch of [Production](#) which models production using a diesel generator.

```
#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.

```
575 {
576     return;
577 } /* 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.

```

605 :
606 Combustion(
607     n_points,
608     n_years,
609     diesel_inputs.combustion_inputs
610 )
611 {
612     // 1. check inputs
613     this->__checkInputs(diesel_inputs);
614
615     // 2. set attributes
616     this->type = CombustionType :: DIESEL;
617     this->type_str = "DIESEL";
618
619     this->replace_running_hrs = diesel_inputs.replace_running_hrs;
620
621     this->fuel_cost_L = diesel_inputs.fuel_cost_L;
622
623     this->minimum_load_ratio = diesel_inputs.minimum_load_ratio;
624     this->minimum_runtime_hrs = diesel_inputs.minimum_runtime_hrs;
625     this->time_since_last_start_hrs = 0;
626
627     this->CO2_emissions_intensity_kgL = diesel_inputs.CO2_emissions_intensity_kgL;
628     this->CO_emissions_intensity_kgL = diesel_inputs.CO_emissions_intensity_kgL;
629     this->NOx_emissions_intensity_kgL = diesel_inputs.NOx_emissions_intensity_kgL;
630     this->SOx_emissions_intensity_kgL = diesel_inputs.SOx_emissions_intensity_kgL;
631     this->CH4_emissions_intensity_kgL = diesel_inputs.CH4_emissions_intensity_kgL;
632     this->PM_emissions_intensity_kgL = diesel_inputs.PM_emissions_intensity_kgL;
633
634     if (diesel_inputs.linear_fuel_slope_LkWh < 0) {
635         this->linear_fuel_slope_LkWh = this->__getGenericFuelSlope();
636     }
637
638     if (diesel_inputs.linear_fuel_intercept_LkWh < 0) {
639         this->linear_fuel_intercept_LkWh = this->__getGenericFuelIntercept();
640     }
641
642     if (diesel_inputs.capital_cost < 0) {
643         this->capital_cost = this->__getGenericCapitalCost();
644     }
645
646     if (diesel_inputs.operation_maintenance_cost_kWh < 0) {
647         this->operation_maintenance_cost_kWh = this->__getGenericOpMaintCost();
648     }
649
650     if (not this->is_sunk) {
651         this->capital_cost_vec[0] = this->capital_cost;
652     }
653
654     // 3. construction print
655     if (this->print_flag) {
656         std::cout << "Diesel object constructed at " << this << std::endl;
657     }
658
659     return;
660 } /* Diesel() */

```

## 4.4.2.3 ~Diesel()

```

Diesel::~Diesel (
    void )

```

Destructor for the [Diesel](#) class.

```

815 {
816     // 1. destruction print
817     if (this->print_flag) {
818         std::cout << "Diesel object at " << this << " destroyed" << std::endl;
819     }
820
821     return;
822 } /* ~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 <code>Diesel</code> 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_kg/L
53     if (diesel_inputs.CO2_emissions_intensity_kg_L < 0) {
54         std::string error_str = "ERROR: Diesel(): ";
55         error_str += "DieselInputs::CO2_emissions_intensity_kg_L 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_kg/L
65     if (diesel_inputs.CO_emissions_intensity_kg_L < 0) {
66         std::string error_str = "ERROR: Diesel(): ";
67         error_str += "DieselInputs::CO_emissions_intensity_kg_L 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_kg/L
77     if (diesel_inputs.NOx_emissions_intensity_kg_L < 0) {
78         std::string error_str = "ERROR: Diesel(): ";
79         error_str += "DieselInputs::NOx_emissions_intensity_kg_L 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_kg/L
89     if (diesel_inputs.SOx_emissions_intensity_kg_L < 0) {
90         std::string error_str = "ERROR: Diesel(): ";
91         error_str += "DieselInputs::SOx_emissions_intensity_kg_L 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 << "Linear Fuel Slope: " << this->linear_fuel_slope_LkWh << " L/kWh \n";
390     ofs << "Linear Fuel Intercept Coefficient: " << this->linear_fuel_intercept_LkWh
391         << " L/kWh \n";
392     ofs << "\n";
393
394     ofs << "Carbon Dioxide (CO2) Emissions Intensity: "
395         << this->CO2_emissions_intensity_kgL << " kg/L \n";
396
397     ofs << "Carbon Monoxide (CO) Emissions Intensity: "
398         << this->CO_emissions_intensity_kgL << " kg/L \n";
399
400     ofs << "Nitrogen Oxides (NOx) Emissions Intensity: "

```

```

401         « this->NOx_emissions_intensity_kgL « " kg/L  \n";
402
403     ofs « "Sulfur Oxides (SOx) Emissions Intensity: "
404         « this->SOx_emissions_intensity_kgL « " kg/L  \n";
405
406     ofs « "Methane (CH4) Emissions Intensity: "
407         « this->CH4_emissions_intensity_kgL « " kg/L  \n";
408
409     ofs « "Particulate Matter (PM) Emissions Intensity: "
410         « this->PM_emissions_intensity_kgL « " kg/L  \n";
411
412     ofs « "\n-----\n\n";
413
414     // 2.3. Diesel attributes
415     ofs « "## Diesel Attributes\n";
416     ofs « "\n";
417
418     ofs « "Minimum Load Ratio: " « this->minimum_load_ratio « " \n";
419     ofs « "Minimum Runtime: " « this->minimum_runtime_hrs « " hrs  \n";
420
421     ofs « "\n-----\n\n";
422
423     // 2.4. Diesel Results
424     ofs « "## Results\n";
425     ofs « "\n";
426
427     ofs « "Net Present Cost: " « this->net_present_cost « " \n";
428     ofs « "\n";
429
430     ofs « "Total Dispatch: " « this->total_dispatch_kWh
431         « " kWh  \n";
432
433     ofs « "Levellized Cost of Energy: " « this->levellized_cost_of_energy_kWh
434         « " per kWh dispatched  \n";
435     ofs « "\n";
436
437     ofs « "Running Hours: " « this->running_hours « " \n";
438     ofs « "Starts: " « this->n_starts « " \n";
439     ofs « "Replacements: " « this->n_replacements « " \n";
440
441     ofs « "Total Fuel Consumed: " « this->total_fuel_consumed_L « " L "
442         « "(Annual Average: " « this->total_fuel_consumed_L / this->n_years
443         « " L/yr)  \n";
444     ofs « "\n";
445
446     ofs « "Total Carbon Dioxide (CO2) Emissions: " «
447         this->total_emissions.CO2_kg « " kg "
448         « "(Annual Average: " « this->total_emissions.CO2_kg / this->n_years
449         « " kg/yr)  \n";
450
451     ofs « "Total Carbon Monoxide (CO) Emissions: " «
452         this->total_emissions.CO_kg « " kg "
453         « "(Annual Average: " « this->total_emissions.CO_kg / this->n_years
454         « " kg/yr)  \n";
455
456     ofs « "Total Nitrogen Oxides (NOx) Emissions: " «
457         this->total_emissions.NOx_kg « " kg "
458         « "(Annual Average: " « this->total_emissions.NOx_kg / this->n_years
459         « " kg/yr)  \n";
460
461     ofs « "Total Sulfur Oxides (SOx) Emissions: " «
462         this->total_emissions.SOx_kg « " kg "
463         « "(Annual Average: " « this->total_emissions.SOx_kg / this->n_years
464         « " kg/yr)  \n";
465
466     ofs « "Total Methane (CH4) Emissions: " « this->total_emissions.CH4_kg « " kg "
467         « "(Annual Average: " « this->total_emissions.CH4_kg / this->n_years
468         « " kg/yr)  \n";
469
470     ofs « "Total Particulate Matter (PM) Emissions: " «
471         this->total_emissions.PM_kg « " kg "
472         « "(Annual Average: " « this->total_emissions.PM_kg / this->n_years
473         « " kg/yr)  \n";
474
475     ofs « "\n-----\n\n";
476
477     ofs.close();
478     return;
479 } /* __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 time_vec_hrs attribute of the <a href="#">ElectricalLoad</a> .
<i>max_lines</i>	The maximum number of lines of output to write.

Reimplemented from [Combustion](#).

```
509 {
510     // 1. create filestream
511     write_path += "time_series_results.csv";
512     std::ofstream ofs;
513     ofs.open(write_path, std::ofstream::out);
514
515     // 2. write time series results (comma separated value)
516     ofs << "Time (since start of data) [hrs],";
517     ofs << "Production [kW],";
518     ofs << "Dispatch [kW],";
519     ofs << "Storage [kW],";
520     ofs << "Curtailment [kW],";
521     ofs << "Is Running (N = 0 / Y = 1),";
522     ofs << "Fuel Consumption [L],";
523     ofs << "Fuel Cost (actual),";
524     ofs << "Carbon Dioxide (CO2) Emissions [kg],";
525     ofs << "Carbon Monoxide (CO) Emissions [kg],";
526     ofs << "Nitrogen Oxides (NOx) Emissions [kg],";
527     ofs << "Sulfur Oxides (SOx) Emissions [kg],";
528     ofs << "Methane (CH4) Emissions [kg],";
529     ofs << "Particulate Matter (PM) Emissions [kg],";
530     ofs << "Capital Cost (actual),";
531     ofs << "Operation and Maintenance Cost (actual),";
532     ofs << "\n";
533
534     for (int i = 0; i < max_lines; i++) {
535         ofs << time_vec_hrs_ptr->at(i) << ", ";
536         ofs << this->production_vec_kW[i] << ", ";
537         ofs << this->dispatch_vec_kW[i] << ", ";
538         ofs << this->storage_vec_kW[i] << ", ";
539         ofs << this->curtailment_vec_kW[i] << ", ";
540         ofs << this->is_running_vec[i] << ", ";
541         ofs << this->fuel_consumption_vec_L[i] << ", ";
542         ofs << this->fuel_cost_vec[i] << ", ";
543         ofs << this->CO2_emissions_vec_kg[i] << ", ";
544         ofs << this->CO_emissions_vec_kg[i] << ", ";
545         ofs << this->NOx_emissions_vec_kg[i] << ", ";
546         ofs << this->SOx_emissions_vec_kg[i] << ", ";
547         ofs << this->CH4_emissions_vec_kg[i] << ", ";
548         ofs << this->PM_emissions_vec_kg[i] << ", ";
549         ofs << this->capital_cost_vec[i] << ", ";
550         ofs << this->operation_maintenance_cost_vec[i] << ", ";
551         ofs << "\n";
552     }
553
554     ofs.close();
555     return;
556 } /* __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](#).

```
773 {
774     // 1. handle start/stop, enforce minimum runtime constraint
775     this->__handleStartStop(timestep, dt_hrs, production_kW);
776
777     // 2. invoke base class method
778     load_kW = Combustion::commit(
779         timestep,
780         dt_hrs,
781         production_kW,
782         load_kW
783     );
784
785     if (this->is_running) {
786         // 3. log time since last start
787         this->time_since_last_start_hrs += dt_hrs;
788
789         // 4. correct operation and maintenance costs (should be non-zero if idling)
790         if (production_kW <= 0) {
791             double produced_kWh = 0.01 * this->capacity_kW * dt_hrs;
792
793             double operation_maintenance_cost =
794                 this->operation_maintenance_cost_kWh * produced_kWh;
795             this->operation_maintenance_cost_vec[timestep] = operation_maintenance_cost;
796         }
797     }
798
799     return load_kW;
800 } /* 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](#).

```

678 {
679     // 1. reset attributes
680     this->time_since_last_start_hrs = 0;
681
682     // 2. invoke base class method
683     Combustion :: handleReplacement(timestep);
684
685     return;
686 } /* __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](#).

```

718 {
719     // 1. return on request of zero
720     if (request_kW <= 0) {
721         return 0;
722     }
723
724     double deliver_kW = request_kW;
725
726     // 2. enforce capacity constraint
727     if (deliver_kW > this->capacity_kW) {
728         deliver_kW = this->capacity_kW;
729     }
730
731     // 3. enforce minimum load ratio
732     if (deliver_kW < this->minimum_load_ratio * this->capacity_kW) {
733         deliver_kW = this->minimum_load_ratio * this->capacity_kW;
734     }
735
736     return deliver_kW;
737 } /* requestProductionkW() */

```

## 4.4.4 Member Data Documentation



#### 4.4.4.1 minimum\_load\_ratio

```
double Diesel::minimum_load_ratio
```

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

#### 4.4.4.2 minimum\_runtime\_hrs

```
double Diesel::minimum_runtime_hrs
```

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

#### 4.4.4.3 time\_since\_last\_start\_hrs

```
double Diesel::time_since_last_start_hrs
```

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

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

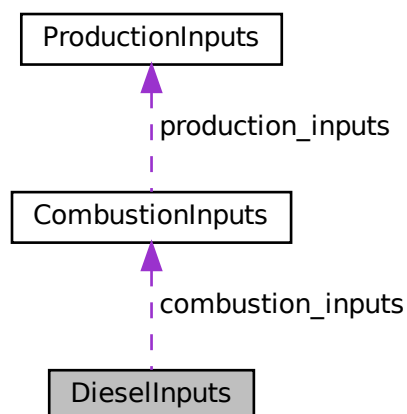
- [header/Production/Combustion/Diesel.h](#)
- [source/Production/Combustion/Diesel.cpp](#)

## 4.5 DieselInputs Struct Reference

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

```
#include <Diesel.h>
```

Collaboration diagram for DieselInputs:



## Public Attributes

- [CombustionInputs](#) `combustion_inputs`  
An encapsulated [CombustionInputs](#) instance.
- double `replace_running_hrs` = 30000  
The number of running hours after which the asset must be replaced. Overwrites the [ProductionInputs](#) attribute.
- double `capital_cost` = -1  
The capital cost of the asset (undefined currency). -1 is a sentinel value, which triggers a generic cost model on construction (in fact, any negative value here will trigger). Note that the generic cost model is in terms of Canadian dollars [CAD].
- double `operation_maintenance_cost_kWh` = -1  
The operation and maintenance cost of the asset [1/kWh] (undefined currency). This is a cost incurred per unit of energy produced. -1 is a sentinel value, which triggers a generic cost model on construction (in fact, any negative value here will trigger). Note that the generic cost model is in terms of Canadian dollars [CAD/kWh].
- double `fuel_cost_L` = 1.70  
The cost of fuel [1/L] (undefined currency).
- double `minimum_load_ratio` = 0.2  
The minimum load ratio of the asset. That is, when the asset is producing, it must produce at least this ratio of its rated capacity.
- double `minimum_runtime_hrs` = 4  
The minimum runtime [hrs] of the asset. This is the minimum time that must elapse between successive starts and stops.
- double `linear_fuel_slope_LkWh` = -1  
The slope [L/kWh] to use in computing linearized fuel consumption. This is fuel consumption per unit energy produced. -1 is a sentinel value, which triggers a generic fuel consumption model on construction (in fact, any negative value here will trigger).
- double `linear_fuel_intercept_LkWh` = -1  
The intercept [L/kWh] to use in computing linearized fuel consumption. This is fuel consumption per unit energy produced. -1 is a sentinel value, which triggers a generic fuel consumption model on construction (in fact, any negative value here will trigger).
- double `CO2_emissions_intensity_kgL` = 2.7  
Carbon dioxide (CO2) emissions intensity [kg/L].
- double `CO_emissions_intensity_kgL` = 0.0178  
Carbon monoxide (CO) emissions intensity [kg/L].
- double `NOx_emissions_intensity_kgL` = 0.0014  
Nitrogen oxide (NOx) emissions intensity [kg/L].
- double `SOx_emissions_intensity_kgL` = 0.0042  
Sulfur oxide (SOx) emissions intensity [kg/L].
- double `CH4_emissions_intensity_kgL` = 0.0007  
Methane (CH4) emissions intensity [kg/L].
- double `PM_emissions_intensity_kgL` = 0.0001  
Particulate Matter (PM) emissions intensity [kg/L].

### 4.5.1 Detailed Description

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

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

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

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

Ref: [NRCan \[2014\]](#)

Ref: [CIMAC \[2008\]](#)

## 4.5.2 Member Data Documentation

### 4.5.2.1 capital\_cost

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

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

### 4.5.2.2 CH4\_emissions\_intensity\_kgL

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

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

### 4.5.2.3 CO2\_emissions\_intensity\_kgL

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

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

### 4.5.2.4 CO\_emissions\_intensity\_kgL

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

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

### 4.5.2.5 combustion\_inputs

```
CombustionInputs DieselInputs::combustion_inputs
```

An encapsulated [CombustionInputs](#) instance.

#### 4.5.2.6 fuel\_cost\_L

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

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

#### 4.5.2.7 linear\_fuel\_intercept\_LkWh

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

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

#### 4.5.2.8 linear\_fuel\_slope\_LkWh

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

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

#### 4.5.2.9 minimum\_load\_ratio

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

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

#### 4.5.2.10 minimum\_runtime\_hrs

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

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

#### 4.5.2.11 NOx\_emissions\_intensity\_kgL

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

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

#### 4.5.2.12 operation\_maintenance\_cost\_kWh

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

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

#### 4.5.2.13 PM\_emissions\_intensity\_kgL

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

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

#### 4.5.2.14 replace\_running\_hrs

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

The number of running hours after which the asset must be replaced. Overwrites the [ProductionInputs](#) attribute.

#### 4.5.2.15 SOx\_emissions\_intensity\_kgL

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

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

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

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

## 4.6 ElectricalLoad Class Reference

A class which contains time and electrical load data. Intended to serve as a component class of [Model](#).

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

## Public Member Functions

- [ElectricalLoad](#) (void)  
*Constructor (dummy) for the [ElectricalLoad](#) class.*
- [ElectricalLoad](#) (std::string)  
*Constructor (intended) for the [ElectricalLoad](#) class.*
- void [readLoadData](#) (std::string)  
*Method to read electrical load data into an already existing [ElectricalLoad](#) object. Clears and overwrites any existing attribute values.*
- void [clear](#) (void)  
*Method to clear all attributes of the [ElectricalLoad](#) object.*
- [~ElectricalLoad](#) (void)  
*Destructor for the [ElectricalLoad](#) class.*

## Public Attributes

- int [n\\_points](#)  
*The number of points in the modelling time series.*
- double [n\\_years](#)  
*The number of years being modelled (inferred from [time\\_vec\\_hrs](#)).*
- double [min\\_load\\_kW](#)  
*The minimum [kW] of the given electrical load time series.*
- double [mean\\_load\\_kW](#)  
*The mean, or average, [kW] of the given electrical load time series.*
- double [max\\_load\\_kW](#)  
*The maximum [kW] of the given electrical load time series.*
- std::string [path\\_2\\_electrical\\_load\\_time\\_series](#)  
*A string defining the path (either relative or absolute) to the given electrical load time series.*
- std::vector< double > [time\\_vec\\_hrs](#)  
*A vector to hold a given sequence of model times [hrs]. This defines the modelling time series.*
- std::vector< double > [dt\\_vec\\_hrs](#)  
*A vector to hold a sequence of model time deltas [hrs].*
- std::vector< double > [load\\_vec\\_kW](#)  
*A vector to hold a given sequence of electrical load values [kW].*

### 4.6.1 Detailed Description

A class which contains time and electrical load data. Intended to serve as a component class of [Model](#).

### 4.6.2 Constructor & Destructor Documentation

#### 4.6.2.1 ElectricalLoad() [1/2]

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

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

```
37 {
38     return;
39 } /* ElectricalLoad() */
```

#### 4.6.2.2 ElectricalLoad() [2/2]

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

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

##### Parameters

<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 Interpolator Class Reference

A class which contains interpolation data and functionality.

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

### Public Member Functions

- [Interpolator](#) (void)  
*Constructor for the [Interpolator](#) class.*
- [~Interpolator](#) (void)  
*Destructor for the [Interpolator](#) class.*

#### 4.8.1 Detailed Description

A class which contains interpolation data and functionality.

#### 4.8.2 Constructor & Destructor Documentation

#### 4.8.2.1 Interpolator()

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

Constructor for the [Interpolator](#) class.

```
49 {
50     //...
51
52     return;
53 } /* Interpolator() */
```

#### 4.8.2.2 ~Interpolator()

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

Destructor for the [Interpolator](#) class.

```
76 {
77     //...
78
79     return;
80 } /* ~Interpolator() */
```

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

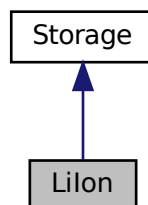
- [header/Interpolator.h](#)
- [source/Interpolator.cpp](#)

## 4.9 Lilon Class Reference

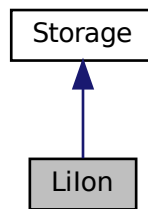
A derived class of [Storage](#) which models energy storage by way of lithium-ion batteries.

```
#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 [ $1/\sqrt{\text{hrs}}$ ] 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](#).*

### 4.9.1 Detailed Description

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

### 4.9.2 Constructor & Destructor Documentation

#### 4.9.2.1 Lilon() [1/2]

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

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

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

#### 4.9.2.2 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="#">Lilon</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() */

```

#### 4.9.2.3 ~LiIon()

```

LiIon::~LiIon (
    void )

```

Destructor for the [LiIon](#) class.

```

990 {
991     // 1. destruction print
992     if (this->print_flag) {
993         std::cout << "LiIon object at " << this << " destroyed" << std::endl;
994     }
995
996     return;
997 } /* ~LiIon() */

```

### 4.9.3 Member Function Documentation

#### 4.9.3.1 \_\_checkInputs()

```

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

```

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

##### Parameters

<i>liion_inputs</i>	A structure of <a href="#">LiIon</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 (lilion_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 (lilion_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 (lilion_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 (lilion_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 (lilion_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 (liion_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() */

```

#### 4.9.3.2 \_\_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 \[2023\]](#)

##### Parameters

<i>SOC</i>	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() */

```

#### 4.9.3.3 \_\_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 \[2023\]](#)

##### 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() */

```

**4.9.3.4 \_\_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() */

```

**4.9.3.5 \_\_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() */

```

**4.9.3.6 \_\_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() */

```

## 4.9.3.7 \_\_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 \[2023\]](#)

## 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 = __getEacal(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() */

```

## 4.9.3.8 \_\_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() */
```

#### 4.9.3.9 \_\_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 LIION 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() */

```

#### 4.9.3.10 \_\_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 time_vec_hrs 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() */

```

#### 4.9.3.11 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() */

```

#### 4.9.3.12 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() */

```

#### 4.9.3.13 getAcceptablekW()

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

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

##### Parameters

<code>dt_hrs</code>	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( */
```

#### 4.9.3.14 getAvailablekW()

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

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

##### Parameters

<code>dt_hrs</code>	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() */

```

#### 4.9.3.15 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() */

```

## 4.9.4 Member Data Documentation

### 4.9.4.1 charging\_efficiency

```
double LiIon::charging_efficiency
```

The charging efficiency of the asset.

#### 4.9.4.2 degradation\_a\_cal

```
double LiIon::degradation_a_cal
```

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

#### 4.9.4.3 degradation\_alpha

```
double LiIon::degradation_alpha
```

A dimensionless acceleration coefficient used in modelling energy capacity degradation.

#### 4.9.4.4 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.

#### 4.9.4.5 degradation\_beta

```
double LiIon::degradation_beta
```

A dimensionless acceleration exponent used in modelling energy capacity degradation.

#### 4.9.4.6 degradation\_Ea\_cal\_0

```
double LiIon::degradation_Ea_cal_0
```

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

#### 4.9.4.7 degradation\_r\_cal

```
double LiIon::degradation_r_cal
```

A dimensionless constant used in modelling energy capacity degradation.

#### 4.9.4.8 degradation\_s\_cal

```
double LiIon::degradation_s_cal
```

A dimensionless constant used in modelling energy capacity degradation.

#### 4.9.4.9 discharging\_efficiency

```
double LiIon::discharging_efficiency
```

The discharging efficiency of the asset.

#### 4.9.4.10 dynamic\_energy\_capacity\_kWh

```
double LiIon::dynamic_energy_capacity_kWh
```

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

#### 4.9.4.11 gas\_constant\_JmolK

```
double LiIon::gas_constant_JmolK
```

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

#### 4.9.4.12 hysteresis\_SOC

```
double LiIon::hysteresis_SOC
```

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

#### 4.9.4.13 init\_SOC

```
double LiIon::init_SOC
```

The initial state of charge of the asset.

#### 4.9.4.14 max\_SOC

```
double LiIon::max_SOC
```

The maximum state of charge of the asset.

#### 4.9.4.15 min\_SOC

```
double LiIon::min_SOC
```

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

#### 4.9.4.16 replace\_SOH

```
double LiIon::replace_SOH
```

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

#### 4.9.4.17 SOH

```
double LiIon::SOH
```

The state of health of the asset.

#### 4.9.4.18 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.

#### 4.9.4.19 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:

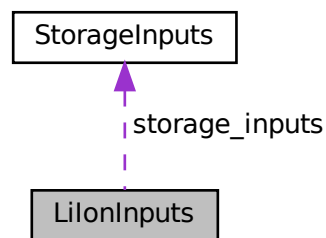
- [header/Storage/Lilon.h](#)
- [source/Storage/Lilon.cpp](#)

## 4.10 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.*

### 4.10.1 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 \[2023\]](#)

## 4.10.2 Member Data Documentation

### 4.10.2.1 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].

### 4.10.2.2 charging\_efficiency

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

The charging efficiency of the asset.

#### 4.10.2.3 degradation\_a\_cal

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

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

#### 4.10.2.4 degradation\_alpha

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

A dimensionless acceleration coefficient used in modelling energy capacity degradation.

#### 4.10.2.5 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.

#### 4.10.2.6 degradation\_beta

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

A dimensionless acceleration exponent used in modelling energy capacity degradation.

#### 4.10.2.7 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.

#### 4.10.2.8 degradation\_r\_cal

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

A dimensionless constant used in modelling energy capacity degradation.

#### 4.10.2.9 degradation\_s\_cal

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

A dimensionless constant used in modelling energy capacity degradation.

#### 4.10.2.10 discharging\_efficiency

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

The discharging efficiency of the asset.

#### 4.10.2.11 gas\_constant\_JmolK

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

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

#### 4.10.2.12 hysteresis\_SOC

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

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

#### 4.10.2.13 init\_SOC

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

The initial state of charge of the asset.

#### 4.10.2.14 max\_SOC

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

The maximum state of charge of the asset.

#### 4.10.2.15 min\_SOC

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

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

#### 4.10.2.16 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].

#### 4.10.2.17 replace\_SOH

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

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

#### 4.10.2.18 storage\_inputs

```
StorageInputs LiIonInputs::storage_inputs
```

An encapsulated [StorageInputs](#) instance.

#### 4.10.2.19 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:

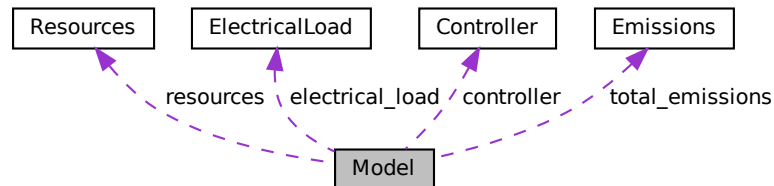
- header/Storage/[Lilon.h](#)

## 4.11 Model Class Reference

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

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

Collaboration diagram for Model:



### Public Member Functions

- [Model](#) (void)  
*Constructor (dummy) for the [Model](#) class.*
- [Model](#) (ModelInputs)  
*Constructor (intended) for the [Model](#) class.*
- void [addDiesel](#) (DieselInputs)  
*Method to add a [Diesel](#) asset to the [Model](#).*
- void [addResource](#) (RenewableType, std::string, int)  
*A method to add a renewable resource time series to the [Model](#).*
- void [addSolar](#) (SolarInputs)  
*Method to add a [Solar](#) asset to the [Model](#).*
- void [addTidal](#) (TidalInputs)  
*Method to add a [Tidal](#) asset to the [Model](#).*
- void [addWave](#) (WaveInputs)  
*Method to add a [Wave](#) asset to the [Model](#).*
- void [addWind](#) (WindInputs)  
*Method to add a [Wind](#) asset to the [Model](#).*
- void [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\\_dispatch\\_discharge\\_kWh](#)  
*The total energy dispatched/discharged [kWh] over the [Model](#) run.*
- double [levellized\\_cost\\_of\\_energy\\_kWh](#)  
*The levellized cost of energy, per unit energy dispatched/discharged, of the [Model](#) [1/kWh] (undefined currency).*
- [Controller](#) [controller](#)  
*[Controller](#) component of [Model](#).*
- [ElectricalLoad](#) [electrical\\_load](#)  
*[ElectricalLoad](#) component of [Model](#).*
- [Resources](#) [resources](#)  
*[Resources](#) component of [Model](#).*
- std::vector< [Combustion](#) \* > [combustion\\_ptr\\_vec](#)  
*A vector of pointers to the various [Combustion](#) assets in the [Model](#).*
- std::vector< [Renewable](#) \* > [renewable\\_ptr\\_vec](#)  
*A vector of pointers to the various [Renewable](#) assets in the [Model](#).*
- std::vector< [Storage](#) \* > [storage\\_ptr\\_vec](#)  
*A vector of pointers to the various [Storage](#) assets in the [Model](#).*

## Private Member Functions

- void [\\_\\_checkInputs](#) ([ModellInputs](#))  
*Helper method (private) to check inputs to the [Model](#) constructor.*
- void [\\_\\_computeFuelAndEmissions](#) (void)  
*Helper method to compute the total fuel consumption and emissions over the [Model](#) run.*
- void [\\_\\_computeNetPresentCost](#) (void)  
*Helper method to compute the overall net present cost, for the [Model](#) run, from the asset-wise net present costs.*
- void [\\_\\_computeLevellizedCostOfEnergy](#) (void)  
*Helper method to compute the overall levellized cost of energy, for the [Model](#) run, from the asset-wise levellized costs of energy.*
- void [\\_\\_computeEconomics](#) (void)  
*Helper method to compute key economic metrics for the [Model](#) run.*
- void [\\_\\_writeSummary](#) (std::string)  
*Helper method to write summary results for [Model](#).*
- void [\\_\\_writeTimeSeries](#) (std::string, int=-1)  
*Helper method to write time series results for [Model](#).*

### 4.11.1 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.

## 4.11.2 Constructor & Destructor Documentation

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

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

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

```
497 {
498     return;
499 } /* Model() */
```

### 4.11.2.2 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.
---------------------	----------------------------------------------------------

```
516 {
517     // 1. check inputs
518     this->__checkInputs(model_inputs);
519
520     // 2. read in electrical load data
521     this->electrical_load.readLoadData(model_inputs.path_2_electrical_load_time_series);
522
523     // 3. set control mode
524     this->controller.setControlMode(model_inputs.control_mode);
525
526     // 4. set public attributes
527     this->total_fuel_consumed_L = 0;
528     this->net_present_cost = 0;
529     this->total_dispatch_discharge_kWh = 0;
530     this->levellized_cost_of_energy_kWh = 0;
531
532     return;
533 } /* Model() */
```

### 4.11.2.3 ~Model()

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

Destructor for the [Model](#) class.

