

PGMcpp: PRIMED Grid Modelling (in C++)

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1 Hierarchical Index	1
1.1 Class Hierarchy	1
2 Class Index	3
2.1 Class List	3
3 File Index	5
3.1 File List	5
4 Class Documentation	9
4.1 Combustion Class Reference	9
4.1.1 Detailed Description	12
4.1.2 Constructor & Destructor Documentation	12
4.1.2.1 Combustion() [1/2]	12
4.1.2.2 Combustion() [2/2]	12
4.1.2.3 ~Combustion()	13
4.1.3 Member Function Documentation	14
4.1.3.1 __checkInputs()	14
4.1.3.2 __writeSummary()	14
4.1.3.3 __writeTimeSeries()	15
4.1.3.4 commit()	15
4.1.3.5 computeEconomics()	16
4.1.3.6 computeFuelAndEmissions()	16
4.1.3.7 getEmissionskg()	17
4.1.3.8 getFuelConsumptionL()	17
4.1.3.9 handleReplacement()	18
4.1.3.10 requestProductionkW()	18
4.1.3.11 writeResults()	19
4.1.4 Member Data Documentation	19
4.1.4.1 CH4_emissions_intensity_kgL	19
4.1.4.2 CH4_emissions_vec_kg	20
4.1.4.3 CO2_emissions_intensity_kgL	20
4.1.4.4 CO2_emissions_vec_kg	20
4.1.4.5 CO_emissions_intensity_kgL	20
4.1.4.6 CO_emissions_vec_kg	20
4.1.4.7 fuel_consumption_vec_L	20
4.1.4.8 fuel_cost_L	21
4.1.4.9 fuel_cost_vec	21
4.1.4.10 fuel_mode	21
4.1.4.11 fuel_mode_str	21
4.1.4.12 linear_fuel_intercept_LkWh	21
4.1.4.13 linear_fuel_slope_LkWh	21
4.1.4.14 