```
960 {
961     this->clear();
962     return;
963 } /* ~Model() */
```

### 4.11.3 Member Function Documentation

#### 4.11.3.1 `__checkInputs()`

```
void Model::__checkInputs (
    ModelInputs ) [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     //...
42
43     return;
44 } /* __checkInputs() */
```

#### 4.11.3.2 `__computeEconomics()`

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

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

```
206 {
207     this->__computeNetPresentCost();
208     this->__computeLevellizedCostOfEnergy();
209
210     return;
211 } /* __computeEconomics() */
```

#### 4.11.3.3 `__computeFuelAndEmissions()`

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

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

```
60 {
61     for (size_t i = 0; i < this->combustion_ptr_vec.size(); i++) {
62         this->combustion_ptr_vec[i]->computeFuelAndEmissions();
63
64         this->total_fuel_consumed_L +=
65             this->combustion_ptr_vec[i]->total_fuel_consumed_L;
66
67         this->total_emissions.CO2_kg +=
68             this->combustion_ptr_vec[i]->total_emissions.CO2_kg;
69
70         this->total_emissions.CO_kg +=
71             this->combustion_ptr_vec[i]->total_emissions.CO_kg;
72
73         this->total_emissions.NOx_kg +=
74             this->combustion_ptr_vec[i]->total_emissions.NOx_kg;
75
76         this->total_emissions.SOx_kg +=
77             this->combustion_ptr_vec[i]->total_emissions.SOx_kg;
```



```

78
79         this->total_emissions.CH4_kg +=
80             this->combustion_ptr_vec[i]->total_emissions.CH4_kg;
81
82         this->total_emissions.PM_kg +=
83             this->combustion_ptr_vec[i]->total_emissions.PM_kg;
84     }
85
86     return;
87 } /* __computeFuelAndEmissions() */

```

#### 4.11.3.4 \_\_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.

```

160 {
161     // 1. account for Combustion economics in levellized cost of energy
162     for (size_t i = 0; i < this->combustion_ptr_vec.size(); i++) {
163         this->levellized_cost_of_energy_kWh +=
164             (
165                 this->combustion_ptr_vec[i]->levellized_cost_of_energy_kWh *
166                 this->combustion_ptr_vec[i]->total_dispatch_kWh
167             ) / this->total_dispatch_discharge_kWh;
168     }
169
170     // 2. account for Renewable economics in levellized cost of energy
171     for (size_t i = 0; i < this->renewable_ptr_vec.size(); i++) {
172         this->levellized_cost_of_energy_kWh +=
173             (
174                 this->renewable_ptr_vec[i]->levellized_cost_of_energy_kWh *
175                 this->renewable_ptr_vec[i]->total_dispatch_kWh
176             ) / this->total_dispatch_discharge_kWh;
177     }
178
179     // 3. account for Storage economics in levellized cost of energy
180     for (size_t i = 0; i < this->storage_ptr_vec.size(); i++) {
181         /*
182         this->levellized_cost_of_energy_kWh +=
183             (
184                 this->storage_ptr_vec[i]->levellized_cost_of_energy_kWh *
185                 this->storage_ptr_vec[i]->total_dispatch_kWh
186             ) / this->total_dispatch_discharge_kWh;
187         */
188     }
189
190     return;
191 } /* __computeLevellizedCostOfEnergy() */

```

#### 4.11.3.5 \_\_computeNetPresentCost()

```

void Model::__computeNetPresentCost (
    void ) [private]

```

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

```

103 {
104     // 1. account for Combustion economics in net present cost
105     // increment total dispatch
106     for (size_t i = 0; i < this->combustion_ptr_vec.size(); i++) {
107         this->combustion_ptr_vec[i]->computeEconomics(
108             &(this->electrical_load.time_vec_hrs)
109         );
110
111         this->net_present_cost += this->combustion_ptr_vec[i]->net_present_cost;
112
113         this->total_dispatch_discharge_kWh +=
114             this->combustion_ptr_vec[i]->total_dispatch_kWh;

```

```

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

```

#### 4.11.3.6 \_\_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.
-------------------	------------------------------------------------------------------------------------------------------------------------------------

```

229 {
230     // 1. create subdirectory
231     write_path += "Model/";
232     std::filesystem::create_directory(write_path);
233
234     // 2. create filestream
235     write_path += "summary_results.md";
236     std::ofstream ofs;
237     ofs.open(write_path, std::ofstream::out);
238
239     // 3. write summary results (markdown)
240     ofs << "## Model Summary Results\n";
241     ofs << "\n-----\n\n";
242
243     // 3.1. ElectricalLoad
244     ofs << "## Electrical Load\n";
245     ofs << "\n";
246     ofs << "Path: " <<
247         this->electrical_load.path_2_electrical_load_time_series << " \n";
248     ofs << "Data Points: " << this->electrical_load.n_points << " \n";
249     ofs << "Years: " << this->electrical_load.n_years << " \n";
250     ofs << "Min: " << this->electrical_load.min_load_kW << " kW \n";
251     ofs << "Mean: " << this->electrical_load.mean_load_kW << " kW \n";
252     ofs << "Max: " << this->electrical_load.max_load_kW << " kW \n";
253     ofs << "\n-----\n\n";
254
255     // 3.2. Controller
256     ofs << "## Controller\n";
257     ofs << "\n";
258     ofs << "Control Mode: " << this->controller.control_string << " \n";
259     ofs << "\n-----\n\n";

```

```

260
261 // 3.3. Resources (1D)
262 ofs << "## 1D Renewable Resources\n";
263 ofs << "\n";
264
265 std::map<int, std::string>::iterator string_map_1D_iter =
266 this->resources.string_map_1D.begin();
267 std::map<int, std::string>::iterator path_map_1D_iter =
268 this->resources.path_map_1D.begin();
269
270 while (
271     string_map_1D_iter != this->resources.string_map_1D.end() and
272     path_map_1D_iter != this->resources.path_map_1D.end()
273 ) {
274     ofs << "Resource Key: " << string_map_1D_iter->first << " \n";
275     ofs << "Type: " << string_map_1D_iter->second << " \n";
276     ofs << "Path: " << path_map_1D_iter->second << " \n";
277     ofs << "\n";
278
279     string_map_1D_iter++;
280     path_map_1D_iter++;
281 }
282
283 ofs << "\n-----\n\n";
284
285 // 3.4. Resources (2D)
286 ofs << "## 2D Renewable Resources\n";
287 ofs << "\n";
288
289 std::map<int, std::string>::iterator string_map_2D_iter =
290 this->resources.string_map_2D.begin();
291 std::map<int, std::string>::iterator path_map_2D_iter =
292 this->resources.path_map_2D.begin();
293
294 while (
295     string_map_2D_iter != this->resources.string_map_2D.end() and
296     path_map_2D_iter != this->resources.path_map_2D.end()
297 ) {
298     ofs << "Resource Key: " << string_map_2D_iter->first << " \n";
299     ofs << "Type: " << string_map_2D_iter->second << " \n";
300     ofs << "Path: " << path_map_2D_iter->second << " \n";
301     ofs << "\n";
302
303     string_map_2D_iter++;
304     path_map_2D_iter++;
305 }
306
307 ofs << "\n-----\n\n";
308
309 // 3.5. Combustion
310 ofs << "## Combustion Assets\n";
311 ofs << "\n";
312
313 for (size_t i = 0; i < this->combustion_ptr_vec.size(); i++) {
314     ofs << "Asset Index: " << i << " \n";
315     ofs << "Type: " << this->combustion_ptr_vec[i]->type_str << " \n";
316     ofs << "Capacity: " << this->combustion_ptr_vec[i]->capacity_kW << " kW \n";
317     ofs << "\n";
318 }
319
320 ofs << "\n-----\n\n";
321
322 // 3.6. Renewable
323 ofs << "## Renewable Assets\n";
324 ofs << "\n";
325
326 for (size_t i = 0; i < this->renewable_ptr_vec.size(); i++) {
327     ofs << "Asset Index: " << i << " \n";
328     ofs << "Type: " << this->renewable_ptr_vec[i]->type_str << " \n";
329     ofs << "Capacity: " << this->renewable_ptr_vec[i]->capacity_kW << " kW \n";
330     ofs << "\n";
331 }
332
333 ofs << "\n-----\n\n";
334
335 // 3.7. Storage
336 ofs << "## Storage Assets\n";
337 ofs << "\n";
338
339 for (size_t i = 0; i < this->storage_ptr_vec.size(); i++) {
340     //...
341 }
342
343 ofs << "\n-----\n\n";
344
345 // 3.8. Model Results
346 ofs << "## Results\n";

```

```

347     ofs << "\n";
348
349     ofs << "Net Present Cost: " << this->net_present_cost << " \n";
350     ofs << "\n";
351
352     ofs << "Total Dispatch + Discharge: " << this->total_dispatch_discharge_kWh
353         << " kWh \n";
354
355     ofs << "Levellized Cost of Energy: " << this->levellized_cost_of_energy_kWh
356         << " per kWh dispatched/discharged \n";
357     ofs << "\n";
358
359     ofs << "Total Fuel Consumed: " << this->total_fuel_consumed_L << " L "
360         << "(Annual Average: " <<
361             this->total_fuel_consumed_L / this->electrical_load.n_years
362         << " L/yr) \n";
363     ofs << "\n";
364
365     ofs << "Total Carbon Dioxide (CO2) Emissions: " <<
366         this->total_emissions.CO2_kg << " kg "
367         << "(Annual Average: " <<
368             this->total_emissions.CO2_kg / this->electrical_load.n_years
369         << " kg/yr) \n";
370
371     ofs << "Total Carbon Monoxide (CO) Emissions: " <<
372         this->total_emissions.CO_kg << " kg "
373         << "(Annual Average: " <<
374             this->total_emissions.CO_kg / this->electrical_load.n_years
375         << " kg/yr) \n";
376
377     ofs << "Total Nitrogen Oxides (NOx) Emissions: " <<
378         this->total_emissions.NOx_kg << " kg "
379         << "(Annual Average: " <<
380             this->total_emissions.NOx_kg / this->electrical_load.n_years
381         << " kg/yr) \n";
382
383     ofs << "Total Sulfur Oxides (SOx) Emissions: " <<
384         this->total_emissions.SOx_kg << " kg "
385         << "(Annual Average: " <<
386             this->total_emissions.SOx_kg / this->electrical_load.n_years
387         << " kg/yr) \n";
388
389     ofs << "Total Methane (CH4) Emissions: " << this->total_emissions.CH4_kg << " kg "
390         << "(Annual Average: " <<
391             this->total_emissions.CH4_kg / this->electrical_load.n_years
392         << " kg/yr) \n";
393
394     ofs << "Total Particulate Matter (PM) Emissions: " <<
395         this->total_emissions.PM_kg << " kg "
396         << "(Annual Average: " <<
397             this->total_emissions.PM_kg / this->electrical_load.n_years
398         << " kg/yr) \n";
399
400     ofs << "\n-----\n\n";
401
402     ofs.close();
403     return;
404 } /* __writeSummary() */

```

#### 4.11.3.7 \_\_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.

```

424 {
425     // 1. create filestream
426     write_path += "Model/time_series_results.csv";
427     std::ofstream ofs;
428     ofs.open(write_path, std::ofstream::out);
429
430     // 2. write time series results header (comma separated value)
431     ofs << "Time (since start of data) [hrs],";
432     ofs << "Electrical Load [kW],";
433     ofs << "Net Load [kW],";
434     ofs << "Missed Load [kW],";
435
436     for (size_t i = 0; i < this->renewable_ptr_vec.size(); i++) {
437         ofs << this->renewable_ptr_vec[i]->capacity_kW << " kW "
438             << this->renewable_ptr_vec[i]->type_str << " Dispatch [kW],";
439     }
440
441     for (size_t i = 0; i < this->storage_ptr_vec.size(); i++) {
442         //...
443     }
444
445     for (size_t i = 0; i < this->combustion_ptr_vec.size(); i++) {
446         ofs << this->combustion_ptr_vec[i]->capacity_kW << " kW "
447             << this->combustion_ptr_vec[i]->type_str << " Dispatch [kW],";
448     }
449
450     ofs << "\n";
451
452     // 3. write time series results values (comma separated value)
453     for (int i = 0; i < max_lines; i++) {
454         // 3.1. load values
455         ofs << this->electrical_load.time_vec_hrs[i] << ",";
456         ofs << this->electrical_load.load_vec_kW[i] << ",";
457         ofs << this->controller.net_load_vec_kW[i] << ",";
458         ofs << this->controller.missed_load_vec_kW[i] << ",";
459
460         // 3.2. asset-wise dispatch/discharge
461         for (size_t j = 0; j < this->renewable_ptr_vec.size(); j++) {
462             ofs << this->renewable_ptr_vec[j]->dispatch_vec_kW[i] << ",";
463         }
464
465         for (size_t j = 0; j < this->storage_ptr_vec.size(); j++) {
466             //...
467         }
468
469         for (size_t j = 0; j < this->combustion_ptr_vec.size(); j++) {
470             ofs << this->combustion_ptr_vec[j]->dispatch_vec_kW[i] << ",";
471         }
472
473         ofs << "\n";
474     }
475
476     ofs.close();
477     return;
478 } /* __writeTimeSeries() */

```

#### 4.11.3.8 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.
----------------------	-----------------------------------------------------------

```

550 {
551     Combustion* diesel_ptr = new Diesel(
552         this->electrical_load.n_points,
553         this->electrical_load.n_years,
554         diesel_inputs
555     );
556
557     this->combustion_ptr_vec.push_back(diesel_ptr);

```

```

558
559     return;
560 } /* addDiesel() */

```

#### 4.11.3.9 addLiIon()

```

void Model::addLiIon (
    LiIonInputs liion_inputs )

```

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

##### Parameters

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

```

723 {
724     Storage* liion_ptr = new LiIon(
725         this->electrical_load.n_points,
726         this->electrical_load.n_years,
727         liion_inputs
728     );
729
730     this->storage_ptr_vec.push_back(liion_ptr);
731
732     return;
733 } /* addLiIon() */

```

#### 4.11.3.10 addResource()

```

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

```

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

##### Parameters

<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.

```

589 {
590     resources.addResource(
591         renewable_type,
592         path_2_resource_data,
593         resource_key,
594         &(this->electrical_load)
595     );
596
597     return;
598 } /* addResource() */

```

#### 4.11.3.11 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.
---------------------	----------------------------------------------------------

```
615 {
616     Renewable* solar_ptr = new Solar(
617         this->electrical_load.n_points,
618         this->electrical_load.n_years,
619         solar_inputs
620     );
621
622     this->renewable_ptr_vec.push_back(solar_ptr);
623
624     return;
625 } /* addSolar() */
```

#### 4.11.3.12 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.
---------------------	----------------------------------------------------------

```
642 {
643     Renewable* tidal_ptr = new Tidal(
644         this->electrical_load.n_points,
645         this->electrical_load.n_years,
646         tidal_inputs
647     );
648
649     this->renewable_ptr_vec.push_back(tidal_ptr);
650
651     return;
652 } /* addTidal() */
```

#### 4.11.3.13 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.
--------------------	---------------------------------------------------------

```

669 {
670     Renewable* wave_ptr = new Wave(
671         this->electrical_load.n_points,
672         this->electrical_load.n_years,
673         wave_inputs
674     );
675
676     this->renewable_ptr_vec.push_back(wave_ptr);
677
678     return;
679 } /* addWave() */

```

#### 4.11.3.14 addWind()

```

void Model::addWind (
    WindInputs wind_inputs )

```

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

##### Parameters

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

```

696 {
697     Renewable* wind_ptr = new Wind(
698         this->electrical_load.n_points,
699         this->electrical_load.n_years,
700         wind_inputs
701     );
702
703     this->renewable_ptr_vec.push_back(wind_ptr);
704
705     return;
706 } /* addWind() */

```

#### 4.11.3.15 clear()

```

void Model::clear (
    void )

```

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

```

839 {
840     // 1. reset
841     this->reset();
842
843     // 2. clear components
844     controller.clear();
845     electrical_load.clear();
846     resources.clear();
847
848     return;
849 } /* clear() */

```

#### 4.11.3.16 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.

```

790 {
791     // 1. clear combustion_ptr_vec
792     for (size_t i = 0; i < this->combustion_ptr_vec.size(); i++) {
793         delete this->combustion_ptr_vec[i];
794     }
795     this->combustion_ptr_vec.clear();
796
797     // 2. clear renewable_ptr_vec
798     for (size_t i = 0; i < this->renewable_ptr_vec.size(); i++) {
799         delete this->renewable_ptr_vec[i];
800     }
801     this->renewable_ptr_vec.clear();
802
803     // 3. clear storage_ptr_vec
804     for (size_t i = 0; i < this->storage_ptr_vec.size(); i++) {
805         delete this->storage_ptr_vec[i];
806     }
807     this->storage_ptr_vec.clear();
808
809     // 4. reset attributes
810     this->total_fuel_consumed_L = 0;
811
812     this->total_emissions.CO2_kg = 0;
813     this->total_emissions.CO_kg = 0;
814     this->total_emissions.NOx_kg = 0;
815     this->total_emissions.SOx_kg = 0;
816     this->total_emissions.CH4_kg = 0;
817     this->total_emissions.PM_kg = 0;
818
819     this->net_present_cost = 0;
820     this->total_dispatch_discharge_kWh = 0;
821     this->levellized_cost_of_energy_kWh = 0;
822
823     return;
824 } /* reset() */

```

#### 4.11.3.17 run()

```

void Model::run (
    void )

```

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

```

748 {
749     // 1. init Controller
750     this->controller.init(
751         &(this->electrical_load),
752         &(this->renewable_ptr_vec),
753         &(this->resources),
754         &(this->combustion_ptr_vec)
755     );
756
757     // 2. apply dispatch control
758     this->controller.applyDispatchControl(
759         &(this->electrical_load),
760         &(this->combustion_ptr_vec),
761         &(this->renewable_ptr_vec),
762         &(this->storage_ptr_vec)
763     );
764
765     // 3. compute total fuel consumption and emissions
766     this->__computeFuelAndEmissions();
767
768     // 4. compute key economic metrics
769     this->__computeEconomics();
770
771     return;
772 } /* run() */

```

#### 4.11.3.18 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.

```
877 {
878     // 1. handle sentinel
879     if (max_lines < 0) {
880         max_lines = this->electrical_load.n_points;
881     }
882
883     // 2. check for pre-existing, warn (and remove), then create
884     if (write_path.back() != '/') {
885         write_path += '/';
886     }
887
888     if (std::filesystem::is_directory(write_path)) {
889         std::string warning_str = "WARNING: Model::writeResults(): ";
890         warning_str += write_path;
891         warning_str += " already exists, contents will be overwritten!";
892
893         std::cout << warning_str << std::endl;
894
895         std::filesystem::remove_all(write_path);
896     }
897
898     std::filesystem::create_directory(write_path);
899
900     // 3. write summary
901     this->__writeSummary(write_path);
902
903     // 4. write time series
904     if (max_lines > this->electrical_load.n_points) {
905         max_lines = this->electrical_load.n_points;
906     }
907
908     if (max_lines > 0) {
909         this->__writeTimeSeries(write_path, max_lines);
910     }
911
912     // 5. call out to Combustion :: writeResults()
913     for (size_t i = 0; i < this->combustion_ptr_vec.size(); i++) {
914         this->combustion_ptr_vec[i]->writeResults(
915             write_path,
916             &(this->electrical_load.time_vec_hrs),
917             i,
918             max_lines
919         );
920     }
921
922     // 6. call out to Renewable :: writeResults()
923     for (size_t i = 0; i < this->renewable_ptr_vec.size(); i++) {
924         this->renewable_ptr_vec[i]->writeResults(
925             write_path,
926             &(this->electrical_load.time_vec_hrs),
927             &(this->resources.resource_map_1D),
928             &(this->resources.resource_map_2D),
929             i,
930             max_lines
931         );
932     }
933
934     // 7. call out to Storage :: writeResults()
935     for (size_t i = 0; i < this->storage_ptr_vec.size(); i++) {
936         this->storage_ptr_vec[i]->writeResults(
937             write_path,
938             &(this->electrical_load.time_vec_hrs),
939             i,
940             max_lines
```

```
941         );  
942     }  
943  
944     return;  
945 } /* writeResults() */
```

## 4.11.4 Member Data Documentation

### 4.11.4.1 combustion\_ptr\_vec

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

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

### 4.11.4.2 controller

`Controller Model::controller`

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

### 4.11.4.3 electrical\_load

`ElectricalLoad Model::electrical_load`

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

### 4.11.4.4 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).

### 4.11.4.5 net\_present\_cost

`double Model::net_present_cost`

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

#### 4.11.4.6 renewable\_ptr\_vec

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

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

#### 4.11.4.7 resources

```
Resources Model::resources
```

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

#### 4.11.4.8 storage\_ptr\_vec

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

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

#### 4.11.4.9 total\_dispatch\_discharge\_kWh

```
double Model::total_dispatch_discharge_kWh
```

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

#### 4.11.4.10 total\_emissions

```
Emissions Model::total_emissions
```

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

#### 4.11.4.11 total\_fuel\_consumed\_L

```
double Model::total_fuel_consumed_L
```

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

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

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

## 4.12 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.*

### 4.12.1 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).

### 4.12.2 Member Data Documentation

#### 4.12.2.1 control\_mode

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

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

#### 4.12.2.2 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:

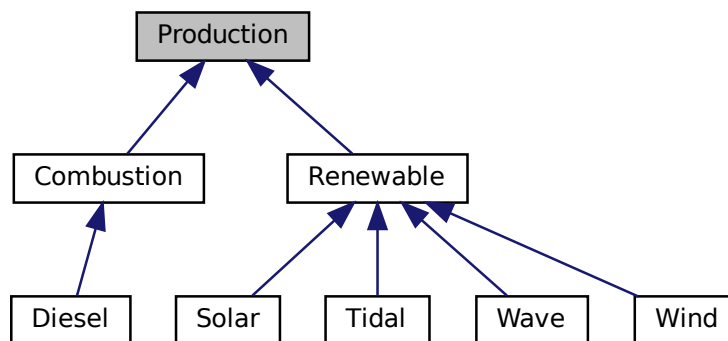
- header/[Model.h](#)

## 4.13 Production Class Reference

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

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

Inheritance diagram for Production:



### Public Member Functions

- [Production](#) (void)  
*Constructor (dummy) for the [Production](#) class.*
- [Production](#) (int, double, [ProductionInputs](#))  
*Constructor (intended) for the [Production](#) class.*
- virtual void [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

- 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.

### 4.13.1 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.

### 4.13.2 Constructor & Destructor Documentation

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

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

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

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

#### 4.13.2.2 [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() */

```

## 4.13.2.3 ~Production()

```

Production::~Production (
    void ) [virtual]

```

Destructor for the [Production](#) class.

```

411 {
412     // 1. destruction print
413     if (this->print_flag) {
414         std::cout << "Production object at " << this << " destroyed" << std::endl;
415     }
416
417     return;
418 } /* ~Production() */

```

### 4.13.3 Member Function Documentation

#### 4.13.3.1 `__checkInputs()`

```
void Production::__checkInputs (
    int n_points,
    double n_years,
    ProductionInputs production_inputs ) [private]
```

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

##### Parameters

<code>n_points</code>	The number of points in the modelling time series.
<code>production_inputs</code>	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() */
```

## 4.13.3.2 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](#), [Diesel](#), and [Combustion](#).

```
352 {
353     // 1. record production
354     this->production_vec_kW[timestep] = production_kW;
355
356     // 2. compute and record dispatch and curtailment
357     double dispatch_kW = 0;
358     double curtailment_kW = 0;
359
360     if (production_kW > load_kW) {
361         dispatch_kW = load_kW;
362         curtailment_kW = production_kW - dispatch_kW;
363     }
364
365     else {
366         dispatch_kW = production_kW;
367     }
368
369     this->dispatch_vec_kW[timestep] = dispatch_kW;
370     this->total_dispatch_kWh += dispatch_kW * dt_hrs;
371     this->curtailment_vec_kW[timestep] = curtailment_kW;
372
373     // 3. update load
374     load_kW -= dispatch_kW;
375
376     // 4. update and log running attributes
377     if (this->is_running) {
378         // 4.1. log running state, running hours
379         this->is_running_vec[timestep] = this->is_running;
380         this->running_hours += dt_hrs;
381
382         // 4.2. incur operation and maintenance costs
383         double produced_kWh = production_kW * dt_hrs;
384
385         double operation_maintenance_cost =
386             this->operation_maintenance_cost_kWh * produced_kWh;
387         this->operation_maintenance_cost_vec[timestep] = operation_maintenance_cost;
388     }
389
390     // 5. trigger replacement, if applicable
391     if (this->running_hours >= (this->n_replacements + 1) * this->replace_running_hrs) {
392         this->handleReplacement(timestep);
393     }
394
395     return load_kW;
396 } /* commit() */
```

#### 4.13.3.3 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 levellized cost of energy (per unit dispatched)

Reimplemented in [Renewable](#), 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     double n_years = time_vec_hrs_ptr->at(this->n_points - 1) / 8760;
302
303     double capital_recovery_factor =
304         (this->real_discount_annual * pow(1 + this->real_discount_annual, n_years)) /
305         (pow(1 + this->real_discount_annual, n_years) - 1);
306
307     double total_annualized_cost = capital_recovery_factor *
308         this->net_present_cost;
309
310     this->levellized_cost_of_energy_kWh =
311         (n_years * total_annualized_cost) /
312         this->total_dispatch_kWh;
313
314     return;
315 } /* computeEconomics() */
```

#### 4.13.3.4 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() */

```

**4.13.3.5 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](#), [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() */

```

**4.13.4 Member Data Documentation****4.13.4.1 capacity\_kW**

```
double Production::capacity_kW
```

The rated production capacity [kW] of the asset.

#### 4.13.4.2 capital\_cost

```
double Production::capital_cost
```

The capital cost of the asset (undefined currency).

#### 4.13.4.3 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).

#### 4.13.4.4 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.

#### 4.13.4.5 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.

#### 4.13.4.6 is\_running

```
bool Production::is_running
```

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

#### 4.13.4.7 is\_running\_vec

```
std::vector<bool> Production::is_running_vec
```

A boolean vector for tracking if the asset is running at a particular point in time.

#### 4.13.4.8 is\_sunk

```
bool Production::is_sunk
```

A boolean which indicates whether or not the asset should be considered a sunk cost (i.e., capital cost incurred at the start of the model, or no).

#### 4.13.4.9 levellized\_cost\_of\_energy\_kWh

```
double Production::levellized_cost_of_energy_kWh
```

The levellized cost of energy [1/kWh] (undefined currency) of this asset. This metric considers only dispatch.

#### 4.13.4.10 n\_points

```
int Production::n_points
```

The number of points in the modelling time series.

#### 4.13.4.11 n\_replacements

```
int Production::n_replacements
```

The number of times the asset has been replaced.

#### 4.13.4.12 n\_starts

```
int Production::n_starts
```

The number of times the asset has been started.

#### 4.13.4.13 n\_years

```
double Production::n_years
```

The number of years being modelled.



**4.13.4.14 net\_present\_cost**

```
double Production::net_present_cost
```

The net present cost of this asset.

**4.13.4.15 nominal\_discount\_annual**

```
double Production::nominal_discount_annual
```

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

**4.13.4.16 nominal\_inflation\_annual**

```
double Production::nominal_inflation_annual
```

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

**4.13.4.17 operation\_maintenance\_cost\_kWh**

```
double Production::operation_maintenance_cost_kWh
```

The operation and maintenance cost of the asset [1/kWh] (undefined currency). This is a cost incurred per unit of energy produced.

**4.13.4.18 operation\_maintenance\_cost\_vec**

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

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

**4.13.4.19 print\_flag**

```
bool Production::print_flag
```

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

#### 4.13.4.20 production\_vec\_kW

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

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

#### 4.13.4.21 real\_discount\_annual

```
double Production::real_discount_annual
```

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

#### 4.13.4.22 replace\_running\_hrs

```
double Production::replace_running_hrs
```

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

#### 4.13.4.23 running\_hours

```
double Production::running_hours
```

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

#### 4.13.4.24 storage\_vec\_kW

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

A vector of storage [kW] at each point in the modelling time series. [Storage](#) is the amount of production that is sent to storage.

#### 4.13.4.25 total\_dispatch\_kWh

```
double Production::total_dispatch_kWh
```

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

#### 4.13.4.26 type\_str

```
std::string Production::type_str
```

A string describing the type of the asset.

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

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

## 4.14 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.*

### 4.14.1 Detailed Description

A structure which bundles the necessary inputs for the [Production](#) constructor. Provides default values for every necessary input.

### 4.14.2 Member Data Documentation

#### 4.14.2.1 capacity\_kW

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

The rated production capacity [kW] of the asset.

#### 4.14.2.2 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).

#### 4.14.2.3 nominal\_discount\_annual

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

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

#### 4.14.2.4 nominal\_inflation\_annual

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

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

#### 4.14.2.5 print\_flag

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

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

#### 4.14.2.6 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:

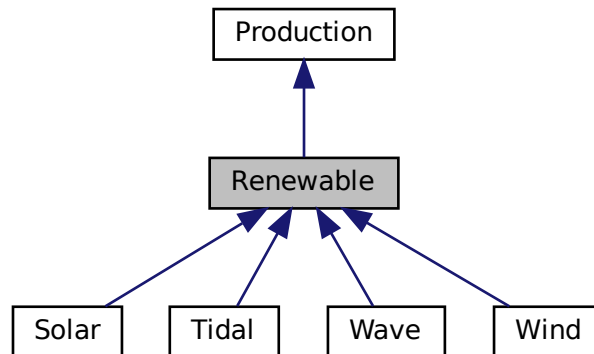
- header/Production/[Production.h](#)

## 4.15 Renewable Class Reference

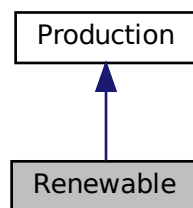
The root of the [Renewable](#) branch of the [Production](#) hierarchy. This branch contains derived classes which model the renewable production of energy.

```
#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)

### 4.15.1 Detailed Description

The root of the [Renewable](#) branch of the [Production](#) hierarchy. This branch contains derived classes which model the renewable production of energy.

### 4.15.2 Constructor & Destructor Documentation

#### 4.15.2.1 [Renewable\(\)](#) [1/2]

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

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

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

## 4.15.2.2 Renewable() [2/2]

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

Constructor (intended) for the [Renewable](#) 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>renewable_inputs</i>	A structure of <a href="#">Renewable</a> constructor inputs.

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

## 4.15.2.3 ~Renewable()

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

Destructor for the [Renewable](#) class.

```
346 {
347     // 1. destruction print
348     if (this->print_flag) {
349         std::cout << "Renewable object at " << this << " destroyed" << std::endl;
350     }
351
352     return;
353 } /* ~Renewable() */
```

## 4.15.3 Member Function Documentation

#### 4.15.3.1 \_\_checkInputs()

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

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

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

#### 4.15.3.2 \_\_handleStartStop()

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

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

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

#### 4.15.3.3 \_\_writeSummary()

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

Reimplemented in [Wind](#), [Wave](#), [Tidal](#), and [Solar](#).

```
72 {return;}
```

#### 4.15.3.4 \_\_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;}
```



#### 4.15.3.5 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](#).

```
227 {
228     // 1. handle start/stop
229     this->__handleStartStop(timestep, dt_hrs, production_kW);
230
231     // 2. invoke base class method
232     load_kW = Production::commit(
233         timestep,
234         dt_hrs,
235         production_kW,
236         load_kW
237     );
238
239
240     //...
241
242     return load_kW;
243 } /* commit() */
```

#### 4.15.3.6 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](#).

```

186 {
187     // 1. invoke base class method
188     Production :: computeEconomics(time_vec_hrs_ptr);
189
190     return;
191 } /* computeEconomics() */

```

#### 4.15.3.7 computeProductionkW() [1/2]

```

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

```

Reimplemented in [Wind](#), [Tidal](#), and [Solar](#).

```

96 {return 0;}

```

#### 4.15.3.8 computeProductionkW() [2/2]

```

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

```

Reimplemented in [Wave](#).

```

97 {return 0;}

```

#### 4.15.3.9 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](#).

```

161 {
162     // 1. reset attributes
163     //...
164
165     // 2. invoke base class method
166     Production :: handleReplacement(timestep);
167
168     return;

```

```
169 } /* __handleReplacement() */
```

#### 4.15.3.10 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.

```
287 {
288     // 1. handle sentinel
289     if (max_lines < 0) {
290         max_lines = this->n_points;
291     }
292
293     // 2. create subdirectories
294     write_path += "Production/";
295     if (not std::filesystem::is_directory(write_path)) {
296         std::filesystem::create_directory(write_path);
297     }
298
299     write_path += "Renewable/";
300     if (not std::filesystem::is_directory(write_path)) {
301         std::filesystem::create_directory(write_path);
302     }
303
304     write_path += this->type_str;
305     write_path += "_";
306     write_path += std::to_string(int(ceil(this->capacity_kW)));
307     write_path += "kW_idx";
308     write_path += std::to_string(renewable_index);
309     write_path += "/";
310     std::filesystem::create_directory(write_path);
311
312     // 3. write summary
313     this->__writeSummary(write_path);
314
315     // 4. write time series
316     if (max_lines > this->n_points) {
317         max_lines = this->n_points;
318     }
319
320     if (max_lines > 0) {
321         this->__writeTimeSeries(
322             write_path,
323             time_vec_hrs_ptr,
324             resource_map_1D_ptr,
325             resource_map_2D_ptr,
326             max_lines
327         );
328     }
```

```
329
330     return;
331 } /* writeResults() */
```

## 4.15.4 Member Data Documentation

### 4.15.4.1 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.

### 4.15.4.2 type

```
RenewableType Renewable::type
```

The type (RenewableType) of the asset.

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

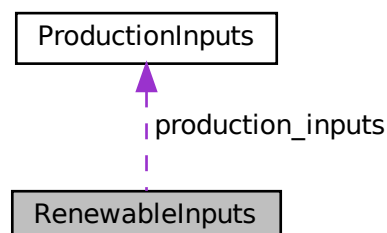
- header/Production/Renewable/[Renewable.h](#)
- source/Production/Renewable/[Renewable.cpp](#)

## 4.16 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.

### 4.16.1 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](#).

### 4.16.2 Member Data Documentation

#### 4.16.2.1 `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`

## 4.17 Resources Class Reference

A class which contains renewable resource data. Intended to serve as a component class of [Model](#).

```
#include <Resources.h>
```

## Public Member Functions

- [Resources](#) (void)  
Constructor for the [Resources](#) class.
- void [addResource](#) ([RenewableType](#), std::string, int, [ElectricalLoad](#) \*)  
A method to add a renewable resource time series to [Resources](#). Checks if given resource key is already in use. The associated helper methods also check against [ElectricalLoad](#) to ensure that all added time series align with the electrical load time series (both in terms of length and which points in time are included).
- void [clear](#) (void)  
Method to clear all attributes of the [Resources](#) object.
- [~Resources](#) (void)  
Destructor for the [Resources](#) class.

## Public Attributes

- `std::map< int, std::vector< double > >` [resource\\_map\\_1D](#)  
A map  $\langle \text{int}, \text{vector} \rangle$  of given 1D renewable resource time series.
- `std::map< int, std::string >` [string\\_map\\_1D](#)  
A map  $\langle \text{int}, \text{string} \rangle$  of descriptors for the type of the given 1D renewable resource time series.
- `std::map< int, std::string >` [path\\_map\\_1D](#)  
A map  $\langle \text{int}, \text{string} \rangle$  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  $\langle \text{int}, \text{vector} \rangle$  of given 2D renewable resource time series.
- `std::map< int, std::string >` [string\\_map\\_2D](#)  
A map  $\langle \text{int}, \text{string} \rangle$  of descriptors for the type of the given 2D renewable resource time series.
- `std::map< int, std::string >` [path\\_map\\_2D](#)  
A map  $\langle \text{int}, \text{string} \rangle$  of the paths (either relative or absolute) to given 2D renewable resource time series.

## Private Member Functions

- `void __checkResourceKey1D (int, RenewableType)`  
Helper method to check if given resource key (1D) is already in use.
- `void __checkResourceKey2D (int, RenewableType)`  
Helper method to check if given resource key (2D) is already in use.
- `void __checkTimePoint (double, double, std::string, ElectricalLoad *)`  
Helper method to check received time point against expected time point.
- `void __throwLengthError (std::string, ElectricalLoad *)`  
Helper method to throw data length error.
- `void __readSolarResource (std::string, int, ElectricalLoad *)`  
Helper method to handle reading a solar resource time series into [Resources](#).
- `void __readTidalResource (std::string, int, ElectricalLoad *)`  
Helper method to handle reading a tidal resource time series into [Resources](#).
- `void __readWaveResource (std::string, int, ElectricalLoad *)`  
Helper method to handle reading a wave resource time series into [Resources](#).
- `void __readWindResource (std::string, int, ElectricalLoad *)`  
Helper method to handle reading a wind resource time series into [Resources](#).

### 4.17.1 Detailed Description

A class which contains renewable resource data. Intended to serve as a component class of [Model](#).

### 4.17.2 Constructor & Destructor Documentation

#### 4.17.2.1 Resources()

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

Constructor for the [Resources](#) class.

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

## 4.17.2.2 ~Resources()

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

Destructor for the [Resources](#) class.

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

## 4.17.3 Member Function Documentation

## 4.17.3.1 \_\_checkResourceKey1D()

```
void Resources::__checkResourceKey1D (
    int resource_key,
    RenewableType renewable_type ) [private]
```

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

## Parameters

<i>resource_key</i>	The key associated with the given renewable resource.
---------------------	-------------------------------------------------------

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

```
87 } /* __checkResourceKey1D() */
```

#### 4.17.3.2 \_\_checkResourceKey2D()

```
void Resources::__checkResourceKey2D (
    int resource_key,
    RenewableType renewable_type ) [private]
```

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

##### Parameters

<i>resource_key</i>	The key associated with the given renewable resource.
---------------------	-------------------------------------------------------

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

#### 4.17.3.3 \_\_checkTimePoint()

```
void Resources::__checkTimePoint (
    double time_received_hrs,
    double time_expected_hrs,
    std::string path_2_resource_data,
    ElectricalLoad * electrical_load_ptr ) [private]
```

Helper method to check received time point against expected time point.

##### Parameters

<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.



```

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

```

#### 4.17.3.4 \_\_readSolarResource()

```

void Resources::__readSolarResource (
    std::string path_2_resource_data,
    int resource_key,
    ElectricalLoad * electrical_load_ptr ) [private]

```

Helper method to handle reading a solar resource time series into [Resources](#).

##### Parameters

<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.

```

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

```

```

295         path_2_resource_data,
296         electrical_load_ptr
297     );
298
299     this->resource_map_1D[resource_key][n_points] = solar_resource_kWm2;
300
301     n_points++;
302 }
303
304 // 4. check data length
305 if (n_points != electrical_load_ptr->n_points) {
306     this->__throwLengthError(path_2_resource_data, electrical_load_ptr);
307 }
308
309 return;
310 } /* __readSolarResource() */

```

#### 4.17.3.5 \_\_readTidalResource()

```

void Resources::__readTidalResource (
    std::string path_2_resource_data,
    int resource_key,
    ElectricalLoad * electrical_load_ptr ) [private]

```

Helper method to handle reading a tidal resource time series into [Resources](#).

##### Parameters

<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</a> <a href="#">ElectricalLoad</a> object.

```

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

```

```

379         );
380
381         this->resource_map_1D[resource_key][n_points] = tidal_resource_ms;
382
383         n_points++;
384     }
385
386     // 4. check data length
387     if (n_points != electrical_load_ptr->n_points) {
388         this->__throwLengthError(path_2_resource_data, electrical_load_ptr);
389     }
390
391     return;
392 } /* __readTidalResource() */

```

#### 4.17.3.6 \_\_readWaveResource()

```

void Resources::__readWaveResource (
    std::string path_2_resource_data,
    int resource_key,
    ElectricalLoad * electrical_load_ptr ) [private]

```

Helper method to handle reading a wave resource time series into [Resources](#).

##### Parameters

<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</a> <a href="#">ElectricalLoad</a> object.

```

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

```

```

463         );
464
465         this->resource_map_2D[resource_key][n_points][0] = significant_wave_height_m;
466         this->resource_map_2D[resource_key][n_points][1] = energy_period_s;
467
468         n_points++;
469     }
470
471     // 4. check data length
472     if (n_points != electrical_load_ptr->n_points) {
473         this->__throwLengthError(path_2_resource_data, electrical_load_ptr);
474     }
475
476     return;
477 } /* __readWaveResource() */

```

#### 4.17.3.7 \_\_readWindResource()

```

void Resources::__readWindResource (
    std::string path_2_resource_data,
    int resource_key,
    ElectricalLoad * electrical_load_ptr ) [private]

```

Helper method to handle reading a wind resource time series into [Resources](#).

##### Parameters

<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</a> <a href="#">ElectricalLoad</a> object.

```

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

```

```

547
548     this->resource_map_1D[resource_key][n_points] = wind_resource_ms;
549
550     n_points++;
551 }
552
553 // 4. check data length
554 if (n_points != electrical_load_ptr->n_points) {
555     this->__throwLengthError(path_2_resource_data, electrical_load_ptr);
556 }
557
558 return;
559 } /* __readWindResource() */

```

#### 4.17.3.8 \_\_throwLengthError()

```

void Resources::__throwLengthError (
    std::string path_2_resource_data,
    ElectricalLoad * electrical_load_ptr ) [private]

```

Helper method to throw data length error.

##### Parameters

<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.

```

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

```

#### 4.17.3.9 addResource()

```

void Resources::addResource (
    RenewableType renewable_type,
    std::string path_2_resource_data,
    int resource_key,
    ElectricalLoad * electrical_load_ptr )

```

A method to add a renewable resource time series to [Resources](#). Checks if given resource key is already in use. The associated helper methods also check against [ElectricalLoad](#) to ensure that all added time series align with the electrical load time series (both in terms of length and which points in time are included).

##### Parameters

<i>renewable_type</i>	The type of renewable resource being added to <a href="#">Resources</a> .
-----------------------	---------------------------------------------------------------------------

## Parameters

<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.

```

616 {
617     switch (renewable_type) {
618         case (RenewableType :: SOLAR): {
619             this->__checkResourceKey1D(resource_key, renewable_type);
620
621             this->__readSolarResource(
622                 path_2_resource_data,
623                 resource_key,
624                 electrical_load_ptr
625             );
626
627             break;
628         }
629
630         case (RenewableType :: TIDAL): {
631             this->__checkResourceKey1D(resource_key, renewable_type);
632
633             this->__readTidalResource(
634                 path_2_resource_data,
635                 resource_key,
636                 electrical_load_ptr
637             );
638
639             break;
640         }
641
642         case (RenewableType :: WAVE): {
643             this->__checkResourceKey2D(resource_key, renewable_type);
644
645             this->__readWaveResource(
646                 path_2_resource_data,
647                 resource_key,
648                 electrical_load_ptr
649             );
650
651             break;
652         }
653
654         case (RenewableType :: WIND): {
655             this->__checkResourceKey1D(resource_key, renewable_type);
656
657             this->__readWindResource(
658                 path_2_resource_data,
659                 resource_key,
660                 electrical_load_ptr
661             );
662
663             break;
664         }
665
666         default: {
667             std::string error_str = "ERROR: Resources :: addResource(: ";
668             error_str += "renewable type ";
669             error_str += std::to_string(renewable_type);
670             error_str += " not recognized";
671
672             #ifndef _WIN32
673                 std::cout << error_str << std::endl;
674             #endif
675
676             throw std::runtime_error(error_str);
677
678             break;
679         }
680     }
681
682     return;
683 } /* addResource() */

```

#### 4.17.3.10 clear()

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

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

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

### 4.17.4 Member Data Documentation

#### 4.17.4.1 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.

#### 4.17.4.2 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.

#### 4.17.4.3 resource\_map\_1D

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

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

#### 4.17.4.4 resource\_map\_2D

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

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

#### 4.17.4.5 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.

#### 4.17.4.6 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:

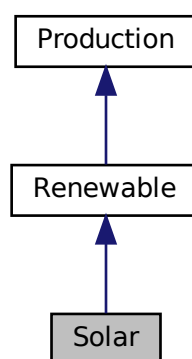
- header/[Resources.h](#)
- source/[Resources.cpp](#)

## 4.18 Solar Class Reference

A derived class of the [Renewable](#) branch of [Production](#) which models solar production.

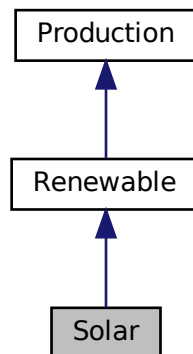
```
#include <Solar.h>
```

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](#).

### 4.18.1 Detailed Description

A derived class of the [Renewable](#) branch of [Production](#) which models solar production.

### 4.18.2 Constructor & Destructor Documentation

#### 4.18.2.1 `Solar()` [1/2]

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

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

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

#### 4.18.2.2 `Solar()` [2/2]

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

Constructor (intended) for the [Solar](#) 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>solar_inputs</code>	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() */

```

#### 4.18.2.3 ~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() */

```

### 4.18.3 Member Function Documentation

#### 4.18.3.1 \_\_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() */

```

#### 4.18.3.2 `__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() */
```

#### 4.18.3.3 `__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() */
```

#### 4.18.3.4 `__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 (ID): " << 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() */

```

#### 4.18.3.5 \_\_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 <i>time_vec_hrs</i> 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() */
```

#### 4.18.3.6 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
472     return load_kW;
473 } /* commit() */
```

**4.18.3.7 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() */
```

#### 4.18.3.8 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() */
```

### 4.18.4 Member Data Documentation

#### 4.18.4.1 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](#)

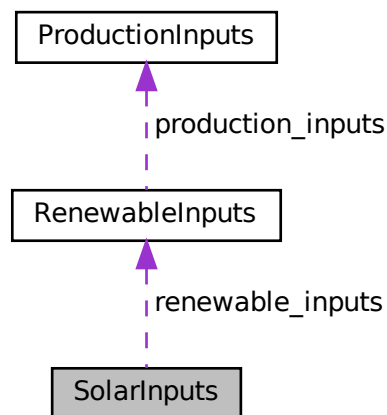
## 4.19 SolarInputs Struct Reference

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.).

### 4.19.1 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](#).

### 4.19.2 Member Data Documentation

#### 4.19.2.1 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].

#### 4.19.2.2 derating

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

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

#### 4.19.2.3 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].

#### 4.19.2.4 renewable\_inputs

```
RenewableInputs SolarInputs::renewable_inputs
```

An encapsulated [RenewableInputs](#) instance.

#### 4.19.2.5 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:

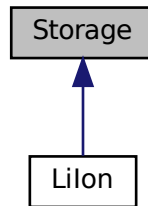
- [header/Production/Renewable/Solar.h](#)

## 4.20 Storage Class Reference

The base class of the [Storage](#) hierarchy. This hierarchy contains derived classes which model the storage of energy.

```
#include <Storage.h>
```

Inheritance diagram for Storage:



### Public Member Functions

- [Storage](#) (void)  
*Constructor (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.*
- 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)

### 4.20.1 Detailed Description

The base class of the [Storage](#) hierarchy. This hierarchy contains derived classes which model the storage of energy.

### 4.20.2 Constructor & Destructor Documentation

#### 4.20.2.1 `Storage()` [1/2]

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

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

```
151 {
152     return;
153 } /* Storage() */
```

#### 4.20.2.2 `Storage()` [2/2]

```
Storage::Storage (
    int n_points,
    double n_years,
    StorageInputs storage_inputs )
```

Constructor (intended) for the [Storage](#) 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>storage_inputs</code>	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() */

```

#### 4.20.2.3 ~Storage()

```

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

```

Destructor for the [Storage](#) class.

```

408 {
409     // 1. destruction print
410     if (this->print_flag) {
411         std::cout << "Storage object at " << this << " destroyed" << std::endl;
412     }
413
414     return;
415 } /* ~Storage() */

```

### 4.20.3 Member Function Documentation

#### 4.20.3.1 \_\_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() */

```

## 4.20.3.2 \_\_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() */
```

### 4.20.3.3 \_\_writeSummary()

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

Reimplemented in [Lilon](#).

```
77 {return;}
```

### 4.20.3.4 \_\_writeTimeSeries()

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

Reimplemented in [Lilon](#).

```
78 {return;}
```

### 4.20.3.5 commitCharge()

```
virtual void Storage::commitCharge (  
    int ,  
    double ,  
    double ) [inline], [virtual]
```

Reimplemented in [Lilon](#).

```
130 {return;}
```

### 4.20.3.6 commitDischarge()

```
virtual double Storage::commitDischarge (  
    int ,  
    double ,  
    double ,  
    double ) [inline], [virtual]
```

Reimplemented in [Lilon](#).

```
131 {return 0;}
```



## 4.20.3.7 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 <i>time_vec_hrs</i> 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     double n_years = time_vec_hrs_ptr->at(this->n_points - 1) / 8760;
303
304     double capital_recovery_factor =
305         (this->real_discount_annual * pow(1 + this->real_discount_annual, n_years)) /
306         (pow(1 + this->real_discount_annual, n_years) - 1);
307
308     double total_annualized_cost = capital_recovery_factor *
309         this->net_present_cost;
310
311     this->levellized_cost_of_energy_kWh =
312         (n_years * total_annualized_cost) /
313         this->total_discharge_kWh;
314
315     return;
316 } /* computeEconomics() */
```

## 4.20.3.8 getAcceptablekW()

```
virtual double Storage::getAcceptablekW (
    double ) [inline], [virtual]
```

Reimplemented in [Lilon](#).

```
128 {return 0;}
```

#### 4.20.3.9 getAvailablekW()

```
virtual double Storage::getAvailablekW (
    double ) [inline], [virtual]
```

Reimplemented in [Lilon](#).

```
127 {return 0;}
```

#### 4.20.3.10 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() */
```

#### 4.20.3.11 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 <i>time_vec_hrs</i> 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.

```

354 {
355     // 1. handle sentinel
356     if (max_lines < 0) {
357         max_lines = this->n_points;
358     }
359
360     // 2. create subdirectories
361     write_path += "Storage/";
362     if (not std::filesystem::is_directory(write_path)) {
363         std::filesystem::create_directory(write_path);
364     }
365
366     write_path += this->type_str;
367     write_path += "_";
368     write_path += std::to_string(int(ceil(this->power_capacity_kW)));
369     write_path += "kW";
370     write_path += std::to_string(int(ceil(this->energy_capacity_kWh)));
371     write_path += "kWh_idx";
372     write_path += std::to_string(storage_index);
373     write_path += "/";
374     std::filesystem::create_directory(write_path);
375
376     // 3. write summary
377     this->__writeSummary(write_path);
378
379     // 4. write time series
380     if (max_lines > this->n_points) {
381         max_lines = this->n_points;
382     }
383
384     if (max_lines > 0) {
385         this->__writeTimeSeries(
386             write_path,
387             time_vec_hrs_ptr,
388             max_lines
389         );
390     }
391
392     return;
393 } /* writeResults() */

```

## 4.20.4 Member Data Documentation

### 4.20.4.1 capital\_cost

double Storage::capital\_cost

The capital cost of the asset (undefined currency).

### 4.20.4.2 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).

#### 4.20.4.3 charge\_kWh

```
double Storage::charge_kWh
```

The energy [kWh] stored in the asset.

#### 4.20.4.4 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.

#### 4.20.4.5 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.

#### 4.20.4.6 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.

#### 4.20.4.7 energy\_capacity\_kWh

```
double Storage::energy_capacity_kWh
```

The rated energy capacity [kWh] of the asset.

#### 4.20.4.8 is\_depleted

```
bool Storage::is_depleted
```

A boolean which indicates whether or not the asset is currently considered depleted.

**4.20.4.9 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).

**4.20.4.10 levellized\_cost\_of\_energy\_kWh**

```
double Storage::levellized_cost_of_energy_kWh
```

The levellized cost of energy [1/kWh] (undefined currency) of this asset. This metric considers only discharge.

**4.20.4.11 n\_points**

```
int Storage::n_points
```

The number of points in the modelling time series.

**4.20.4.12 n\_replacements**

```
int Storage::n_replacements
```

The number of times the asset has been replaced.

**4.20.4.13 n\_years**

```
double Storage::n_years
```

The number of years being modelled.

**4.20.4.14 net\_present\_cost**

```
double Storage::net_present_cost
```

The net present cost of this asset.

#### 4.20.4.15 nominal\_discount\_annual

```
double Storage::nominal_discount_annual
```

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

#### 4.20.4.16 nominal\_inflation\_annual

```
double Storage::nominal_inflation_annual
```

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

#### 4.20.4.17 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.

#### 4.20.4.18 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).

#### 4.20.4.19 power\_capacity\_kW

```
double Storage::power_capacity_kW
```

The rated power capacity [kW] of the asset.

#### 4.20.4.20 power\_kW

```
double Storage::power_kW
```

The power [kW] currently being charged/discharged by the asset.

#### 4.20.4.21 print\_flag

```
bool Storage::print_flag
```

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

#### 4.20.4.22 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.

#### 4.20.4.23 total\_discharge\_kWh

```
double Storage::total_discharge_kWh
```

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

#### 4.20.4.24 type

```
StorageType Storage::type
```

The type (StorageType) of the asset.

#### 4.20.4.25 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](#)

## 4.21 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.*

### 4.21.1 Detailed Description

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

### 4.21.2 Member Data Documentation

#### 4.21.2.1 `energy_capacity_kWh`

```
double StorageInputs::energy_capacity_kWh = 1000
```

The rated energy capacity [kWh] of the asset.

#### 4.21.2.2 `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).

#### 4.21.2.3 `nominal_discount_annual`

```
double StorageInputs::nominal_discount_annual = 0.04
```

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



#### 4.21.2.4 nominal\_inflation\_annual

```
double StorageInputs::nominal_inflation_annual = 0.02
```

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

#### 4.21.2.5 power\_capacity\_kW

```
double StorageInputs::power_capacity_kW = 100
```

The rated power capacity [kW] of the asset.

#### 4.21.2.6 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:

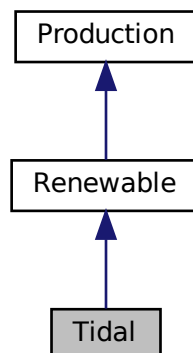
- [header/Storage/Storage.h](#)

## 4.22 Tidal Class Reference

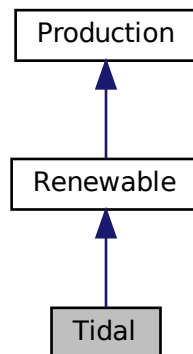
A derived class of the [Renewable](#) branch of [Production](#) which models tidal production.

```
#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](#).*

### 4.22.1 Detailed Description

A derived class of the [Renewable](#) branch of [Production](#) which models tidal production.

### 4.22.2 Constructor & Destructor Documentation

#### 4.22.2.1 `Tidal()` [1/2]

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

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

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

#### 4.22.2.2 `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
481             break;
482         }
483
484         case (TidalPowerProductionModel :: TIDAL_POWER_EXPONENTIAL): {
485             this->power_model_string = "EXPONENTIAL";
486
487             break;
488         }
489
490         case (TidalPowerProductionModel :: TIDAL_POWER_LOOKUP): {
491             this->power_model_string = "LOOKUP";
492
493             break;
494         }
495
496         default: {
497             std::string error_str = "ERROR: Tidal(): ";
498             error_str += "power production model ";
499             error_str += std::to_string(this->power_model);
500             error_str += " not recognized";
501
502             #ifdef _WIN32
503                 std::cout << error_str << std::endl;
504             #endif
505
506             throw std::runtime_error(error_str);
507
508             break;
509         }
510     }
511
512     if (tidal_inputs.capital_cost < 0) {
513         this->capital_cost = this->__getGenericCapitalCost();
514     }
515
516     if (tidal_inputs.operation_maintenance_cost_kWh < 0) {
517         this->operation_maintenance_cost_kWh = this->__getGenericOpMaintCost();
518     }
519
520     if (not this->is_sunk) {
521         this->capital_cost_vec[0] = this->capital_cost;
522     }
523
524     // 3. construction print
525     if (this->print_flag) {
526         std::cout << "Tidal object constructed at " << this << std::endl;
527     }
528
529     return;
530 } /* Renewable() */

```

### 4.22.2.3 ~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() */
```

## 4.22.3 Member Function Documentation

### 4.22.3.1 \_\_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() */
```

### 4.22.3.2 \_\_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() */

```

**4.22.3.3 \_\_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() */

```

#### 4.22.3.4 \_\_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() */

```

#### 4.22.3.5 \_\_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() */

```

#### 4.22.3.6 `__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() */
```

#### 4.22.3.7 `__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 (1D): " << this->resource_key << " \n";
306
307     ofs << "\n-----\n\n";
308
309     // 2.3. Tidal attributes
310     ofs << "## Tidal Attributes\n";
311     ofs << "\n";
312
313     ofs << "Power Production Model: " << this->power_model_string << " \n";
314     ofs << "Design Speed: " << this->design_speed_ms << " m/s \n";
315
316     ofs << "\n-----\n\n";
317
318     // 2.4. Tidal Results
319     ofs << "## Results\n";
320     ofs << "\n";
321
322     ofs << "Net Present Cost: " << this->net_present_cost << " \n";
323     ofs << "\n";
324
325     ofs << "Total Dispatch: " << this->total_dispatch_kWh
326         << " kWh \n";
327
328     ofs << "Levellized Cost of Energy: " << this->levellized_cost_of_energy_kWh
329         << " per kWh dispatched \n";
330     ofs << "\n";
331
332     ofs << "Running Hours: " << this->running_hours << " \n";
333     ofs << "Replacements: " << this->n_replacements << " \n";
334
335     ofs << "\n-----\n\n";
336
337     ofs.close();
338
339     return;
340 } /* __writeSummary() */

```

#### 4.22.3.8 \_\_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_ID_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() */

```

#### 4.22.3.9 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() */

```

#### 4.22.3.10 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
609         case (TidalPowerProductionModel :: TIDAL_POWER_EXPONENTIAL): {
610             production_kW = this->__computeExponentialProductionkW(
611                 timestep,
612                 dt_hrs,
613                 tidal_resource_ms
614             );
615
616             break;
617         }
618
619         case (TidalPowerProductionModel :: TIDAL_POWER_LOOKUP): {
620             production_kW = this->__computeLookupProductionkW(
621                 timestep,
622                 dt_hrs,
623                 tidal_resource_ms
624             );
625
626             break;
627         }

```

```

628
629     default: {
630         std::string error_str = "ERROR: Tidal::computeProductionkW(): ";
631         error_str += "power model ";
632         error_str += std::to_string(this->power_model);
633         error_str += " not recognized";
634
635         #ifdef _WIN32
636             std::cout << error_str << std::endl;
637         #endif
638
639         throw std::runtime_error(error_str);
640
641         break;
642     }
643 }
644
645 return production_kW;
646 } /* computeProductionkW() */

```

#### 4.22.3.11 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() */

```

### 4.22.4 Member Data Documentation

#### 4.22.4.1 design\_speed\_ms

```
double Tidal::design_speed_ms
```

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

#### 4.22.4.2 power\_model

```
TidalPowerProductionModel Tidal::power_model
```

The tidal power production model to be applied.

#### 4.22.4.3 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:

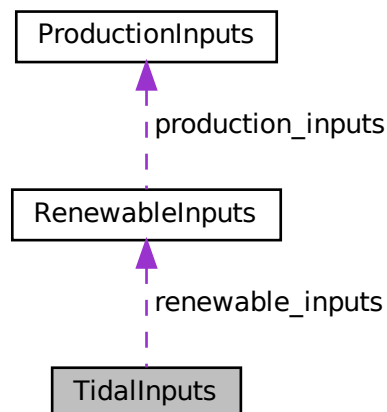
- [header/Production/Renewable/Tidal.h](#)
- [source/Production/Renewable/Tidal.cpp](#)

## 4.23 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.*

### 4.23.1 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](#).

### 4.23.2 Member Data Documentation

#### 4.23.2.1 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].

#### 4.23.2.2 design\_speed\_ms

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

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

#### 4.23.2.3 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].

#### 4.23.2.4 power\_model

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

The tidal power production model to be applied.

#### 4.23.2.5 renewable\_inputs

```
RenewableInputs TidalInputs::renewable_inputs
```

An encapsulated [RenewableInputs](#) instance.

#### 4.23.2.6 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:

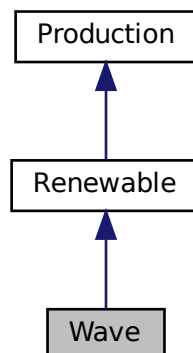
- [header/Production/Renewable/Tidal.h](#)

## 4.24 Wave Class Reference

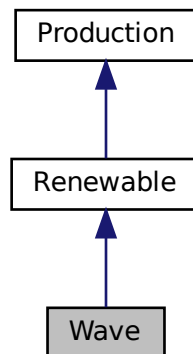
A derived class of the [Renewable](#) branch of [Production](#) which models wave production.

```
#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](#).*

### 4.24.1 Detailed Description

A derived class of the [Renewable](#) branch of [Production](#) which models wave production.

### 4.24.2 Constructor & Destructor Documentation

#### 4.24.2.1 `Wave()` [1/2]

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

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

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

#### 4.24.2.2 `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.

```

510 :
511 Renewable(
512     n_points,
513     n_years,
514     wave_inputs.renewable_inputs
515 )
516 {
517     // 1. check inputs
518     this->__checkInputs(wave_inputs);
519
520     // 2. set attributes
521     this->type = RenewableType :: WAVE;
522     this->type_str = "WAVE";
523
524     this->resource_key = wave_inputs.resource_key;
525
526     this->design_significant_wave_height_m =
527         wave_inputs.design_significant_wave_height_m;
528     this->design_energy_period_s = wave_inputs.design_energy_period_s;
529
530     this->power_model = wave_inputs.power_model;
531
532     switch (this->power_model) {
533         case (WavePowerProductionModel :: WAVE_POWER_GAUSSIAN): {
534             this->power_model_string = "GAUSSIAN";
535
536             break;
537         }
538
539         case (WavePowerProductionModel :: WAVE_POWER_PARABOLOID): {
540             this->power_model_string = "PARABOLOID";
541
542             break;
543         }
544
545         case (WavePowerProductionModel :: WAVE_POWER_LOOKUP): {
546             this->power_model_string = "LOOKUP";
547
548             break;
549         }
550
551         default: {
552             std::string error_str = "ERROR: Wave(): ";
553             error_str += "power production model ";
554             error_str += std::to_string(this->power_model);
555             error_str += " not recognized";
556
557             #ifndef _WIN32
558                 std::cout << error_str << std::endl;
559             #endif
560
561             throw std::runtime_error(error_str);
562
563             break;
564         }
565     }
566
567     if (wave_inputs.capital_cost < 0) {
568         this->capital_cost = this->__getGenericCapitalCost();
569     }
570
571     if (wave_inputs.operation_maintenance_cost_kWh < 0) {
572         this->operation_maintenance_cost_kWh = this->__getGenericOpMaintCost();
573     }
574
575     if (not this->is_sunk) {
576         this->capital_cost_vec[0] = this->capital_cost;
577     }
578
579     // 3. construction print
580     if (this->print_flag) {
581         std::cout << "Wave object constructed at " << this << std::endl;
582     }
583
584     return;
585 } /* Renewable() */

```

## 4.24.2.3 ~Wave()

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

Destructor for the [Wave](#) class.

```
771 {
772     // 1. destruction print
773     if (this->print_flag) {
774         std::cout << "Wave object at " << this << " destroyed" << std::endl;
775     }
776
777     return;
778 } /* ~Wave() */
```

## 4.24.3 Member Function Documentation

## 4.24.3.1 \_\_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     return;
65 } /* __checkInputs() */
```

## 4.24.3.2 \_\_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.

```
160 {
161     double H_s_nondim =
162         (significant_wave_height_m - this->design_significant_wave_height_m) /
163         this->design_significant_wave_height_m;
164
165     double T_e_nondim =
166         (energy_period_s - this->design_energy_period_s) /
167         this->design_energy_period_s;
168
169     double production = exp(
170         -2.25119 * pow(T_e_nondim, 2) +
171         3.44570 * T_e_nondim * H_s_nondim -
172         4.01508 * pow(H_s_nondim, 2)
173     );
174
175     return production * this->capacity_kW;
176 } /* __computeGaussianProductionkW() */
```

#### 4.24.3.3 \_\_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.

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

## 4.24.3.4 \_\_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.

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

#### 4.24.3.5 `__getGenericCapitalCost()`

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

Helper method to generate a generic wave energy converter capital cost.

Note that this model expresses cost in terms of Canadian dollars [CAD].

Ref: [MacDougall \[2019\]](#)

##### Returns

A generic capital cost for the wave energy converter [CAD].

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

#### 4.24.3.6 `__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].

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

#### 4.24.3.7 `__writeSummary()`

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

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

## 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](#).

```

299 {
300     // 1. create filestream
301     write_path += "summary_results.md";
302     std::ofstream ofs;
303     ofs.open(write_path, std::ofstream::out);
304
305     // 2. write summary results (markdown)
306     ofs << "# ";
307     ofs << std::to_string(int(ceil(this->capacity_kW)));
308     ofs << " kW WAVE Summary Results\n";
309     ofs << "\n-----\n\n";
310
311     // 2.1. Production attributes
312     ofs << "## Production Attributes\n";
313     ofs << "\n";
314
315     ofs << "Capacity: " << this->capacity_kW << "kW \n";
316     ofs << "\n";
317
318     ofs << "Sunk Cost (N = 0 / Y = 1): " << this->is_sunk << " \n";
319     ofs << "Capital Cost: " << this->capital_cost << " \n";
320     ofs << "Operation and Maintenance Cost: " << this->operation_maintenance_cost_kWh
321     << " per kWh produced \n";
322     ofs << "Nominal Inflation Rate (annual): " << this->nominal_inflation_annual
323     << " \n";
324     ofs << "Nominal Discount Rate (annual): " << this->nominal_discount_annual
325     << " \n";
326     ofs << "Real Discount Rate (annual): " << this->real_discount_annual << " \n";
327     ofs << "\n";
328
329     ofs << "Replacement Running Hours: " << this->replace_running_hrs << " \n";
330     ofs << "\n-----\n\n";
331
332     // 2.2. Renewable attributes
333     ofs << "## Renewable Attributes\n";
334     ofs << "\n";
335
336     ofs << "Resource Key (2D): " << this->resource_key << " \n";
337
338     ofs << "\n-----\n\n";
339
340     // 2.3. Wave attributes
341     ofs << "## Wave Attributes\n";
342     ofs << "\n";
343
344     ofs << "Power Production Model: " << this->power_model_string << " \n";
345     switch (this->power_model) {
346     case (WavePowerProductionModel :: WAVE_POWER_GAUSSIAN): {
347         ofs << "Design Significant Wave Height: "
348         << this->design_significant_wave_height_m << " m \n";
349
350         ofs << "Design Energy Period: " << this->design_energy_period_s << " s \n";
351
352         break;
353     }
354
355     case (WavePowerProductionModel :: WAVE_POWER_LOOKUP): {
356         //...
357
358         break;
359     }
360
361     default: {
362         // write nothing!
363
364         break;
365     }
366 }
367
368     ofs << "\n-----\n\n";
369
370     // 2.4. Wave Results
371     ofs << "## Results\n";
372     ofs << "\n";
373
374     ofs << "Net Present Cost: " << this->net_present_cost << " \n";
375     ofs << "\n";

```

```

376
377 ofs << "Total Dispatch: " << this->total_dispatch_kWh
378     << " kWh \n";
379
380 ofs << "Levellized Cost of Energy: " << this->levellized_cost_of_energy_kWh
381     << " per kWh dispatched \n";
382 ofs << "\n";
383
384 ofs << "Running Hours: " << this->running_hours << " \n";
385 ofs << "Replacements: " << this->n_replacements << " \n";
386
387 ofs << "\n-----\n\n";
388
389 ofs.close();
390
391 return;
392 } /* __writeSummary() */

```

#### 4.24.3.8 \_\_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](#).

```

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

```



```

458         ofs « "\n";
459     }
460
461     return;
462 } /* __writeTimeSeries() */

```

#### 4.24.3.9 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](#).

```

743 {
744     // 1. invoke base class method
745     load_kW = Renewable::commit(
746         timestep,
747         dt_hrs,
748         production_kW,
749         load_kW
750     );
751
752
753     //...
754
755     return load_kW;
756 } /* commit() */

```

#### 4.24.3.10 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>significant_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](#).

```

647 {
648     // check if no resource
649     if (significant_wave_height_m <= 0 or energy_period_s <= 0) {
650         return 0;
651     }
652
653     // compute production
654     double production_kW = 0;
655
656     switch (this->power_model) {
657         case (WavePowerProductionModel :: WAVE_POWER_PARABOLOID): {
658             production_kW = this->__computeParaboloidProductionkW(
659                 timestep,
660                 dt_hrs,
661                 significant_wave_height_m,
662                 energy_period_s
663             );
664
665             break;
666         }
667
668         case (WavePowerProductionModel :: WAVE_POWER_GAUSSIAN): {
669             production_kW = this->__computeGaussianProductionkW(
670                 timestep,
671                 dt_hrs,
672                 significant_wave_height_m,
673                 energy_period_s
674             );
675
676             break;
677         }
678
679         case (WavePowerProductionModel :: WAVE_POWER_LOOKUP): {
680             production_kW = this->__computeLookupProductionkW(
681                 timestep,
682                 dt_hrs,
683                 significant_wave_height_m,
684                 energy_period_s
685             );
686
687             break;
688         }
689
690         default: {
691             std::string error_str = "ERROR: Wave::computeProductionkW(): ";
692             error_str += "power model ";
693             error_str += std::to_string(this->power_model);
694             error_str += " not recognized";
695
696             #ifdef _WIN32
697                 std::cout << error_str << std::endl;
698             #endif
699
700             throw std::runtime_error(error_str);
701
702             break;
703         }
704     }
705
706     return production_kW;
707 } /* computeProductionkW() */

```

#### 4.24.3.11 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](#).

```
603 {
604     // 1. reset attributes
605     //...
606
607     // 2. invoke base class method
608     Renewable :: handleReplacement(timestep);
609
610     return;
611 } /* __handleReplacement() */
```

### 4.24.4 Member Data Documentation

#### 4.24.4.1 design\_energy\_period\_s

```
double Wave::design_energy_period_s
```

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

#### 4.24.4.2 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.

#### 4.24.4.3 power\_model

```
WavePowerProductionModel Wave::power_model
```

The wave power production model to be applied.

#### 4.24.4.4 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:

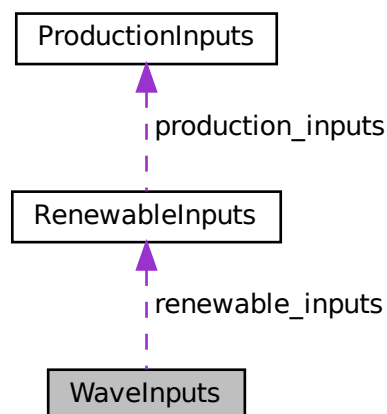
- [header/Production/Renewable/Wave.h](#)
- [source/Production/Renewable/Wave.cpp](#)

## 4.25 WaveInputs Struct Reference

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

```
#include <Wave.h>
```

Collaboration diagram for WaveInputs:



### Public Attributes

- [RenewableInputs renewable\\_inputs](#)  
An encapsulated [RenewableInputs](#) instance.
- int [resource\\_key](#) = 0  
A key used to index into the [Resources](#) object, to associate this asset with the appropriate resource time series.
- double [capital\\_cost](#) = -1  
The capital cost of the asset (undefined currency). -1 is a sentinel value, which triggers a generic cost model on construction (in fact, any negative value here will trigger). Note that the generic cost model is in terms of Canadian dollars [CAD].
- double [operation\\_maintenance\\_cost\\_kWh](#) = -1

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

- double `design_significant_wave_height_m` = 3

*The significant wave height [m] at which the wave energy converter achieves its rated capacity.*

- double `design_energy_period_s` = 10

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

- `WavePowerProductionModel power_model` = `WavePowerProductionModel` :: `WAVE_POWER_PARABOLOID`

*The wave power production model to be applied.*

## 4.25.1 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](#).

## 4.25.2 Member Data Documentation

### 4.25.2.1 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].

### 4.25.2.2 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.

### 4.25.2.3 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.

#### 4.25.2.4 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].

#### 4.25.2.5 power\_model

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

The wave power production model to be applied.

#### 4.25.2.6 renewable\_inputs

```
RenewableInputs WaveInputs::renewable_inputs
```

An encapsulated [RenewableInputs](#) instance.

#### 4.25.2.7 resource\_key

```
int WaveInputs::resource_key = 0
```

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

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

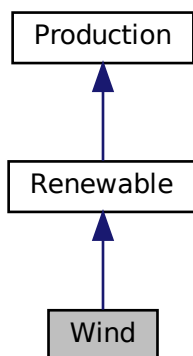
- [header/Production/Renewable/Wave.h](#)

## 4.26 Wind Class Reference

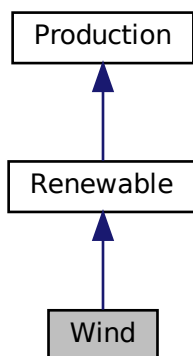
A derived class of the [Renewable](#) branch of [Production](#) which models wind production.

```
#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](#).

### 4.26.1 Detailed Description

A derived class of the [Renewable](#) branch of [Production](#) which models wind production.

### 4.26.2 Constructor & Destructor Documentation



## 4.26.2.1 Wind() [1/2]

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

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

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

## 4.26.2.2 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() */

```

#### 4.26.2.3 ~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() */

```

### 4.26.3 Member Function Documentation

#### 4.26.3.1 \_\_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() */

```

#### 4.26.3.2 \_\_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() */

```

#### 4.26.3.3 \_\_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() */

```

**4.26.3.4 \_\_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() */

```

**4.26.3.5 \_\_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() */

```

**4.26.3.6 \_\_writeSummary()**

```

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

```

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

## 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](#).

```

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     // 2.1. Production attributes
226     ofs << "## Production Attributes\n";
227     ofs << "\n";
228
229     ofs << "Capacity: " << this->capacity_kW << "kW \n";
230     ofs << "\n";
231
232     ofs << "Sunk Cost (N = 0 / Y = 1): " << this->is_sunk << " \n";
233     ofs << "Capital Cost: " << this->capital_cost << " \n";
234     ofs << "Operation and Maintenance Cost: " << this->operation_maintenance_cost_kWh
235         << " per kWh produced \n";
236     ofs << "Nominal Inflation Rate (annual): " << this->nominal_inflation_annual
237         << " \n";
238     ofs << "Nominal Discount Rate (annual): " << this->nominal_discount_annual
239         << " \n";
240     ofs << "Real Discount Rate (annual): " << this->real_discount_annual << " \n";
241     ofs << "\n";
242
243     ofs << "Replacement Running Hours: " << this->replace_running_hrs << " \n";
244     ofs << "\n-----\n\n";
245
246     // 2.2. Renewable attributes
247     ofs << "## Renewable Attributes\n";
248     ofs << "\n";
249
250     ofs << "Resource Key (ID): " << this->resource_key << " \n";
251
252     ofs << "\n-----\n\n";
253
254     // 2.3. Wind attributes
255     ofs << "## Wind Attributes\n";
256     ofs << "\n";
257
258     ofs << "Power Production Model: " << this->power_model_string << " \n";
259     switch (this->power_model) {
260     case (WindPowerProductionModel :: WIND_POWER_EXPONENTIAL): {
261         ofs << "Design Speed: " << this->design_speed_ms << " m/s \n";
262
263         break;
264     }
265
266     case (WindPowerProductionModel :: WIND_POWER_LOOKUP): {
267         //...
268
269         break;
270     }
271
272     default: {
273         // write nothing!
274
275         break;
276     }
277 }
278
279     ofs << "\n-----\n\n";
280
281     // 2.4. Wind Results
282     ofs << "## Results\n";
283     ofs << "\n";
284
285     ofs << "Net Present Cost: " << this->net_present_cost << " \n";
286     ofs << "\n";
287
288     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() */

```

#### 4.26.3.7 \_\_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 « "Curtailment [kW],";
355     ofs « "Capital Cost (actual),";
356     ofs « "Operation and Maintenance Cost (actual),";
357     ofs « "\n";
358
359     for (int i = 0; i < max_lines; i++) {
360         ofs « time_vec_hrs_ptr->at(i) « ",";
361         ofs « resource_map_1D_ptr->at(this->resource_key)[i] « ",";
362         ofs « this->production_vec_kW[i] « ",";
363         ofs « this->dispatch_vec_kW[i] « ",";
364         ofs « this->storage_vec_kW[i] « ",";
365         ofs « this->curtailment_vec_kW[i] « ",";
366         ofs « this->capital_cost_vec[i] « ",";
367         ofs « this->operation_maintenance_cost_vec[i] « ",";
368         ofs « "\n";
369     }
370
371     return;

```

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

#### 4.26.3.8 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
640     return load_kW;
641 } /* commit() */
```

#### 4.26.3.9 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>Generated by Dxygen</i> <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() */

```

**4.26.3.10 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() */
```

## 4.26.4 Member Data Documentation

### 4.26.4.1 design\_speed\_ms

```
double Wind::design_speed_ms
```

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

### 4.26.4.2 power\_model

```
WindPowerProductionModel Wind::power_model
```

The wind power production model to be applied.

### 4.26.4.3 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:

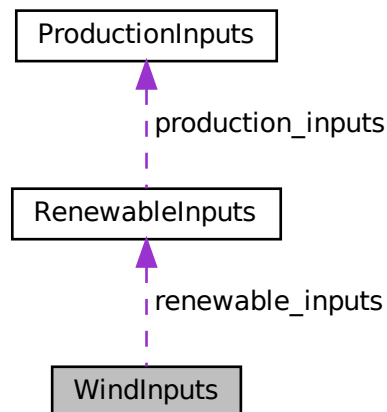
- header/Production/Renewable/[Wind.h](#)
- source/Production/Renewable/[Wind.cpp](#)

## 4.27 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.

### 4.27.1 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](#).

## 4.27.2 Member Data Documentation

### 4.27.2.1 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].

### 4.27.2.2 design\_speed\_ms

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

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

### 4.27.2.3 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].

### 4.27.2.4 power\_model

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

The wind power production model to be applied.

### 4.27.2.5 renewable\_inputs

```
RenewableInputs WindInputs::renewable_inputs
```

An encapsulated [RenewableInputs](#) instance.

### 4.27.2.6 resource\_key

```
int WindInputs::resource_key = 0
```

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

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

- [header/Production/Renewable/Wind.h](#)



## Chapter 5

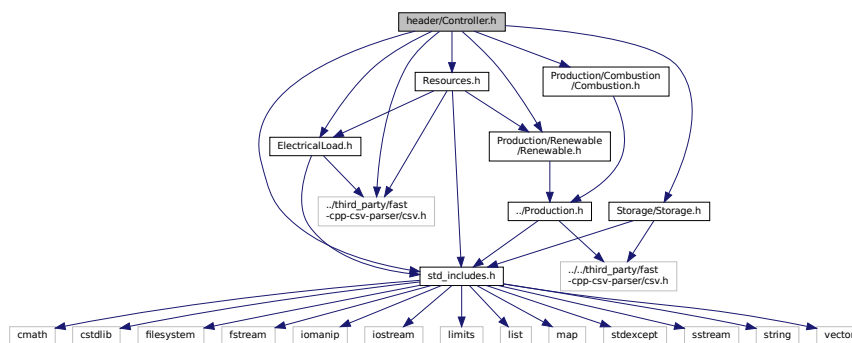
# File Documentation

### 5.1 header/Controller.h File Reference

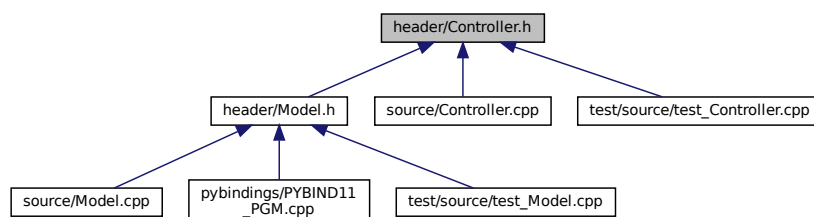
Header file the [Controller](#) class.

```
#include "std_includes.h"
#include "../third_party/fast-cpp-csv-parser/csv.h"
#include "ElectricalLoad.h"
#include "Resources.h"
#include "Production/Combustion/Combustion.h"
#include "Production/Renewable/Renewable.h"
#include "Storage/Storage.h"
```

Include dependency graph for Controller.h:



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



## Classes

- class [Controller](#)

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

## Enumerations

- enum [ControlMode](#) { [LOAD\\_FOLLOWING](#) , [CYCLE\\_CHARGING](#) , [N\\_CONTROL\\_MODES](#) }

*An enumeration of the types of control modes supported by PGMcpp.*

### 5.1.1 Detailed Description

Header file the [Controller](#) class.

### 5.1.2 Enumeration Type Documentation

#### 5.1.2.1 ControlMode

enum [ControlMode](#)

An enumeration of the types of control modes supported by PGMcpp.

##### Enumerator

<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.

```

43         {
44     LOAD\_FOLLOWING,
45     CYCLE\_CHARGING,
46     N\_CONTROL\_MODES
47 };

```

## 5.2 header/ElectricalLoad.h File Reference

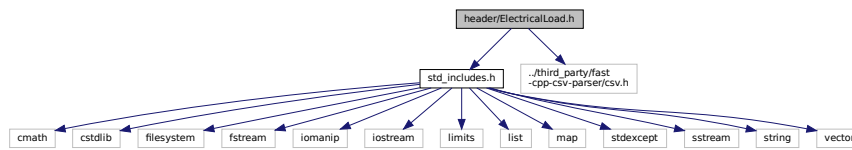
Header file the [ElectricalLoad](#) class.

```

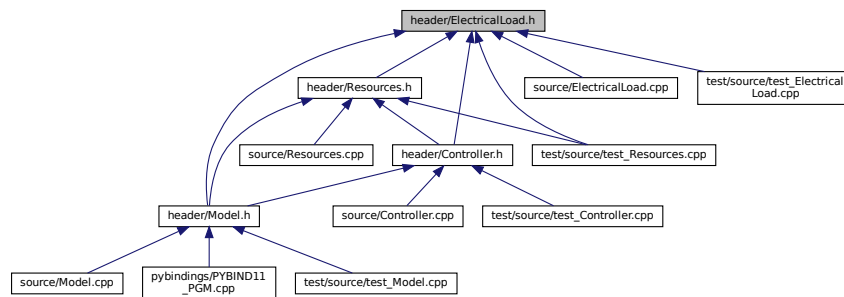
#include "std_includes.h"
#include "../third_party/fast-cpp-csv-parser/csv.h"

```

Include dependency graph for ElectricalLoad.h:



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



## Classes

- class [ElectricalLoad](#)

*A class which contains time and electrical load data. Intended to serve as a component class of [Model](#).*

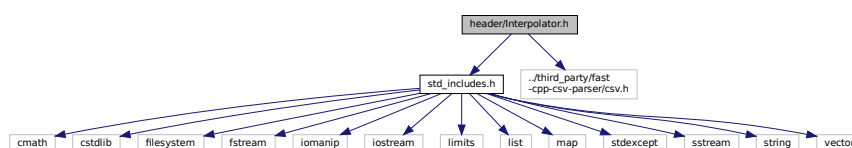
### 5.2.1 Detailed Description

Header file the [ElectricalLoad](#) class.

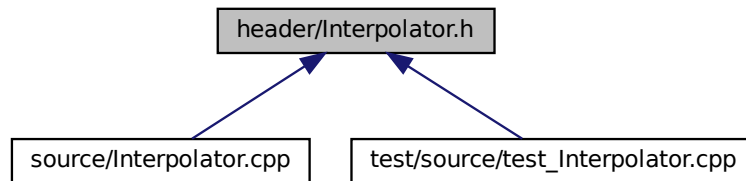
## 5.3 header/Interpolator.h File Reference

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

- class [Interpolator](#)

*A class which contains interpolation data and functionality.*

### 5.3.1 Detailed Description

Header file for the [Interpolator](#) class.

## 5.4 header/Model.h File Reference

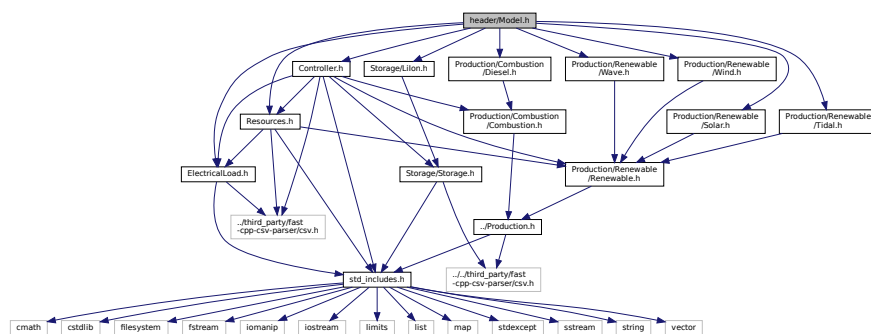
Header file the [Model](#) class.

```

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

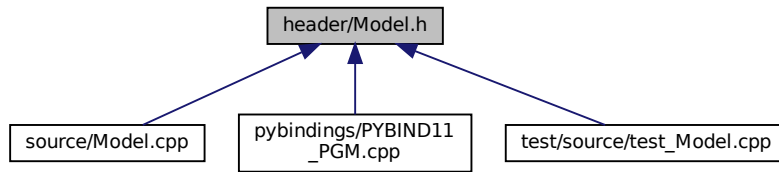
```

Include dependency graph for `Model.h`:





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



## Classes

- struct [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.

### 5.4.1 Detailed Description

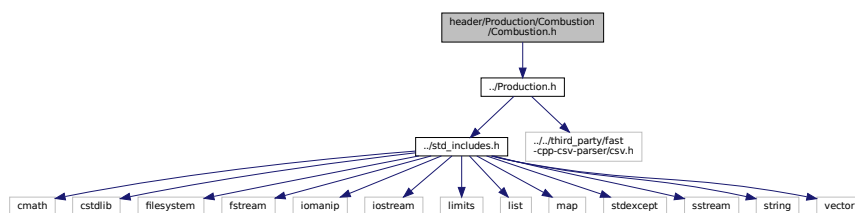
Header file the [Model](#) class.

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

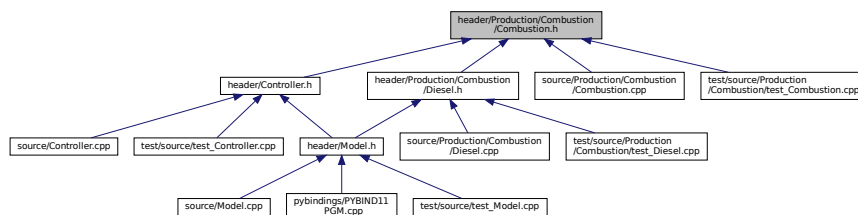
Header file the [Combustion](#) class.

```
#include "../Production.h"
```

Include dependency graph for Combustion.h:



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



## Classes

- struct [CombustionInputs](#)  
A structure which bundles the necessary inputs for the [Combustion](#) constructor. Provides default values for every necessary input. Note that this structure encapsulates [ProductionInputs](#).
- struct [Emissions](#)  
A structure which bundles the emitted masses of various emissions chemistries.
- class [Combustion](#)  
The root of the [Combustion](#) branch of the [Production](#) hierarchy. This branch contains derived classes which model the production of energy by way of combustibles.

## Enumerations

- enum [CombustionType](#) { [DIESEL](#) , [N\\_COMBUSTION\\_TYPES](#) }  
An enumeration of the types of [Combustion](#) asset supported by PGMcpp.

### 5.5.1 Detailed Description

Header file the [Combustion](#) class.

### 5.5.2 Enumeration Type Documentation

#### 5.5.2.1 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> .

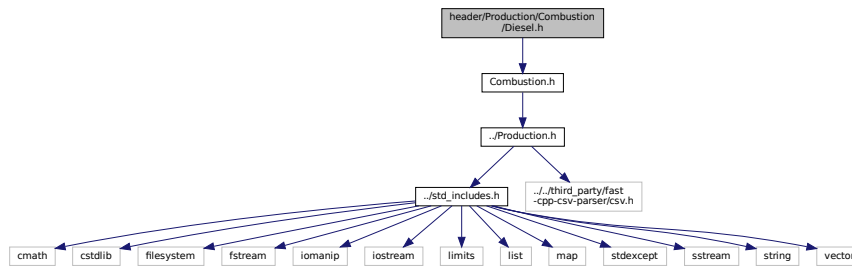
```
33         {
34     DIESEL,
35     N\_COMBUSTION\_TYPES
36 };
```

## 5.6 header/Production/Combustion/Diesel.h File Reference

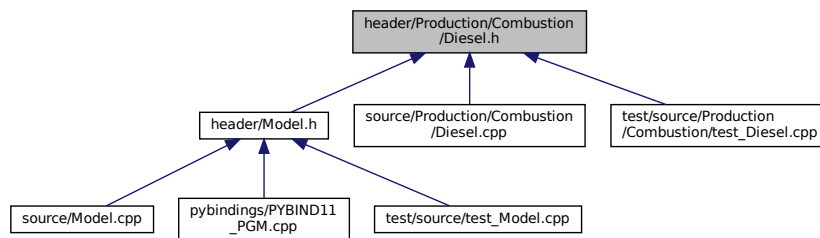
Header file the [Diesel](#) class.

```
#include "Combustion.h"
```

Include dependency graph for Diesel.h:



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



## Classes

- struct [DieselInputs](#)  
A structure which bundles the necessary inputs for the [Diesel](#) constructor. Provides default values for every necessary input. Note that this structure encapsulates [CombustionInputs](#).
- class [Diesel](#)  
A derived class of the [Combustion](#) branch of [Production](#) which models production using a diesel generator.

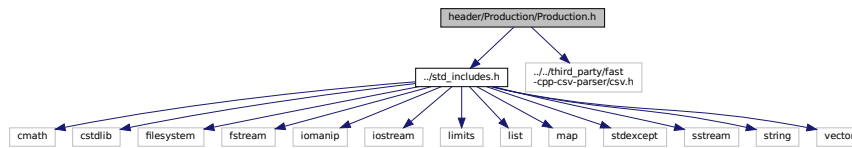
### 5.6.1 Detailed Description

Header file the [Diesel](#) class.

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

Header file the [Production](#) class.

```
#include "../std_includes.h"
#include "../../third_party/fast-cpp-csv-parser/csv.h"
Include dependency graph for Production.h:
```



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



## Classes

- struct [ProductionInputs](#)

A structure which bundles the necessary inputs for the [Production](#) constructor. Provides default values for every necessary input.

- class [Production](#)

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

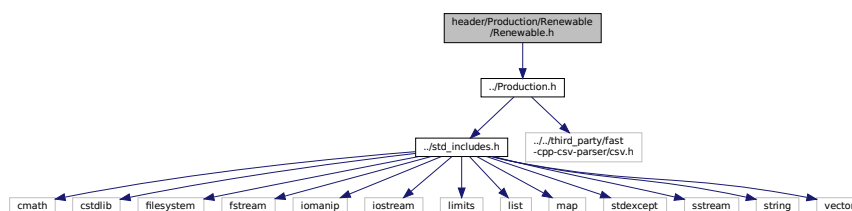
### 5.7.1 Detailed Description

Header file the [Production](#) class.

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

Header file the [Renewable](#) class.

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



[illegible]

- 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.*

- enum RenewableType {  
SOLAR , TIDAL , WAVE , WIND ,  
N\_RENEWABLE\_TYPES }

*An enumeration of the types of [Renewable](#) asset supported by PGMcpp.*

Header file the **Renewable** class.

### 5.8.2.1 RenewableType

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

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

```

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

```

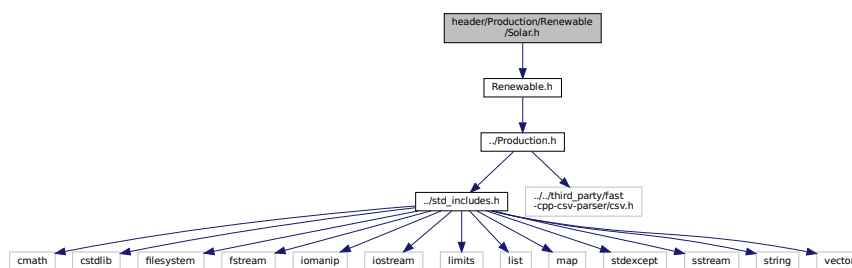
## 5.9 header/Production/Renewable/Solar.h File Reference

Header file the [Solar](#) class.

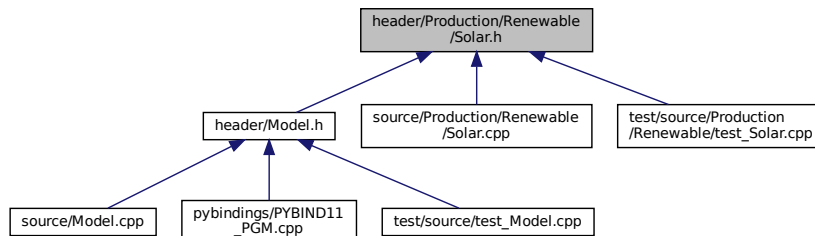
```
#include "Renewable.h"

```

Include dependency graph for Solar.h:



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



## Classes

- struct [SolarInputs](#)

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

- class [Solar](#)

A derived class of the [Renewable](#) branch of [Production](#) which models solar production.

### 5.9.1 Detailed Description

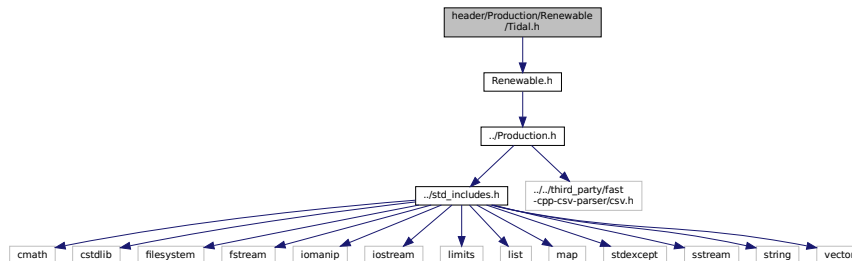
Header file the [Solar](#) class.

## 5.10 header/Production/Renewable/Tidal.h File Reference

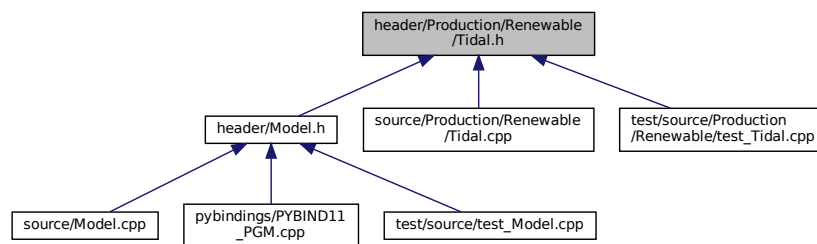
Header file the [Tidal](#) class.

```
#include "Renewable.h"
```

Include dependency graph for Tidal.h:



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



### Classes

- struct [TidalInputs](#)

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

- class [Tidal](#)

*A derived class of the [Renewable](#) branch of [Production](#) which models tidal production.*

### Enumerations

- enum [TidalPowerProductionModel](#) { [TIDAL\\_POWER\\_CUBIC](#) , [TIDAL\\_POWER\\_EXPONENTIAL](#) , [TIDAL\\_POWER\\_LOOKUP](#) , [N\\_TIDAL\\_POWER\\_PRODUCTION\\_MODELS](#) }

#### 5.10.1 Detailed Description

Header file the [Tidal](#) class.

## 5.10.2 Enumeration Type Documentation

### 5.10.2.1 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 };

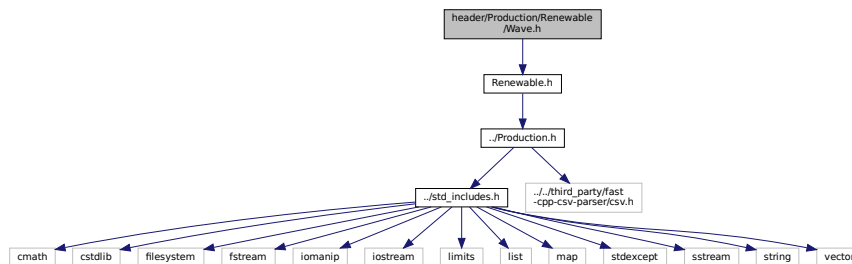
```

## 5.11 header/Production/Renewable/Wave.h File Reference

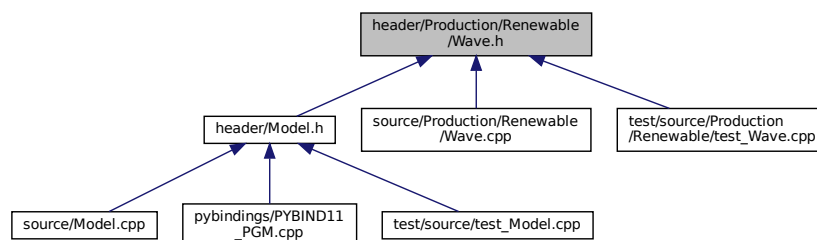
Header file the [Wave](#) class.

```
#include "Renewable.h"
```

Include dependency graph for Wave.h:



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





## Classes

- struct [WaveInputs](#)

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

- class [Wave](#)

A derived class of the [Renewable](#) branch of [Production](#) which models wave production.

## Enumerations

- enum [WavePowerProductionModel](#) { [WAVE\\_POWER\\_GAUSSIAN](#) , [WAVE\\_POWER\\_PARABOLOID](#) , [WAVE\\_POWER\\_LOOKUP](#) , [N\\_WAVE\\_POWER\\_PRODUCTION\\_MODELS](#) }

### 5.11.1 Detailed Description

Header file the [Wave](#) class.

### 5.11.2 Enumeration Type Documentation

#### 5.11.2.1 WavePowerProductionModel

```
enum WavePowerProductionModel
```

Enumerator

<a href="#">WAVE_POWER_GAUSSIAN</a>	A Gaussian power production model.
<a href="#">WAVE_POWER_PARABOLOID</a>	A paraboloid power production model.
<a href="#">WAVE_POWER_LOOKUP</a>	Lookup from a given performance matrix.
<a href="#">N_WAVE_POWER_PRODUCTION_MODELS</a>	A simple hack to get the number of elements in <a href="#">WavePowerProductionModel</a> .

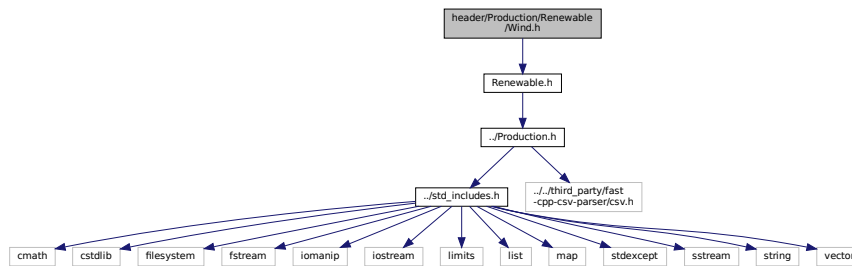
```
34     {
35     WAVE\_POWER\_GAUSSIAN,
36     WAVE\_POWER\_PARABOLOID,
37     WAVE\_POWER\_LOOKUP,
38     N\_WAVE\_POWER\_PRODUCTION\_MODELS
39  };
```

## 5.12 header/Production/Renewable/Wind.h File Reference

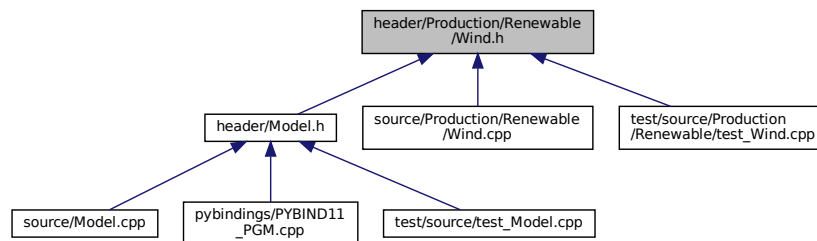
Header file the [Wind](#) class.

```
#include "Renewable.h"
```

Include dependency graph for Wind.h:



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



## Classes

- struct [WindInputs](#)  
A structure which bundles the necessary inputs for the [Wind](#) constructor. Provides default values for every necessary input. Note that this structure encapsulates [RenewableInputs](#).
- class [Wind](#)  
A derived class of the [Renewable](#) branch of [Production](#) which models wind production.

## Enumerations

- enum [WindPowerProductionModel](#) { [WIND\\_POWER\\_EXPONENTIAL](#) , [WIND\\_POWER\\_LOOKUP](#) , [N\\_WIND\\_POWER\\_PRODUCTION\\_MODELS](#) }

### 5.12.1 Detailed Description

Header file the [Wind](#) class.

### 5.12.2 Enumeration Type Documentation

#### 5.12.2.1 WindPowerProductionModel

```
enum WindPowerProductionModel
```

## Enumerator

WIND_POWER_EXPONENTIAL	An exponential power production model.
WIND_POWER_LOOKUP	Lookup from a given set of power curve data.
N_WIND_POWER_PRODUCTION_MODELS	A simple hack to get the number of elements in WindPowerProductionModel.

```

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

```

## 5.13 header/Resources.h File Reference

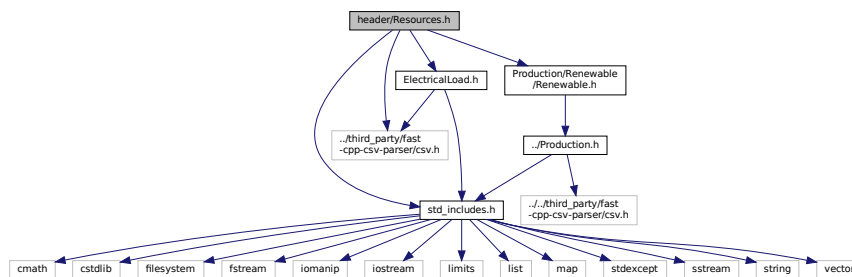
Header file the [Resources](#) class.

```

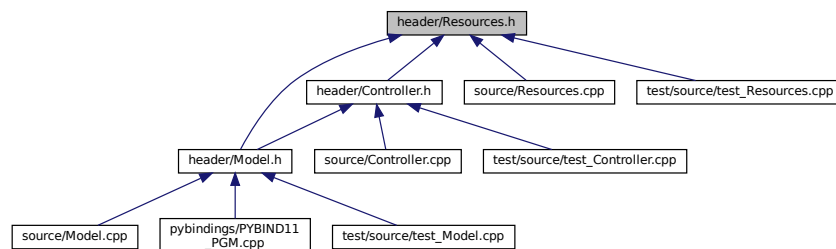
#include "std_includes.h"
#include "../third_party/fast-cpp-csv-parser/csv.h"
#include "ElectricalLoad.h"
#include "Production/Renewable/Renewable.h"

```

Include dependency graph for Resources.h:



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



## Classes

- class [Resources](#)

*A class which contains renewable resource data. Intended to serve as a component class of [Model](#).*

### 5.13.1 Detailed Description

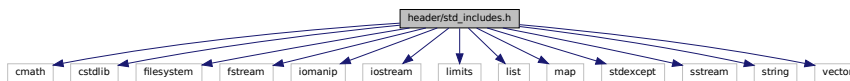
Header file the [Resources](#) class.

## 5.14 header/std\_includes.h File Reference

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

```
#include <cmath>
#include <cstdlib>
#include <filesystem>
#include <fstream>
#include <iomanip>
#include <iostream>
#include <limits>
#include <list>
#include <map>
#include <stdexcept>
#include <sstream>
#include <string>
#include <vector>
```

Include dependency graph for std\_includes.h:



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



### 5.14.1 Detailed Description

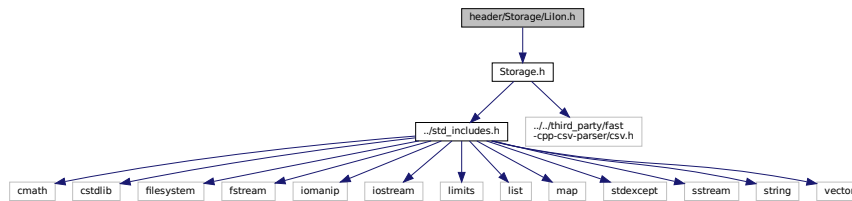
Header file which simply batches together the usual, standard includes.

## 5.15 header/Storage/Lilon.h File Reference

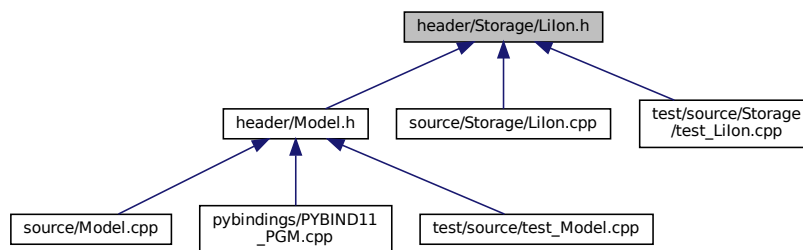
Header file the [Lilon](#) class.

```
#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.

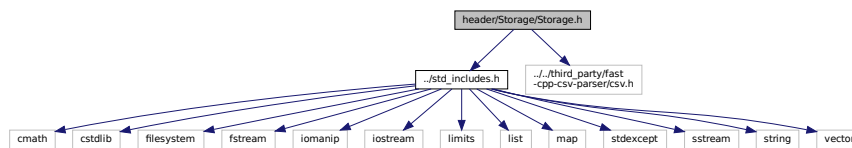
### 5.15.1 Detailed Description

Header file the [Lilon](#) class.

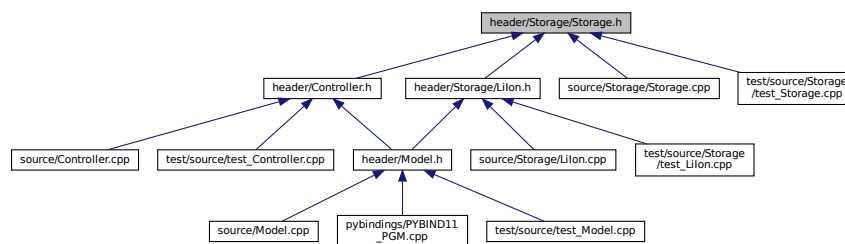
## 5.16 header/Storage/Storage.h File Reference

Header file the [Storage](#) class.

```
#include "../std_includes.h"
#include "../../third_party/fast-cpp-csv-parser/csv.h"
Include dependency graph for Storage.h:
```



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



## Classes

- 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.

### 5.16.1 Detailed Description

Header file the [Storage](#) class.

### 5.16.2 Enumeration Type Documentation

#### 5.16.2.1 StorageType

```
enum StorageType
```

An enumeration of the types of [Storage](#) asset supported by PGMcpp.

## Enumerator

LIION	A system of lithium ion batteries.
N_STORAGE_TYPES	A simple hack to get the number of elements in StorageType.

```

34         {
35     LIION,
36     N_STORAGE_TYPES
37 };

```

## 5.17 pybindings/PYBIND11\_PGM.cpp File Reference

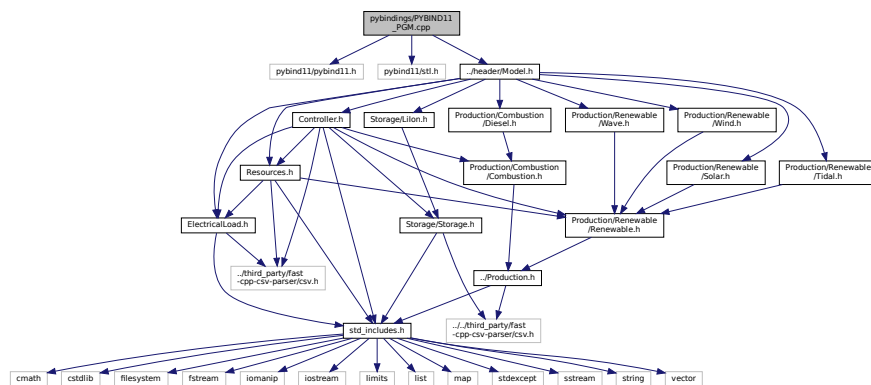
Python 3 bindings file for PGMcpp.

```

#include <pybind11/pybind11.h>
#include <pybind11/stl.h>
#include "../header/Model.h"

```

Include dependency graph for PYBIND11\_PGM.cpp:



## Functions

- [PYBIND11\\_MODULE](#) (PGMcpp, m)

### 5.17.1 Detailed Description

Python 3 bindings file for PGMcpp.

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

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

### 5.17.2 Function Documentation

### 5.17.2.1 PYBIND11\_MODULE()

```

PYBIND11_MODULE (
    PGMcpp ,
    m )
{
30
31
32 // ===== Controller ===== //
33 /*
34 pybind11::class_<Controller>(m, "Controller")
35     .def(pybind11::init());
36 */
37 // ===== END Controller ===== //
38
39
40
41 // ===== ElectricalLoad ===== //
42 /*
43 pybind11::class_<ElectricalLoad>(m, "ElectricalLoad")
44     .def_readwrite("n_points", &ElectricalLoad::n_points)
45     .def_readwrite("max_load_kW", &ElectricalLoad::max_load_kW)
46     .def_readwrite("mean_load_kW", &ElectricalLoad::mean_load_kW)
47     .def_readwrite("min_load_kW", &ElectricalLoad::min_load_kW)
48     .def_readwrite("dt_vec_hrs", &ElectricalLoad::dt_vec_hrs)
49     .def_readwrite("load_vec_kW", &ElectricalLoad::load_vec_kW)
50     .def_readwrite("time_vec_hrs", &ElectricalLoad::time_vec_hrs)
51
52     .def(pybind11::init<std::string>());
53 */
54 // ===== END ElectricalLoad ===== //
55
56
57
58 // ===== Model ===== //
59 /*
60 pybind11::class_<Model>(m, "Model")
61     .def(
62         pybind11::init<
63             ElectricalLoad*,
64             RenewableResources*
65         >()
66     );
67 */
68 // ===== END Model ===== //
69
70
71
72 // ===== RenewableResources ===== //
73 /*
74 pybind11::class_<RenewableResources>(m, "RenewableResources")
75     .def(pybind11::init());
76     /*
77     .def(pybind11::init<>());
78     */
79 */
80 // ===== END RenewableResources ===== //
81
82 } /* PYBIND11_MODULE() */

```

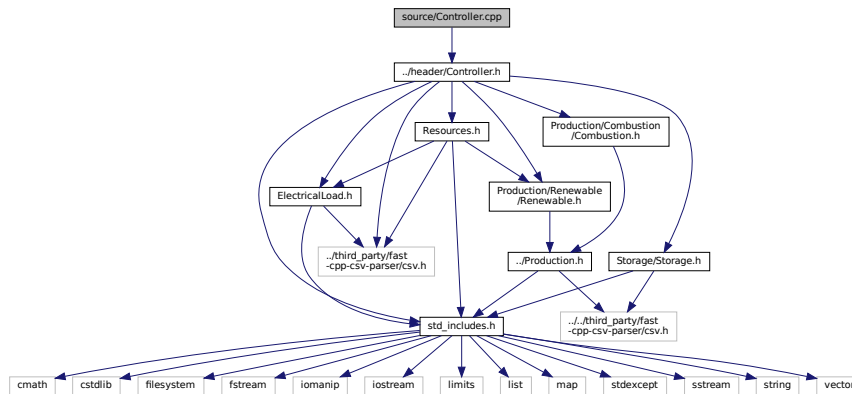
## 5.18 source/Controller.cpp File Reference

Implementation file for the [Controller](#) class.



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

Include dependency graph for Controller.cpp:



### 5.18.1 Detailed Description

Implementation file for the [Controller](#) class.

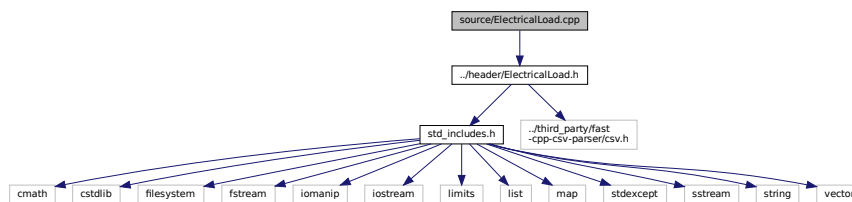
A class which contains a various dispatch control logic. Intended to serve as a component class of [Controller](#).

## 5.19 source/ElectricalLoad.cpp File Reference

Implementation file for the [ElectricalLoad](#) class.

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

Include dependency graph for ElectricalLoad.cpp:



### 5.19.1 Detailed Description

Implementation file for the [ElectricalLoad](#) class.

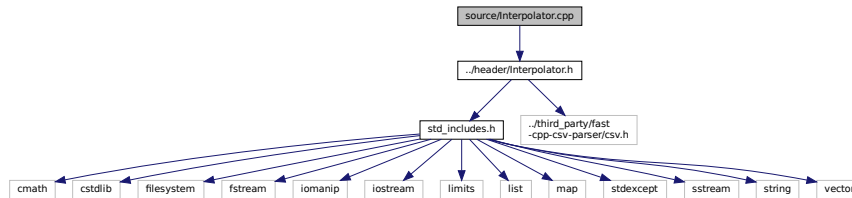
A class which contains time and electrical load data. Intended to serve as a component class of [Model](#).

## 5.20 source/Interpolator.cpp File Reference

Implementation file for the [Interpolator](#) class.

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

Include dependency graph for Interpolator.cpp:



### 5.20.1 Detailed Description

Implementation file for the [Interpolator](#) class.

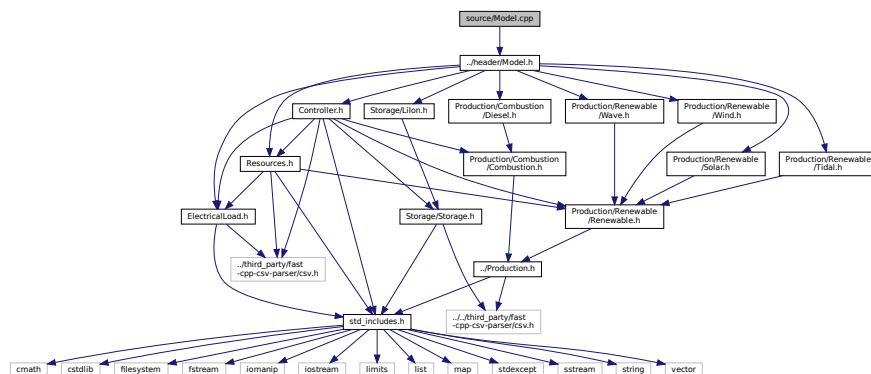
A class which contains interpolation data and functionality.

## 5.21 source/Model.cpp File Reference

Implementation file for the [Model](#) class.

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

Include dependency graph for Model.cpp:



### 5.21.1 Detailed Description

Implementation file for the [Model](#) class.

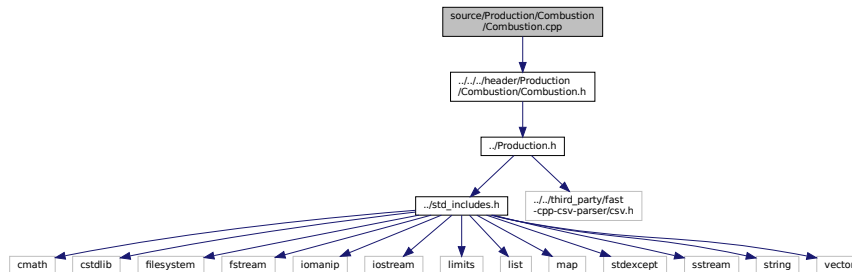
A container class which forms the centre of PGMcpp. The [Model](#) class is intended to serve as the primary user interface with the functionality of PGMcpp, and as such it contains all other classes.

## 5.22 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:



### 5.22.1 Detailed Description

Implementation file for the [Combustion](#) class.

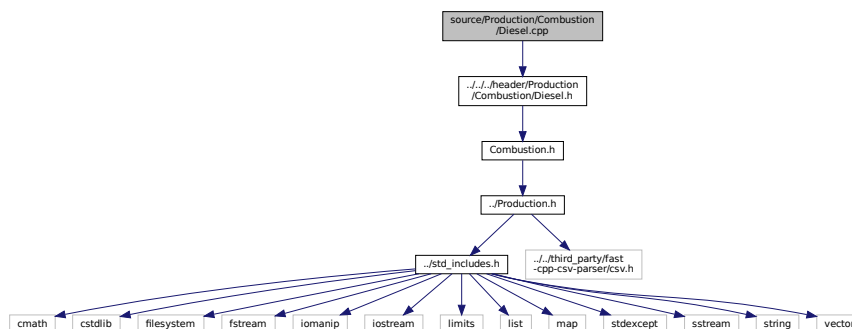
The root of the [Combustion](#) branch of the [Production](#) hierarchy. This branch contains derived classes which model the production of energy by way of combustibles.

## 5.23 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:



### 5.23.1 Detailed Description

Implementation file for the [Diesel](#) class.

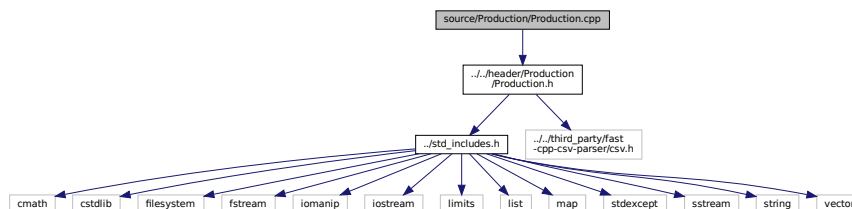
A derived class of the [Combustion](#) branch of [Production](#) which models production using a diesel generator.

## 5.24 source/Production/Production.cpp File Reference

Implementation file for the [Production](#) class.

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

Include dependency graph for Production.cpp:



### 5.24.1 Detailed Description

Implementation file for the [Production](#) class.

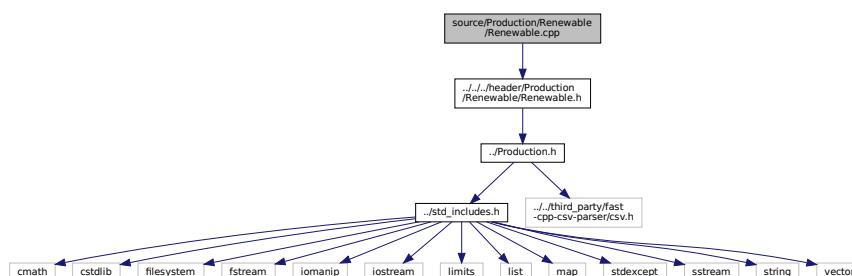
The base class of the [Production](#) hierarchy. This hierarchy contains derived classes which model the production of energy, be it renewable or otherwise.

## 5.25 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:



### 5.25.1 Detailed Description

Implementation file for the [Renewable](#) class.

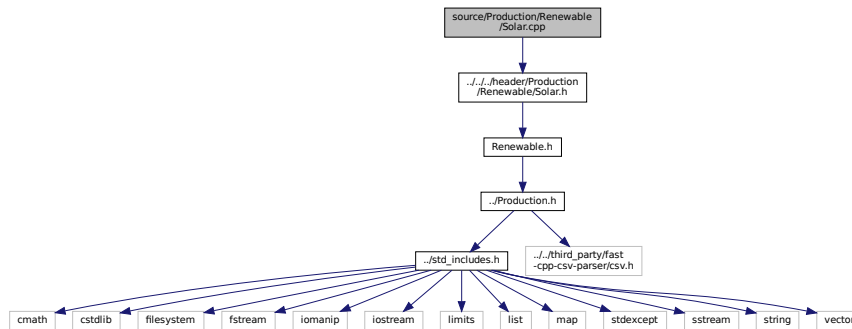
The root of the [Renewable](#) branch of the [Production](#) hierarchy. This branch contains derived classes which model the renewable production of energy.

## 5.26 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:



### 5.26.1 Detailed Description

Implementation file for the [Solar](#) class.

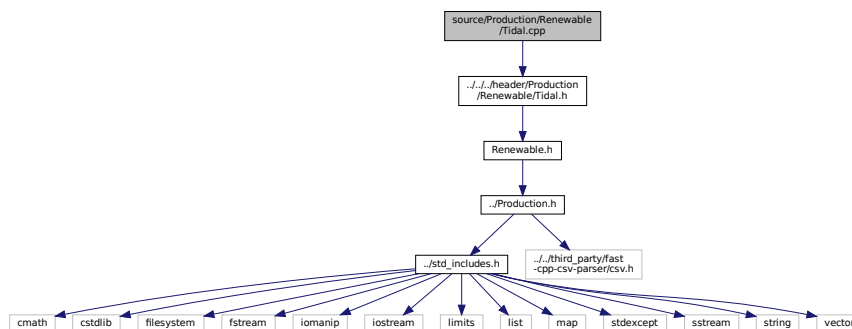
A derived class of the [Renewable](#) branch of [Production](#) which models solar production.

## 5.27 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:



### 5.27.1 Detailed Description

Implementation file for the [Tidal](#) class.

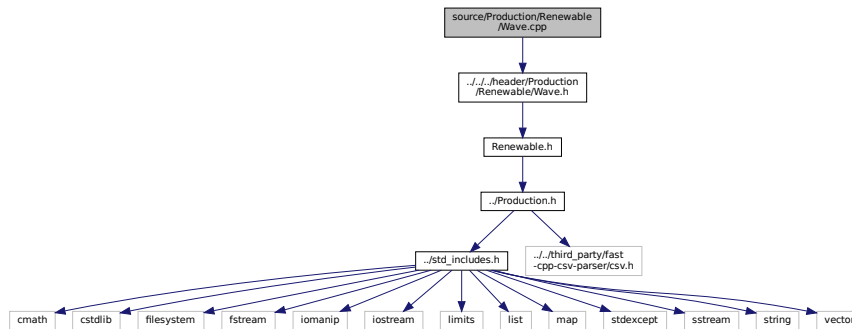
A derived class of the [Renewable](#) branch of [Production](#) which models tidal production.

## 5.28 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:



### 5.28.1 Detailed Description

Implementation file for the [Wave](#) class.

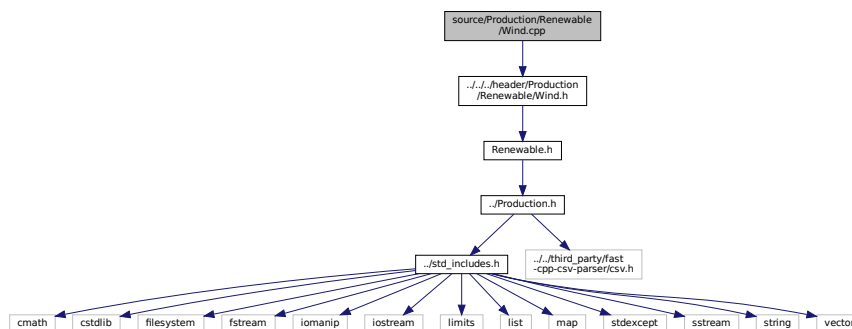
A derived class of the [Renewable](#) branch of [Production](#) which models wave production.

## 5.29 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:



### 5.29.1 Detailed Description

Implementation file for the [Wind](#) class.

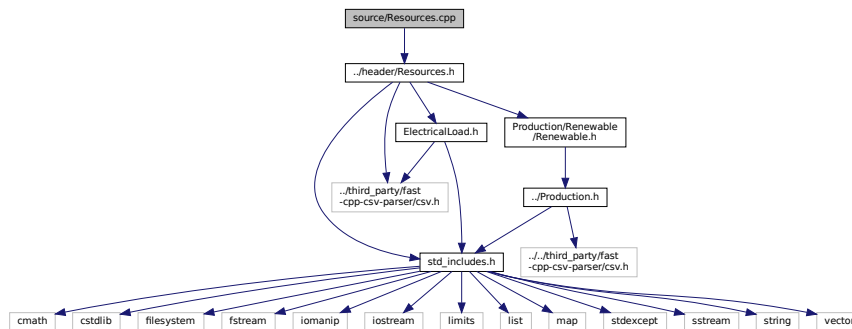
A derived class of the [Renewable](#) branch of [Production](#) which models wind production.

## 5.30 source/Resources.cpp File Reference

Implementation file for the [Resources](#) class.

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

Include dependency graph for Resources.cpp:



### 5.30.1 Detailed Description

Implementation file for the [Resources](#) class.

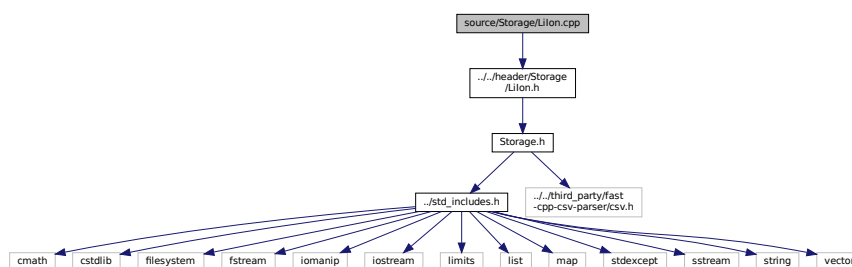
A class which contains renewable resource data. Intended to serve as a component class of [Model](#).

## 5.31 source/Storage/Lilon.cpp File Reference

Implementation file for the [Lilon](#) class.

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

Include dependency graph for Lilon.cpp:



### 5.31.1 Detailed Description

Implementation file for the [Lilon](#) class.

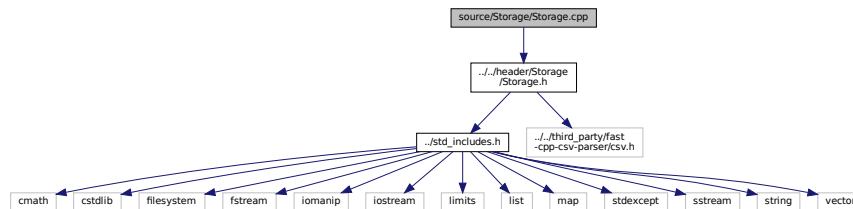
A derived class of [Storage](#) which models energy storage by way of lithium-ion batteries.

## 5.32 source/Storage/Storage.cpp File Reference

Implementation file for the [Storage](#) class.

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

Include dependency graph for Storage.cpp:



### 5.32.1 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.

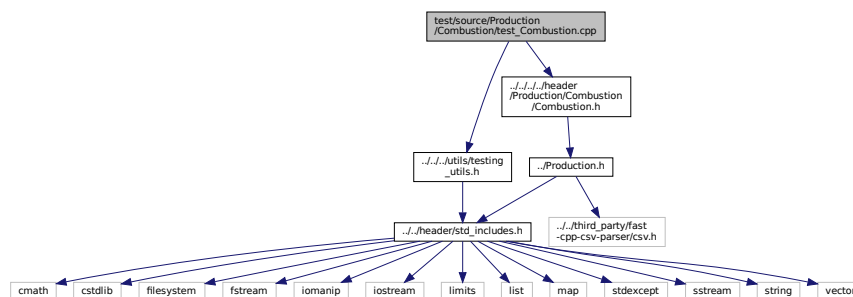
## 5.33 test/source/Production/Combustion/test\_Combustion.cpp File Reference

Testing suite for [Combustion](#) class.

```
#include "../../../utils/testing_utils.h"
```

```
#include "../../../header/Production/Combustion/Combustion.h"
```

Include dependency graph for test\_Combustion.cpp:



## Functions

- int [main](#) (int argc, char \*\*argv)



### 5.33.1 Detailed Description

Testing suite for [Combustion](#) class.

A suite of tests for the [Combustion](#) class.

### 5.33.2 Function Documentation

#### 5.33.2.1 main()

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

```

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

```

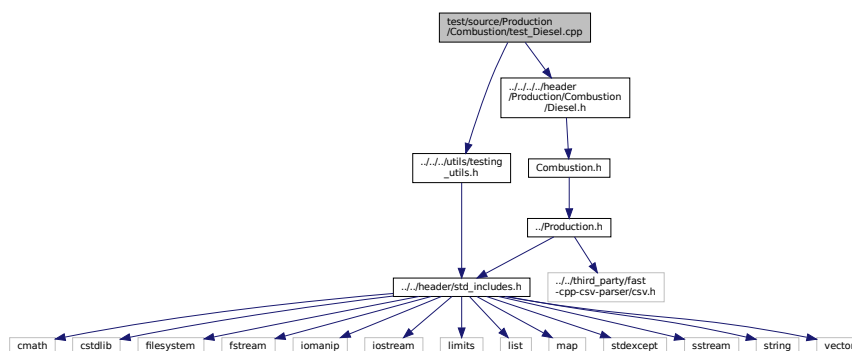
## 5.34 test/source/Production/Combustion/test\_Diesel.cpp File Reference

Testing suite for [Diesel](#) class.

```
#include "../.../utils/testing_utils.h"
```

```
#include "../.../header/Production/Combustion/Diesel.h"
```

Include dependency graph for test\_Diesel.cpp:



## Functions

- int [main](#) (int argc, char \*\*argv)

### 5.34.1 Detailed Description

Testing suite for [Diesel](#) class.

A suite of tests for the [Diesel](#) class.

### 5.34.2 Function Documentation

#### 5.34.2.1 main()

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

```

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

```

```

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

```

```

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

```

```

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

```

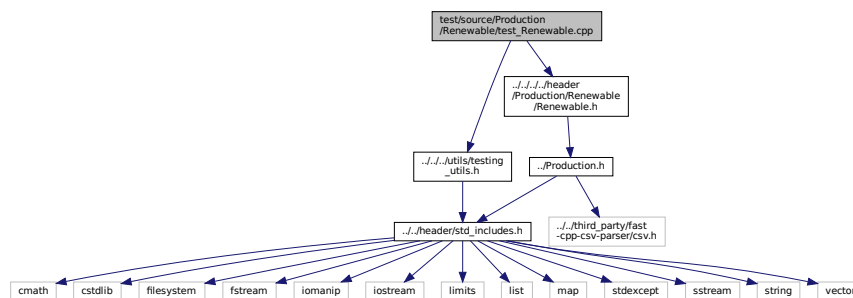
## 5.35 test/source/Production/Renewable/test\_Renewable.cpp File Reference

Testing suite for [Renewable](#) class.

```
#include "../.../utils/testing_utils.h"
```

```
#include "../.../header/Production/Renewable/Renewable.h"
```

Include dependency graph for test\_Renewable.cpp:



### Functions

- int [main](#) (int argc, char \*\*argv)

#### 5.35.1 Detailed Description

Testing suite for [Renewable](#) class.

A suite of tests for the [Renewable](#) class.

#### 5.35.2 Function Documentation

##### 5.35.2.1 main()

```

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

```



```

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

```

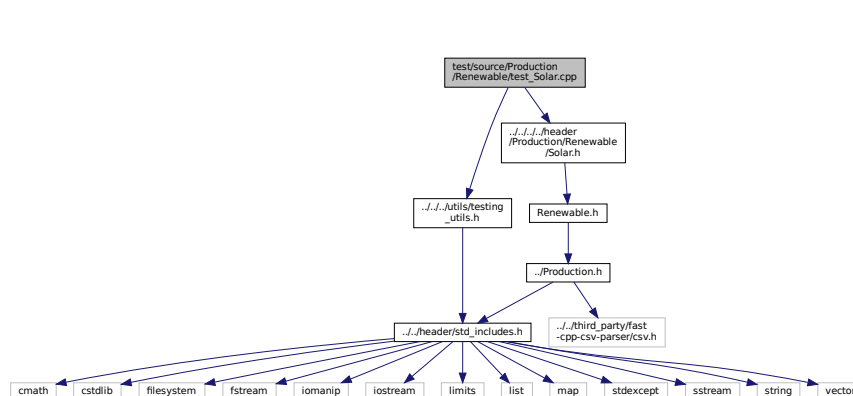
## 5.36 test/source/Production/Renewable/test\_Solar.cpp File Reference

Testing suite for [Solar](#) class.

```
#include "../.../utils/testing_utils.h"
```

```
#include "../.../header/Production/Renewable/Solar.h"
```

Include dependency graph for test\_Solar.cpp:



## Functions

- int [main](#) (int argc, char \*\*argv)

### 5.36.1 Detailed Description

Testing suite for [Solar](#) class.

A suite of tests for the [Solar](#) class.

### 5.36.2 Function Documentation

#### 5.36.2.1 main()

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

    printGold("\tTesting Production <-- Renewable <-- Solar");
    srand(time(NULL));
    Renewable* test_solar_ptr;

    try {
        // ===== CONSTRUCTION ===== //
        bool error_flag = true;
        try {
            SolarInputs bad_solar_inputs;
            bad_solar_inputs.derating = -1;
            Solar bad_solar(8760, 1, bad_solar_inputs);
            error_flag = false;
        } catch (...) {
            // Task failed successfully! =P
        }
        if (not error_flag) {
            expectedErrorNotDetected(__FILE__, __LINE__);
        }
        SolarInputs solar_inputs;
        test_solar_ptr = new Solar(8760, 1, solar_inputs);
        // ===== END CONSTRUCTION ===== //

        // ===== ATTRIBUTES ===== //
        testTruth(
            not solar_inputs.renewable_inputs.production_inputs.print_flag,
            __FILE__,
            __LINE__
        );
        testFloatEquals(
            test_solar_ptr->type,
            RenewableType :: SOLAR,
            __FILE__,
            __LINE__
        );
        testTruth(
            test_solar_ptr->type_str == "SOLAR",
            __FILE__,
            __LINE__
        );
    }
}
```

```

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

```

```

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

```

```

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

```

## 5.37 test/source/Production/Renewable/test\_Tidal.cpp File Reference

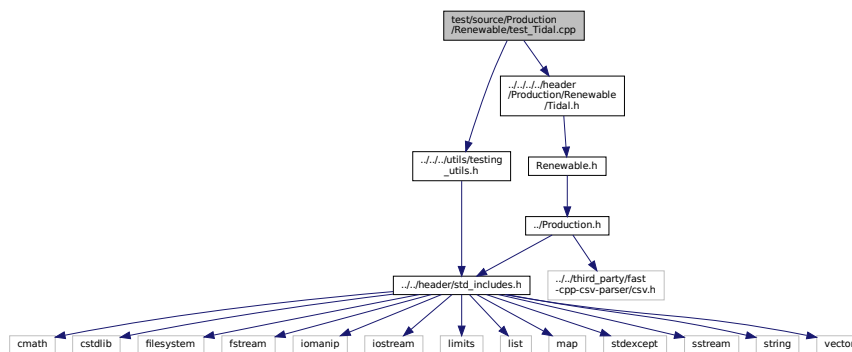
Testing suite for [Tidal](#) class.

```

#include "../.../utils/testing_utils.h"
#include "../.../header/Production/Renewable/Tidal.h"

```

Include dependency graph for test\_Tidal.cpp:



## Functions

- int [main](#) (int argc, char \*\*argv)

### 5.37.1 Detailed Description

Testing suite for [Tidal](#) class.

A suite of tests for the [Tidal](#) class.

### 5.37.2 Function Documentation

## 5.37.2.1 main()

```

int main (
    int argc,
    char ** argv )
27 {
28     #ifdef _WIN32
29         activateVirtualTerminal();
30     #endif /* _WIN32 */
31
32     printGold("\tTesting Production <-- Renewable <-- Tidal");
33
34     srand(time(NULL));
35
36     Renewable* test_tidal_ptr;
37
38     try {
39
40         // ===== CONSTRUCTION ===== //
41
42         bool error_flag = true;
43
44         try {
45             TidalInputs bad_tidal_inputs;
46             bad_tidal_inputs.design_speed_ms = -1;
47
48             Tidal bad_tidal(8760, 1, bad_tidal_inputs);
49
50             error_flag = false;
51         } catch (...) {
52             // Task failed successfully! =P
53         }
54         if (not error_flag) {
55             expectedErrorNotDetected(__FILE__, __LINE__);
56         }
57
58         TidalInputs tidal_inputs;
59
60         test_tidal_ptr = new Tidal(8760, 1, tidal_inputs);
61
62         // ===== END CONSTRUCTION ===== //
63
64
65
66         // ===== ATTRIBUTES ===== //
67
68         testTruth(
69             not tidal_inputs.renewable_inputs.production_inputs.print_flag,
70             __FILE__,
71             __LINE__
72 );
73
74         testFloatEquals(
75             test_tidal_ptr->type,
76             RenewableType :: TIDAL,
77             __FILE__,
78             __LINE__
79 );
80
81         testTruth(
82             test_tidal_ptr->type_str == "TIDAL",
83             __FILE__,
84             __LINE__
85 );
86
87         testFloatEquals(
88             test_tidal_ptr->capital_cost,
89             500237.446725,
90             __FILE__,
91             __LINE__
92 );
93
94         testFloatEquals(
95             test_tidal_ptr->operation_maintenance_cost_kWh,
96             0.069905,
97             __FILE__,
98             __LINE__
99 );
100
101         // ===== END ATTRIBUTES ===== //
102
103
104
105         // ===== METHODS ===== //
106

```

```

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

```

```

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

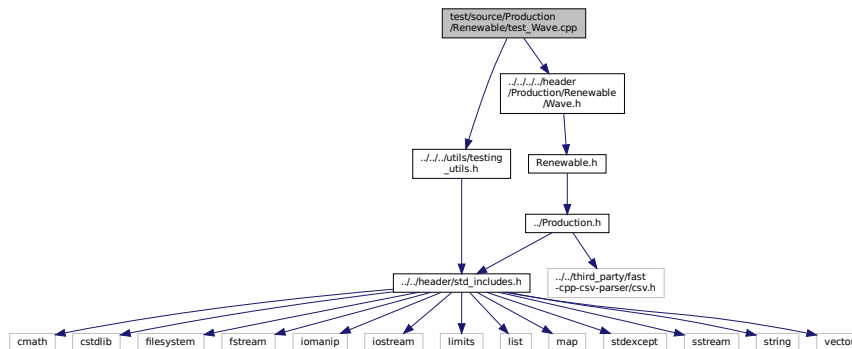
```

## 5.38 test/source/Production/Renewable/test\_Wave.cpp File Reference

Testing suite for [Wave](#) class.



```
#include "../../utils/testing_utils.h"
#include "../../header/Production/Renewable/Wave.h"
Include dependency graph for test_Wave.cpp:
```



## Functions

- int [main](#) (int argc, char \*\*argv)

### 5.38.1 Detailed Description

Testing suite for [Wave](#) class.

A suite of tests for the [Wave](#) class.

### 5.38.2 Function Documentation

#### 5.38.2.1 main()

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

```

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

```

```

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

```

```

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

```

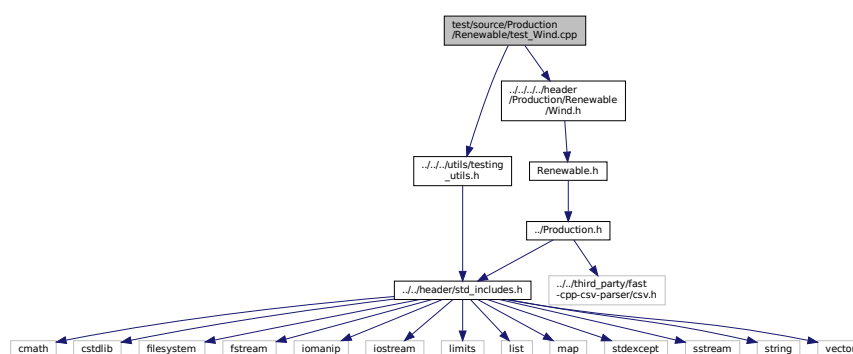
## 5.39 test/source/Production/Renewable/test\_Wind.cpp File Reference

Testing suite for [Wind](#) class.

```
#include "../.../utils/testing_utils.h"
```

```
#include "../.../header/Production/Renewable/Wind.h"
```

Include dependency graph for test\_Wind.cpp:



## Functions

- int [main](#) (int argc, char \*\*argv)

### 5.39.1 Detailed Description

Testing suite for [Wind](#) class.

A suite of tests for the [Wind](#) class.

### 5.39.2 Function Documentation

#### 5.39.2.1 main()

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

```

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

```

```

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

```

```

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

```

## 5.40 test/source/Production/test\_Production.cpp File Reference

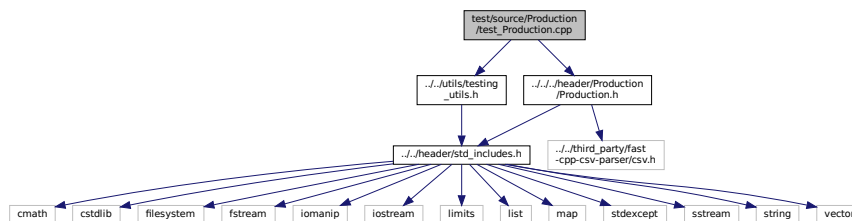
Testing suite for [Production](#) class.

```

#include "../utils/testing_utils.h"
#include "../../header/Production/Production.h"

```

Include dependency graph for test\_Production.cpp:



## Functions

- int [main](#) (int argc, char \*\*argv)

### 5.40.1 Detailed Description

Testing suite for [Production](#) class.

A suite of tests for the [Production](#) class.

### 5.40.2 Function Documentation



## 5.40.2.1 main()

```

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

```

```

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

```

## 5.41 test/source/Storage/test\_Lilon.cpp File Reference

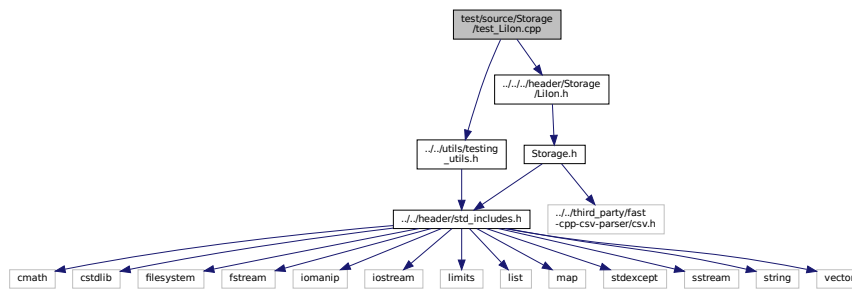
Testing suite for [Lilon](#) class.

```

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

```

Include dependency graph for test\_Lilon.cpp:



## Functions

- int [main](#) (int argc, char \*\*argv)

### 5.41.1 Detailed Description

Testing suite for [Lilon](#) class.

A suite of tests for the [Lilon](#) class.

### 5.41.2 Function Documentation

#### 5.41.2.1 main()

```

int main (
    int argc,
    char ** argv )
{
    27 {
    28     #ifdef _WIN32
    29         activateVirtualTerminal();
    30     #endif /* _WIN32 */
    31
    32     printGold("\tTesting Storage <-- LiIon");
    33
    34     srand(time(NULL));
    35
    36
    37     try {
    38
    39     // ===== CONSTRUCTION ===== //
    40
    41     bool error_flag = true;
    42
    43     try {
    44         LiIonInputs bad_liion_inputs;
    45         bad_liion_inputs.min_SOC = -1;
    46
    47         LiIon bad_liion(8760, 1, bad_liion_inputs);
    48
    49         error_flag = false;
    50     } catch (...) {
    51         // Task failed successfully! =P
    52     }
  
```

```

53 if (not error_flag) {
54     expectedErrorNotDetected(__FILE__, __LINE__);
55 }
56
57 LiIonInputs liion_inputs;
58
59 LiIon test_liion(8760, 1, liion_inputs);
60
61 // ===== END CONSTRUCTION ===== //
62
63
64
65 // ===== ATTRIBUTES ===== //
66
67 testTruth(
68     test_liion.type_str == "LIION",
69     __FILE__,
70     __LINE__
71 );
72
73 testFloatEquals(
74     test_liion.init_SOC,
75     0.5,
76     __FILE__,
77     __LINE__
78 );
79
80 testFloatEquals(
81     test_liion.min_SOC,
82     0.15,
83     __FILE__,
84     __LINE__
85 );
86
87 testFloatEquals(
88     test_liion.hysteresis_SOC,
89     0.5,
90     __FILE__,
91     __LINE__
92 );
93
94 testFloatEquals(
95     test_liion.max_SOC,
96     0.9,
97     __FILE__,
98     __LINE__
99 );
100
101 testFloatEquals(
102     test_liion.charging_efficiency,
103     0.9,
104     __FILE__,
105     __LINE__
106 );
107
108 testFloatEquals(
109     test_liion.discharging_efficiency,
110     0.9,
111     __FILE__,
112     __LINE__
113 );
114
115 testFloatEquals(
116     test_liion.replace_SOH,
117     0.8,
118     __FILE__,
119     __LINE__
120 );
121
122 testFloatEquals(
123     test_liion.power_kW,
124     0,
125     __FILE__,
126     __LINE__
127 );
128
129 testFloatEquals(
130     test_liion.SOH_vec.size(),
131     8760,
132     __FILE__,
133     __LINE__
134 );
135
136 // ===== END ATTRIBUTES ===== //
137
138
139

```

```

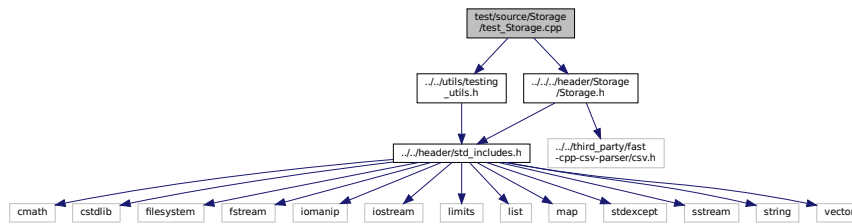
140 // ===== METHODS ===== //
141
142 testFloatEquals(
143     test_liion.getAvailablekW(1),
144     100, // hits power capacity constraint
145     __FILE__,
146     __LINE__
147 );
148
149 testFloatEquals(
150     test_liion.getAcceptablekW(1),
151     100, // hits power capacity constraint
152     __FILE__,
153     __LINE__
154 );
155
156 test_liion.power_kW = 100;
157
158 testFloatEquals(
159     test_liion.getAvailablekW(1),
160     100, // hits power capacity constraint
161     __FILE__,
162     __LINE__
163 );
164
165 testFloatEquals(
166     test_liion.getAcceptablekW(1),
167     100, // hits power capacity constraint
168     __FILE__,
169     __LINE__
170 );
171
172 test_liion.power_kW = 1e6;
173
174 testFloatEquals(
175     test_liion.getAvailablekW(1),
176     0, // is already hitting power capacity constraint
177     __FILE__,
178     __LINE__
179 );
180
181 testFloatEquals(
182     test_liion.getAcceptablekW(1),
183     0, // is already hitting power capacity constraint
184     __FILE__,
185     __LINE__
186 );
187
188 test_liion.commitCharge(0, 1, 100);
189
190 testFloatEquals(
191     test_liion.power_kW,
192     0,
193     __FILE__,
194     __LINE__
195 );
196
197 // ===== END METHODS ===== //
198
199 } /* try */
200
201
202 catch (...) {
203     //...
204
205     printGold(" ..... ");
206     printRed("FAIL");
207     std::cout << std::endl;
208     throw;
209 }
210
211
212 printGold(" ..... ");
213 printGreen("PASS");
214 std::cout << std::endl;
215 return 0;
216 } /* main() */

```

## 5.42 test/source/Storage/test\_Storage.cpp File Reference

Testing suite for [Storage](#) class.

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



## Functions

- int [main](#) (int argc, char \*\*argv)

### 5.42.1 Detailed Description

Testing suite for [Storage](#) class.

A suite of tests for the [Storage](#) class.

### 5.42.2 Function Documentation

#### 5.42.2.1 main()

```
int main (
    int argc,
    char ** argv )
{
    27 {
    28     #ifdef _WIN32
    29         activateVirtualTerminal();
    30     #endif /* _WIN32 */
    31
    32     printGold("\tTesting Storage");
    33
    34     srand(time(NULL));
    35
    36
    37     try {
    38
    39         // ===== CONSTRUCTION ===== //
    40
    41     bool error_flag = true;
    42
    43     try {
    44         StorageInputs bad_storage_inputs;
    45         bad_storage_inputs.energy_capacity_kWh = 0;
    46
    47         Storage bad_storage(8760, 1, bad_storage_inputs);
    48
    49         error_flag = false;
    50     } catch (...) {
    51         // Task failed successfully! =P
    52     }
```

```

53 if (not error_flag) {
54     expectedErrorNotDetected(__FILE__, __LINE__);
55 }
56
57 StorageInputs storage_inputs;
58
59 Storage test_storage(8760, 1, storage_inputs);
60
61 // ===== END CONSTRUCTION ===== //
62
63
64
65 // ===== ATTRIBUTES ===== //
66
67 testFloatEquals(
68     test_storage.power_capacity_kW,
69     100,
70     __FILE__,
71     __LINE__
72 );
73
74 testFloatEquals(
75     test_storage.energy_capacity_kWh,
76     1000,
77     __FILE__,
78     __LINE__
79 );
80
81 testFloatEquals(
82     test_storage.charge_vec_kWh.size(),
83     8760,
84     __FILE__,
85     __LINE__
86 );
87
88 testFloatEquals(
89     test_storage.charging_power_vec_kW.size(),
90     8760,
91     __FILE__,
92     __LINE__
93 );
94
95 testFloatEquals(
96     test_storage.discharging_power_vec_kW.size(),
97     8760,
98     __FILE__,
99     __LINE__
100 );
101
102 testFloatEquals(
103     test_storage.capital_cost_vec.size(),
104     8760,
105     __FILE__,
106     __LINE__
107 );
108
109 testFloatEquals(
110     test_storage.operation_maintenance_cost_vec.size(),
111     8760,
112     __FILE__,
113     __LINE__
114 );
115
116 // ===== END ATTRIBUTES ===== //
117
118
119
120 // ===== METHODS ===== //
121
122 //...
123
124 // ===== END METHODS ===== //
125
126 } /* try */
127
128
129 catch (...) {
130     //...
131
132     printGold(" ..... ");
133     printRed("FAIL");
134     std::cout << std::endl;
135     throw;
136 }
137
138
139 printGold(" ..... ");

```

```

140 printGreen("PASS");
141 std::cout << std::endl;
142 return 0;
143 } /* main() */

```

## 5.43 test/source/test\_Controller.cpp File Reference

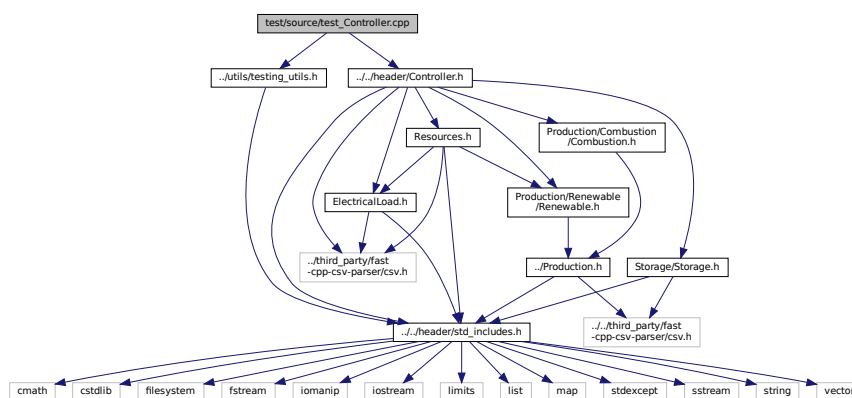
Testing suite for [Controller](#) class.

```

#include "../utils/testing_utils.h"
#include "../../header/Controller.h"

```

Include dependency graph for test\_Controller.cpp:



## Functions

- int [main](#) (int argc, char \*\*argv)

### 5.43.1 Detailed Description

Testing suite for [Controller](#) class.

A suite of tests for the [Controller](#) class.

### 5.43.2 Function Documentation



## 5.43.2.1 main()

```

int main (
    int argc,
    char ** argv )
27 {
28     #ifdef _WIN32
29         activateVirtualTerminal();
30     #endif /* _WIN32 */
31
32     printGold("\tTesting Controller");
33
34     srand(time(NULL));
35
36
37     try {
38
39         // ===== CONSTRUCTION ===== //
40
41         Controller test_controller;
42
43         // ===== END CONSTRUCTION =====//
44
45
46
47         // ===== ATTRIBUTES ===== //
48
49         //...
50
51         // ===== END ATTRIBUTES ===== //
52
53
54
55         // ===== METHODS ===== //
56
57         //...
58
59         // ===== END METHODS ===== //
60
61     } /* try */
62
63
64     catch (...) {
65         //...
66
67         printGold(" ..... ");
68         printRed("FAIL");
69         std::cout << std::endl;
70         throw;
71     }
72
73
74     printGold(" ..... ");
75     printGreen("PASS");
76     std::cout << std::endl;
77     return 0;
78 } /* main() */

```

## 5.44 test/source/test\_ElectricalLoad.cpp File Reference

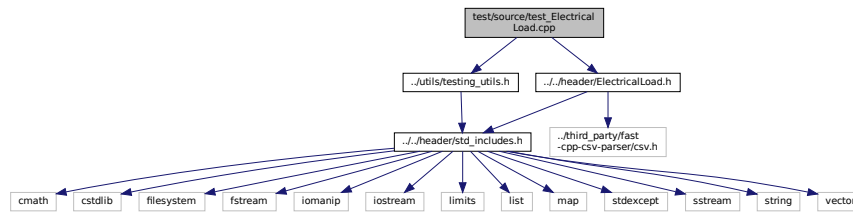
Testing suite for [ElectricalLoad](#) class.

```

#include "../utils/testing_utils.h"
#include "../header/ElectricalLoad.h"

```

Include dependency graph for test\_ElectricalLoad.cpp:



## Functions

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

### 5.44.1 Detailed Description

Testing suite for `ElectricalLoad` class.

A suite of tests for the `ElectricalLoad` class.

### 5.44.2 Function Documentation

#### 5.44.2.1 main()

```

int main (
    int argc,
    char ** argv )
{
    27 {
    28     #ifdef _WIN32
    29         activateVirtualTerminal();
    30     #endif /* _WIN32 */
    31
    32     printGold("\tTesting ElectricalLoad");
    33
    34     srand(time(NULL));
    35
    36
    37     try {
    38
    39 // ===== CONSTRUCTION ===== //
    40
    41     std::string path_2_electrical_load_time_series =
    42         "data/test/electrical_load_generic_peak-500kW_1yr_dt-1hr.csv";
    43
    44     ElectricalLoad test_electrical_load(path_2_electrical_load_time_series);
    45
    46 // ===== END CONSTRUCTION ===== //
    47
    48
    49
    50 // ===== ATTRIBUTES ===== //
    51
    52     testTruth(
    53         test_electrical_load.path_2_electrical_load_time_series ==
    54         path_2_electrical_load_time_series,
    55         __FILE__,

```

```

56     __LINE__
57 );
58
59 testFloatEquals(
60     test_electrical_load.n_points,
61     8760,
62     __FILE__,
63     __LINE__
64 );
65
66 testFloatEquals(
67     test_electrical_load.n_years,
68     0.999886,
69     __FILE__,
70     __LINE__
71 );
72
73 testFloatEquals(
74     test_electrical_load.min_load_kW,
75     82.1211213927802,
76     __FILE__,
77     __LINE__
78 );
79
80 testFloatEquals(
81     test_electrical_load.mean_load_kW,
82     258.373472633202,
83     __FILE__,
84     __LINE__
85 );
86
87
88 testFloatEquals(
89     test_electrical_load.max_load_kW,
90     500,
91     __FILE__,
92     __LINE__
93 );
94
95
96 std::vector<double> expected_dt_vec_hrs (48, 1);
97
98 std::vector<double> expected_time_vec_hrs = {
99     0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11,
100    12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23,
101    24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35,
102    36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47
103 };
104
105 std::vector<double> expected_load_vec_kW = {
106    360.253836463674,
107    355.171277826775,
108    353.776453532298,
109    353.75405737934,
110    346.592867404975,
111    340.132411175118,
112    337.354867340578,
113    340.644115618736,
114    363.639028500678,
115    378.787797779238,
116    372.215798201712,
117    395.093925731298,
118    402.325427142659,
119    386.907725462306,
120    380.709170928091,
121    372.062070914977,
122    372.328646856954,
123    391.841444284136,
124    394.029351759596,
125    383.369407765254,
126    381.093099675206,
127    382.604158946193,
128    390.744843709034,
129    383.13949492437,
130    368.150393976985,
131    364.629744480226,
132    363.572736804082,
133    359.854924202248,
134    355.207590170267,
135    349.094656012401,
136    354.365935871597,
137    343.380608328546,
138    404.673065729266,
139    486.296896820126,
140    480.225974100847,
141    457.318764401085,
142    418.177339948609,

```

```

143     414.399018364126,
144     409.678420185754,
145     404.768766016563,
146     401.699589920585,
147     402.44339040654,
148     398.138372541906,
149     396.010498627646,
150     390.165117432277,
151     375.850429417013,
152     365.567100746484,
153     365.429624610923
154 };
155
156 for (int i = 0; i < 48; i++) {
157     testFloatEquals(
158         test_electrical_load.dt_vec_hrs[i],
159         expected_dt_vec_hrs[i],
160         __FILE__,
161         __LINE__
162     );
163
164     testFloatEquals(
165         test_electrical_load.time_vec_hrs[i],
166         expected_time_vec_hrs[i],
167         __FILE__,
168         __LINE__
169     );
170
171     testFloatEquals(
172         test_electrical_load.load_vec_kW[i],
173         expected_load_vec_kW[i],
174         __FILE__,
175         __LINE__
176     );
177 }
178
179 // ===== END ATTRIBUTES ===== //
180
181 } /* try */
182
183 catch (...) {
184     //...
185
186     printGold(" ..... ");
187     printRed("FAIL");
188     std::cout << std::endl;
189     throw;
190 }
191
192
193
194 printGold(" ..... ");
195 printGreen("PASS");
196 std::cout << std::endl;
197 return 0;
198 } /* main() */

```

## 5.45 test/source/test\_Interpolator.cpp File Reference

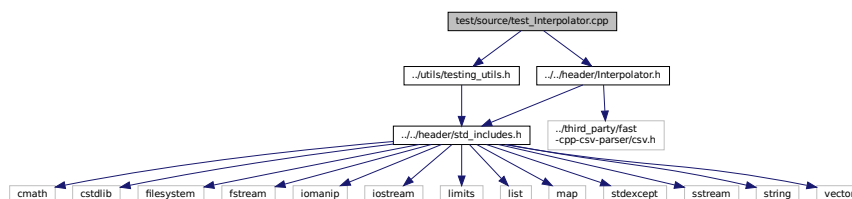
Testing suite for [Interpolator](#) class.

```

#include "../utils/testing_utils.h"
#include "../header/Interpolator.h"

```

Include dependency graph for test\_Interpolator.cpp:



## Functions

- int [main](#) (int argc, char \*\*argv)

### 5.45.1 Detailed Description

Testing suite for [Interpolator](#) class.

A suite of tests for the [Interpolator](#) class.

### 5.45.2 Function Documentation

#### 5.45.2.1 main()

```
int main (
    int argc,
    char ** argv )
27 {
28     #ifdef _WIN32
29         activateVirtualTerminal();
30     #endif /* _WIN32 */
31
32     printGold("\n\tTesting Interpolator");
33
34     srand(time(NULL));
35
36
37     try {
38
39         // ===== CONSTRUCTION ===== //
40
41         //...
42
43         // ===== END CONSTRUCTION =====//
44
45
46
47         // ===== ATTRIBUTES ===== //
48
49         //...
50
51         // ===== END ATTRIBUTES ===== //
52
53
54
55         // ===== METHODS ===== //
56
57         //...
58
59         // ===== END METHODS ===== //
60
61     } /* try */
62
63
64     catch (...) {
65         //...
66
67         printGold(" ..... ");
68         printRed("FAIL");
69         std::cout << std::endl;
70         throw;
71     }
72
73
74     printGold(" ..... ");
75     printGreen("PASS");
76     std::cout << std::endl;
77     return 0;
78 } /* main() */
```

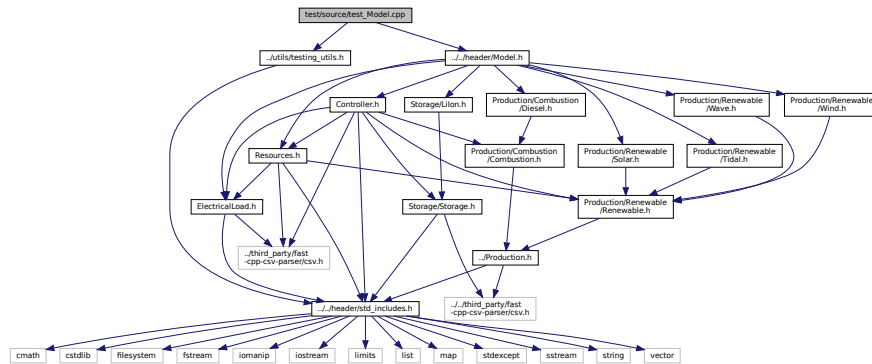
## 5.46 test/source/test\_Model.cpp File Reference

Testing suite for [Model](#) class.

```
#include "../utils/testing_utils.h"
```

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

Include dependency graph for test\_Model.cpp:



### Functions

- [int main](#) (int argc, char \*\*argv)

#### 5.46.1 Detailed Description

Testing suite for [Model](#) class.

A suite of tests for the [Model](#) class.

#### 5.46.2 Function Documentation

##### 5.46.2.1 main()

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

```

40
41 bool error_flag = true;
42
43 try {
44     ModelInputs bad_model_inputs;
45     bad_model_inputs.path_2_electrical_load_time_series =
46         "data/test/bad_path_240984069830.csv";
47
48     Model bad_model(bad_model_inputs);
49
50     error_flag = false;
51 } catch (...) {
52     // Task failed successfully! =P
53 }
54 if (not error_flag) {
55     expectedErrorNotDetected(__FILE__, __LINE__);
56 }
57
58 std::string path_2_electrical_load_time_series =
59     "data/test/electrical_load_generic_peak-500kW_1yr_dt-1hr.csv";
60
61 ModelInputs test_model_inputs;
62 test_model_inputs.path_2_electrical_load_time_series =
63     path_2_electrical_load_time_series;
64
65 Model test_model(test_model_inputs);
66
67 // ===== END CONSTRUCTION ===== //
68
69
70 // ===== ATTRIBUTES ===== //
71
72 testTruth(
73     test_model.electrical_load.path_2_electrical_load_time_series ==
74     path_2_electrical_load_time_series,
75     __FILE__,
76     __LINE__
77 );
78
79 testFloatEquals(
80     test_model.electrical_load.n_points,
81     8760,
82     __FILE__,
83     __LINE__
84 );
85
86 testFloatEquals(
87     test_model.electrical_load.n_years,
88     0.999886,
89     __FILE__,
90     __LINE__
91 );
92
93 testFloatEquals(
94     test_model.electrical_load.min_load_kW,
95     82.1211213927802,
96     __FILE__,
97     __LINE__
98 );
99
100 testFloatEquals(
101     test_model.electrical_load.mean_load_kW,
102     258.373472633202,
103     __FILE__,
104     __LINE__
105 );
106
107
108 testFloatEquals(
109     test_model.electrical_load.max_load_kW,
110     500,
111     __FILE__,
112     __LINE__
113 );
114
115
116 std::vector<double> expected_dt_vec_hrs (48, 1);
117
118 std::vector<double> expected_time_vec_hrs = {
119     0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11,
120     12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23,
121     24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35,
122     36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47
123 };
124
125 std::vector<double> expected_load_vec_kW = {
126     360.253836463674,

```

```

127     355.171277826775,
128     353.776453532298,
129     353.75405737934,
130     346.592867404975,
131     340.132411175118,
132     337.354867340578,
133     340.644115618736,
134     363.639028500678,
135     378.787797779238,
136     372.215798201712,
137     395.093925731298,
138     402.325427142659,
139     386.907725462306,
140     380.709170928091,
141     372.062070914977,
142     372.328646856954,
143     391.841444284136,
144     394.029351759596,
145     383.369407765254,
146     381.093099675206,
147     382.604158946193,
148     390.744843709034,
149     383.13949492437,
150     368.150393976985,
151     364.629744480226,
152     363.572736804082,
153     359.854924202248,
154     355.207590170267,
155     349.094656012401,
156     354.365935871597,
157     343.380608328546,
158     404.673065729266,
159     486.296896820126,
160     480.225974100847,
161     457.318764401085,
162     418.177339948609,
163     414.399018364126,
164     409.678420185754,
165     404.768766016563,
166     401.699589920585,
167     402.44339040654,
168     398.138372541906,
169     396.010498627646,
170     390.165117432277,
171     375.850429417013,
172     365.567100746484,
173     365.429624610923
174 };
175
176 for (int i = 0; i < 48; i++) {
177     testFloatEquals(
178         test_model.electrical_load.dt_vec_hrs[i],
179         expected_dt_vec_hrs[i],
180         __FILE__,
181         __LINE__
182     );
183
184     testFloatEquals(
185         test_model.electrical_load.time_vec_hrs[i],
186         expected_time_vec_hrs[i],
187         __FILE__,
188         __LINE__
189     );
190
191     testFloatEquals(
192         test_model.electrical_load.load_vec_kW[i],
193         expected_load_vec_kW[i],
194         __FILE__,
195         __LINE__
196     );
197 }
198
199 // ===== END ATTRIBUTES ===== //
200
201
202
203 // ===== METHODS ===== //
204
205 // add Solar resource
206 int solar_resource_key = 0;
207 std::string path_2_solar_resource_data =
208     "data/test/solar_GHI_peak-1kWm2_1yr_dt-1hr.csv";
209
210 test_model.addResource(
211     RenewableType :: SOLAR,
212     path_2_solar_resource_data,
213     solar_resource_key

```



```

214 );
215
216 std::vector<double> expected_solar_resource_vec_kWm2 = {
217     0,
218     0,
219     0,
220     0,
221     0,
222     0,
223     8.51702662684015E-05,
224     0.000348341567045,
225     0.00213793728593,
226     0.004099863613322,
227     0.000997135230553,
228     0.009534527624657,
229     0.022927996790616,
230     0.0136071715294,
231     0.002535134127751,
232     0.005206897515821,
233     0.005627658648597,
234     0.000701186722215,
235     0.00017119827089,
236     0,
237     0,
238     0,
239     0,
240     0,
241     0,
242     0,
243     0,
244     0,
245     0,
246     0,
247     0,
248     0.000141055102242,
249     0.00084525014743,
250     0.024893647822702,
251     0.091245556190749,
252     0.158722176731637,
253     0.152859680515876,
254     0.149922903895116,
255     0.13049996570866,
256     0.03081254222795,
257     0.001218928911125,
258     0.000206092647423,
259     0,
260     0,
261     0,
262     0,
263     0,
264     0
265 };
266
267 for (size_t i = 0; i < expected_solar_resource_vec_kWm2.size(); i++) {
268     testFloatEquals(
269         test_model.resources.resource_map_1D[solar_resource_key][i],
270         expected_solar_resource_vec_kWm2[i],
271         __FILE__,
272         __LINE__
273     );
274 }
275
276
277 // add Tidal resource
278 int tidal_resource_key = 1;
279 std::string path_2_tidal_resource_data =
280     "data/test/tidal_speed_peak-3ms_lyr_dt-1hr.csv";
281
282 test_model.addResource(
283     RenewableType :: TIDAL,
284     path_2_tidal_resource_data,
285     tidal_resource_key
286 );
287
288
289 // add Wave resource
290 int wave_resource_key = 2;
291 std::string path_2_wave_resource_data =
292     "data/test/waves_H_s_peak-8m_T_e_peak-15s_lyr_dt-1hr.csv";
293
294 test_model.addResource(
295     RenewableType :: WAVE,
296     path_2_wave_resource_data,
297     wave_resource_key
298 );
299
300

```

```

301 // add Wind resource
302 int wind_resource_key = 3;
303 std::string path_2_wind_resource_data =
304     "data/test/wind_speed_peak-25ms_1yr_dt-1hr.csv";
305
306 test_model.addResource(
307     RenewableType :: WIND,
308     path_2_wind_resource_data,
309     wind_resource_key
310 );
311
312
313 // add Diesel assets
314 DieselInputs diesel_inputs;
315 diesel_inputs.combustion_inputs.production_inputs.capacity_kW = 100;
316 diesel_inputs.combustion_inputs.production_inputs.is_sunk = true;
317
318 test_model.addDiesel(diesel_inputs);
319
320 testFloatEquals(
321     test_model.combustion_ptr_vec.size(),
322     1,
323     __FILE__,
324     __LINE__
325 );
326
327 testFloatEquals(
328     test_model.combustion_ptr_vec[0]->type,
329     CombustionType :: DIESEL,
330     __FILE__,
331     __LINE__
332 );
333
334 diesel_inputs.combustion_inputs.production_inputs.capacity_kW = 150;
335
336 test_model.addDiesel(diesel_inputs);
337
338 diesel_inputs.combustion_inputs.production_inputs.capacity_kW = 250;
339
340 test_model.addDiesel(diesel_inputs);
341
342 testFloatEquals(
343     test_model.combustion_ptr_vec.size(),
344     3,
345     __FILE__,
346     __LINE__
347 );
348
349 std::vector<int> expected_diesel_capacity_vec_kW = {100, 150, 250};
350
351 for (int i = 0; i < 3; i++) {
352     testFloatEquals(
353         test_model.combustion_ptr_vec[i]->capacity_kW,
354         expected_diesel_capacity_vec_kW[i],
355         __FILE__,
356         __LINE__
357     );
358 }
359
360 diesel_inputs.combustion_inputs.production_inputs.capacity_kW = 100;
361
362 for (int i = 0; i < 2 * ((double)rand() / RAND_MAX); i++) {
363     test_model.addDiesel(diesel_inputs);
364 }
365
366
367 // add Solar asset
368 SolarInputs solar_inputs;
369 solar_inputs.resource_key = solar_resource_key;
370
371 test_model.addSolar(solar_inputs);
372
373 testFloatEquals(
374     test_model.renewable_ptr_vec.size(),
375     1,
376     __FILE__,
377     __LINE__
378 );
379
380 testFloatEquals(
381     test_model.renewable_ptr_vec[0]->type,
382     RenewableType :: SOLAR,
383     __FILE__,
384     __LINE__
385 );
386
387

```

```
388 // add Tidal asset
389 TidalInputs tidal_inputs;
390 tidal_inputs.resource_key = tidal_resource_key;
391
392 test_model.addTidal(tidal_inputs);
393
394 testFloatEquals(
395     test_model.renewable_ptr_vec.size(),
396     2,
397     __FILE__,
398     __LINE__
399 );
400
401 testFloatEquals(
402     test_model.renewable_ptr_vec[1]->type,
403     RenewableType :: TIDAL,
404     __FILE__,
405     __LINE__
406 );
407
408
409 // add Wave asset
410 WaveInputs wave_inputs;
411 wave_inputs.resource_key = wave_resource_key;
412
413 test_model.addWave(wave_inputs);
414
415 testFloatEquals(
416     test_model.renewable_ptr_vec.size(),
417     3,
418     __FILE__,
419     __LINE__
420 );
421
422 testFloatEquals(
423     test_model.renewable_ptr_vec[2]->type,
424     RenewableType :: WAVE,
425     __FILE__,
426     __LINE__
427 );
428
429
430 // add Wind asset
431 WindInputs wind_inputs;
432 wind_inputs.resource_key = wind_resource_key;
433
434 test_model.addWind(wind_inputs);
435
436 testFloatEquals(
437     test_model.renewable_ptr_vec.size(),
438     4,
439     __FILE__,
440     __LINE__
441 );
442
443 testFloatEquals(
444     test_model.renewable_ptr_vec[3]->type,
445     RenewableType :: WIND,
446     __FILE__,
447     __LINE__
448 );
449
450
451 // add LiIon asset
452 LiIonInputs liion_inputs;
453
454 test_model.addLiIon(liion_inputs);
455
456 testFloatEquals(
457     test_model.storage_ptr_vec.size(),
458     1,
459     __FILE__,
460     __LINE__
461 );
462
463 testFloatEquals(
464     test_model.storage_ptr_vec[0]->type,
465     StorageType :: LIION,
466     __FILE__,
467     __LINE__
468 );
469
470
471 // run
472 test_model.run();
473
474
```

```

475 // write results
476 test_model.writeResults("test/test_results/");
477
478
479 // test post-run attributes
480 double net_load_kW;
481
482 Combustion* combustion_ptr;
483 Renewable* renewable_ptr;
484 Storage* storage_ptr;
485
486 for (int i = 0; i < test_model.electrical_load.n_points; i++) {
487     net_load_kW = test_model.controller.net_load_vec_kW[i];
488
489     testLessThanOrEqualTo(
490         test_model.controller.net_load_vec_kW[i],
491         test_model.electrical_load.max_load_kW,
492         __FILE__,
493         __LINE__
494     );
495
496     for (size_t j = 0; j < test_model.combustion_ptr_vec.size(); j++) {
497         combustion_ptr = test_model.combustion_ptr_vec[j];
498
499         testFloatEquals(
500             combustion_ptr->production_vec_kW[i] -
501             combustion_ptr->dispatch_vec_kW[i] -
502             combustion_ptr->curtailment_vec_kW[i] -
503             combustion_ptr->storage_vec_kW[i],
504             0,
505             __FILE__,
506             __LINE__
507         );
508
509         net_load_kW -= combustion_ptr->production_vec_kW[i];
510     }
511
512     for (size_t j = 0; j < test_model.renewable_ptr_vec.size(); j++) {
513         renewable_ptr = test_model.renewable_ptr_vec[j];
514
515         testFloatEquals(
516             renewable_ptr->production_vec_kW[i] -
517             renewable_ptr->dispatch_vec_kW[i] -
518             renewable_ptr->curtailment_vec_kW[i] -
519             renewable_ptr->storage_vec_kW[i],
520             0,
521             __FILE__,
522             __LINE__
523         );
524
525         net_load_kW -= renewable_ptr->production_vec_kW[i];
526     }
527
528     for (size_t j = 0; j < test_model.storage_ptr_vec.size(); j++) {
529         storage_ptr = test_model.storage_ptr_vec[j];
530
531         testTruth(
532             not (
533                 storage_ptr->charging_power_vec_kW[i] > 0 and
534                 storage_ptr->discharging_power_vec_kW[i] > 0
535             ),
536             __FILE__,
537             __LINE__
538         );
539
540         net_load_kW -= storage_ptr->discharging_power_vec_kW[i];
541     }
542
543     testLessThanOrEqualTo(
544         net_load_kW,
545         0,
546         __FILE__,
547         __LINE__
548     );
549 }
550
551 testGreaterThan(
552     test_model.net_present_cost,
553     0,
554     __FILE__,
555     __LINE__
556 );
557
558 testFloatEquals(
559     test_model.total_dispatch_discharge_kWh,
560     2263351.62026685,
561     __FILE__,

```

```

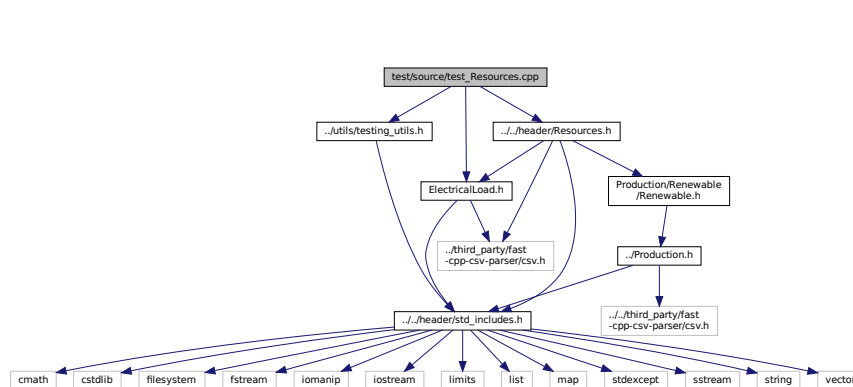
562     __LINE__
563 );
564
565 testGreaterThan(
566     test_model.levelized_cost_of_energy_kWh,
567     0,
568     __FILE__,
569     __LINE__
570 );
571
572 testGreaterThan(
573     test_model.total_fuel_consumed_L,
574     0,
575     __FILE__,
576     __LINE__
577 );
578
579 testGreaterThan(
580     test_model.total_emissions.CO2_kg,
581     0,
582     __FILE__,
583     __LINE__
584 );
585
586 testGreaterThan(
587     test_model.total_emissions.CO_kg,
588     0,
589     __FILE__,
590     __LINE__
591 );
592
593 testGreaterThan(
594     test_model.total_emissions.NOx_kg,
595     0,
596     __FILE__,
597     __LINE__
598 );
599
600 testGreaterThan(
601     test_model.total_emissions.SOx_kg,
602     0,
603     __FILE__,
604     __LINE__
605 );
606
607 testGreaterThan(
608     test_model.total_emissions.CH4_kg,
609     0,
610     __FILE__,
611     __LINE__
612 );
613
614 testGreaterThan(
615     test_model.total_emissions.PM_kg,
616     0,
617     __FILE__,
618     __LINE__
619 );
620
621 // ===== END METHODS ===== //
622
623 } /* try */
624
625
626 catch (...) {
627     //...
628
629     printGold(" ..... ");
630     printRed("FAIL");
631     std::cout << std::endl;
632     throw;
633 }
634
635
636 printGold(" ..... ");
637 printGreen("PASS");
638 std::cout << std::endl;
639 return 0;
640 } /* main() */

```

## 5.47 test/source/test\_Resources.cpp File Reference

Testing suite for [Resources](#) class.

```
#include "../utils/testing_utils.h"
#include "../../header/Resources.h"
#include "../../header/ElectricalLoad.h"
Include dependency graph for test_Resources.cpp:
```



## Functions

- int [main](#) (int argc, char \*\*argv)

### 5.47.1 Detailed Description

Testing suite for [Resources](#) class.

A suite of tests for the [Resources](#) class.

### 5.47.2 Function Documentation

#### 5.47.2.1 main()

```
int main (
    int argc,
    char ** argv )
{
    #ifdef _WIN32
        activateVirtualTerminal();
    #endif /* _WIN32 */
    printGold("\tTesting Resources");
    srand(time(NULL));

    try {
        // ===== CONSTRUCTION =====
        std::string path_2_electrical_load_time_series =
            "data/test/electrical_load_generic_peak-500kW_1yr-dt-1hr.csv";
        ElectricalLoad test_electrical_load(path_2_electrical_load_time_series);
    }
}
```

```

47 Resources test_resources;
48
49 // ===== END CONSTRUCTION ===== //
50
51
52
53 // ===== ATTRIBUTES ===== //
54
55 testFloatEquals(
56     test_resources.resource_map_1D.size(),
57     0,
58     __FILE__,
59     __LINE__
60 );
61
62 testFloatEquals(
63     test_resources.path_map_1D.size(),
64     0,
65     __FILE__,
66     __LINE__
67 );
68
69 testFloatEquals(
70     test_resources.resource_map_2D.size(),
71     0,
72     __FILE__,
73     __LINE__
74 );
75
76 testFloatEquals(
77     test_resources.path_map_2D.size(),
78     0,
79     __FILE__,
80     __LINE__
81 );
82
83 // ===== END ATTRIBUTES ===== //
84
85
86 // ===== METHODS ===== //
87
88 int solar_resource_key = 0;
89 std::string path_2_solar_resource_data =
90     "data/test/solar_GHI_peak-1kWm2_1yr_dt-1hr.csv";
91
92 test_resources.addResource(
93     RenewableType::SOLAR,
94     path_2_solar_resource_data,
95     solar_resource_key,
96     &test_electrical_load
97 );
98
99 bool error_flag = true;
100 try {
101     test_resources.addResource(
102         RenewableType::SOLAR,
103         path_2_solar_resource_data,
104         solar_resource_key,
105         &test_electrical_load
106     );
107
108     error_flag = false;
109 } catch (...) {
110     // Task failed successfully! =P
111 }
112 if (not error_flag) {
113     expectedErrorNotDetected(__FILE__, __LINE__);
114 }
115
116
117 try {
118     std::string path_2_solar_resource_data_BAD_TIMES =
119         "data/test/solar_GHI_peak-1kWm2_1yr_dt-1hr_BAD_TIMES.csv";
120
121     test_resources.addResource(
122         RenewableType::SOLAR,
123         path_2_solar_resource_data_BAD_TIMES,
124         -1,
125         &test_electrical_load
126     );
127
128     error_flag = false;
129 } catch (...) {
130     // Task failed successfully! =P
131 }
132 if (not error_flag) {
133     expectedErrorNotDetected(__FILE__, __LINE__);

```

```

134 }
135
136
137 try {
138     std::string path_2_solar_resource_data_BAD_LENGTH =
139         "data/test/solar_GHI_peak-1kWm2_1yr_dt-1hr_BAD_LENGTH.csv";
140
141     test_resources.addResource(
142         RenewableType::SOLAR,
143         path_2_solar_resource_data_BAD_LENGTH,
144         -2,
145         &test_electrical_load
146     );
147
148     error_flag = false;
149 } catch (...) {
150     // Task failed successfully! =P
151 }
152 if (not error_flag) {
153     expectedErrorNotDetected(__FILE__, __LINE__);
154 }
155
156 std::vector<double> expected_solar_resource_vec_kWm2 = {
157     0,
158     0,
159     0,
160     0,
161     0,
162     0,
163     8.51702662684015E-05,
164     0.000348341567045,
165     0.00213793728593,
166     0.004099863613322,
167     0.000997135230553,
168     0.009534527624657,
169     0.022927996790616,
170     0.0136071715294,
171     0.002535134127751,
172     0.005206897515821,
173     0.005627658648597,
174     0.000701186722215,
175     0.00017119827089,
176     0,
177     0,
178     0,
179     0,
180     0,
181     0,
182     0,
183     0,
184     0,
185     0,
186     0,
187     0,
188     0.000141055102242,
189     0.00084525014743,
190     0.024893647822702,
191     0.091245556190749,
192     0.158722176731637,
193     0.152859680515876,
194     0.149922903895116,
195     0.13049996570866,
196     0.03081254222795,
197     0.001218928911125,
198     0.000206092647423,
199     0,
200     0,
201     0,
202     0,
203     0,
204     0
205 };
206
207 for (size_t i = 0; i < expected_solar_resource_vec_kWm2.size(); i++) {
208     testFloatEquals(
209         test_resources.resource_map_1D[solar_resource_key][i],
210         expected_solar_resource_vec_kWm2[i],
211         __FILE__,
212         __LINE__
213     );
214 }
215
216
217 int tidal_resource_key = 1;
218 std::string path_2_tidal_resource_data =
219     "data/test/tidal_speed_peak-3ms_1yr_dt-1hr.csv";
220

```



```

221 test_resources.addResource(
222     RenewableType::TIDAL,
223     path_2_tidal_resource_data,
224     tidal_resource_key,
225     &test_electrical_load
226 );
227
228 std::vector<double> expected_tidal_resource_vec_ms = {
229     0.347439913040533,
230     0.770545522195602,
231     0.731352084836198,
232     0.293389814389542,
233     0.209959110813115,
234     0.610609623896497,
235     1.78067162013604,
236     2.53522775118089,
237     2.75966627832024,
238     2.521011111143895,
239     2.05389330201031,
240     1.3461515862445,
241     0.28909254878384,
242     0.897754086048563,
243     1.71406453837407,
244     1.85047408742869,
245     1.71507908595979,
246     1.33540349705416,
247     0.434586143463003,
248     0.500623815700637,
249     1.37172172646733,
250     1.68294125491228,
251     1.56101300975417,
252     1.04925834219412,
253     0.211395463930223,
254     1.03720048903385,
255     1.85059536356448,
256     1.85203242794517,
257     1.4091471616277,
258     0.767776539039899,
259     0.251464906990961,
260     1.47018469375652,
261     2.36260493698197,
262     2.46653750048625,
263     2.12851908739291,
264     1.62783753197988,
265     0.734594890957439,
266     0.441886297300355,
267     1.6574418350918,
268     2.0684558286637,
269     1.87717416992136,
270     1.58871262337931,
271     1.03451227609235,
272     0.193371305159817,
273     0.976400122458815,
274     1.6583227369707,
275     1.76690616570953,
276     1.54801328553115
277 };
278
279 for (size_t i = 0; i < expected_tidal_resource_vec_ms.size(); i++) {
280     testFloatEquals(
281         test_resources.resource_map_1D[tidal_resource_key][i],
282         expected_tidal_resource_vec_ms[i],
283         __FILE__,
284         __LINE__
285     );
286 }
287
288
289 int wave_resource_key = 2;
290 std::string path_2_wave_resource_data =
291     "data/test/waves_H_s_peak-8m_T_e_peak-15s_1yr_dt-1hr.csv";
292
293 test_resources.addResource(
294     RenewableType::WAVE,
295     path_2_wave_resource_data,
296     wave_resource_key,
297     &test_electrical_load
298 );
299
300 std::vector<double> expected_significant_wave_height_vec_m = {
301     4.26175222125028,
302     4.25020976167872,
303     4.25656524330349,
304     4.27193854786718,
305     4.28744955711233,
306     4.29421815278154,
307     4.2839937266082,

```

```
308     4.25716982457976,
309     4.22419391611483,
310     4.19588925217606,
311     4.17338788587412,
312     4.14672746914214,
313     4.10560041173665,
314     4.05074966447193,
315     3.9953696962433,
316     3.95316976150866,
317     3.92771018142378,
318     3.91129562488595,
319     3.89558312094911,
320     3.87861093931749,
321     3.86538307240754,
322     3.86108961027929,
323     3.86459448853189,
324     3.86796474016882,
325     3.86357412779993,
326     3.85554872014731,
327     3.86044266668675,
328     3.89445961915999,
329     3.95554798115731,
330     4.02265508610476,
331     4.07419587011404,
332     4.10314247143958,
333     4.11738045085928,
334     4.12554995596708,
335     4.12923992001675,
336     4.1229292327442,
337     4.10123955307441,
338     4.06748827895363,
339     4.0336230651344,
340     4.01134236393876,
341     4.00136570034559,
342     3.99368787690411,
343     3.97820924247644,
344     3.95369335178055,
345     3.92742545608532,
346     3.90683362771686,
347     3.89331520944006,
348     3.88256045801583
349 };
350
351 std::vector<double> expected_energy_period_vec_s = {
352     10.4456008226821,
353     10.4614151137651,
354     10.4462827795433,
355     10.4127692097884,
356     10.3734397942723,
357     10.3408599227669,
358     10.32637292093,
359     10.3245412676322,
360     10.310409818185,
361     10.2589529840966,
362     10.1728100603103,
363     10.0862908658929,
364     10.03480243813,
365     10.023673635806,
366     10.0243418565116,
367     10.0063487117653,
368     9.96050302286607,
369     9.9011999635568,
370     9.84451822125472,
371     9.79726875879626,
372     9.75614594835158,
373     9.7173447961368,
374     9.68342904390577,
375     9.66380508567062,
376     9.6674009575699,
377     9.68927134575103,
378     9.70979984863046,
379     9.70967357906908,
380     9.68983025704562,
381     9.6722855524805,
382     9.67973599910003,
383     9.71977125328293,
384     9.78450442291421,
385     9.86532355233449,
386     9.96158937600019,
387     10.0807018356507,
388     10.2291022504937,
389     10.39458528356,
390     10.5464393581004,
391     10.6553277500484,
392     10.7245553190084,
393     10.7893127285064,
394     10.8846512240849,
```

```

395     11.0148158739075,
396     11.1544325654719,
397     11.2772785848343,
398     11.3744362756187,
399     11.4533643503183
400 };
401
402 for (size_t i = 0; i < expected_significant_wave_height_vec_m.size(); i++) {
403     testFloatEquals(
404         test_resources.resource_map_2D[wave_resource_key][i][0],
405         expected_significant_wave_height_vec_m[i],
406         __FILE__,
407         __LINE__
408     );
409
410     testFloatEquals(
411         test_resources.resource_map_2D[wave_resource_key][i][1],
412         expected_energy_period_vec_s[i],
413         __FILE__,
414         __LINE__
415     );
416 }
417
418
419 int wind_resource_key = 3;
420 std::string path_2_wind_resource_data =
421     "data/test/wind_speed_peak-25ms_lyr_dt-1hr.csv";
422
423 test_resources.addResource(
424     RenewableType::WIND,
425     path_2_wind_resource_data,
426     wind_resource_key,
427     &test_electrical_load
428 );
429
430 std::vector<double> expected_wind_resource_vec_ms = {
431     6.88566688469997,
432     5.02177105466549,
433     3.74211715899568,
434     5.67169579985362,
435     4.90670669971858,
436     4.29586955031368,
437     7.41155377205065,
438     10.2243290476943,
439     13.1258696725555,
440     13.7016198628274,
441     16.2481482330233,
442     16.5096744355418,
443     13.4354482206162,
444     14.0129230731609,
445     14.5554549260515,
446     13.4454539065912,
447     13.3447169512094,
448     11.7372615098554,
449     12.7200070078013,
450     10.6421127908149,
451     6.09869498990661,
452     5.66355596602321,
453     4.97316966910831,
454     3.48937138360567,
455     2.15917470979169,
456     1.29061103587027,
457     3.43475751425219,
458     4.11706326260927,
459     4.28905275747408,
460     5.75850263196241,
461     8.98293663055264,
462     11.7069822941315,
463     12.4031987075858,
464     15.4096570910089,
465     16.6210843829552,
466     13.3421219142573,
467     15.2112831900548,
468     18.350864533037,
469     15.8751799822971,
470     15.3921198799796,
471     15.9729192868434,
472     12.4728950178772,
473     10.177050481096,
474     10.7342247355551,
475     8.98846695631389,
476     4.14671169124739,
477     3.17256452697149,
478     3.40036336968628
479 };
480
481 for (size_t i = 0; i < expected_wind_resource_vec_ms.size(); i++) {

```

```

482     testFloatEquals (
483         test_resources.resource_map_1D[wind_resource_key][i],
484         expected_wind_resource_vec_ms[i],
485         __FILE__,
486         __LINE__
487     );
488 }
489
490 // ===== END METHODS ===== //
491
492 } /* try */
493
494
495 catch (...) {
496     printGold(" ..... ");
497     printRed("FAIL");
498     std::cout << std::endl;
499     throw;
500 }
501
502
503 printGold(" ..... ");
504 printGreen("PASS");
505 std::cout << std::endl;
506 return 0;
507 } /* main() */

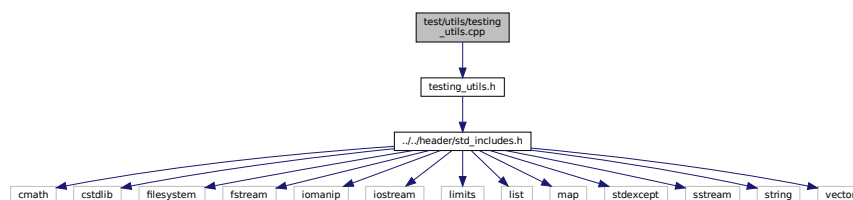
```

## 5.48 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.*

### 5.48.1 Detailed Description

Header file for various PGMcpp testing utilities.

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

### 5.48.2 Function Documentation

#### 5.48.2.1 [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 "__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() */
```

#### 5.48.2.2 [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 <code>std::cout</code> .
------------------	---------------------------------------------------------------

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

**5.48.2.3 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 <code>std::cout</code> .
------------------	---------------------------------------------------------------

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

**5.48.2.4 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() */
```

**5.48.2.5 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 "__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() */

```

## 5.48.2.6 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() */

```

#### 5.48.2.7 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() */

```

#### 5.48.2.8 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.
----------	-----------------------------------



## 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__").

```

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() */

```

## 5.48.2.9 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() */
```

### 5.48.2.10 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__").

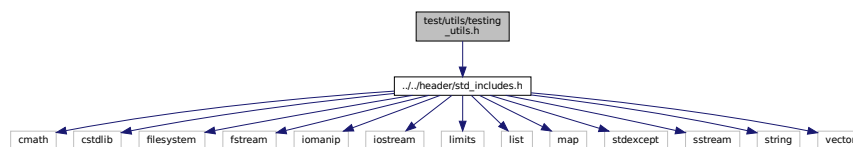
```
392 {
393     if (statement) {
394         return;
395     }
396
397     std::string error_str = "ERROR: testTruth():\t in ";
398     error_str += file;
399     error_str += "\tline ";
400     error_str += std::to_string(line);
401     error_str += ":\t\n";
402     error_str += "Given statement is 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() */
```

## 5.49 test/utils/testing\_utils.h File Reference

Header file for various PGMcpp testing utilities.

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

Include dependency graph for testing\_utils.h:



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



## Macros

- `#define FLOAT_TOLERANCE 1e-6`  
*A tolerance for application to floating point equality tests.*

## Functions

- void `printGreen` (std::string)  
*A function that sends green text to std::cout.*
- void `printGold` (std::string)  
*A function that sends gold text to std::cout.*
- void `printRed` (std::string)  
*A function that sends red text to std::cout.*
- void `testFloatEquals` (double, double, std::string, int)  
*Tests for the equality of two floating point numbers x and y (to within FLOAT\_TOLERANCE).*
- void `testGreaterThan` (double, double, std::string, int)  
*Tests if  $x > y$ .*
- void `testGreaterThanOrEqualTo` (double, double, std::string, int)  
*Tests if  $x \geq y$ .*
- 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.*

### 5.49.1 Detailed Description

Header file for various PGMcpp testing utilities.

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

### 5.49.2 Macro Definition Documentation

#### 5.49.2.1 FLOAT\_TOLERANCE

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

A tolerance for application to floating point equality tests.

### 5.49.3 Function Documentation

#### 5.49.3.1 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() */

```

## 5.49.3.2 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() */

```

## 5.49.3.3 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() */

```

## 5.49.3.4 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 <code>std::cout</code> .
------------------	---------------------------------------------------------------

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

### 5.49.3.5 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.
<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() */
```

### 5.49.3.6 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() */
```

#### 5.49.3.7 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() */

```

### 5.49.3.8 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() */

```

### 5.49.3.9 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() */

```

## 5.49.3.10 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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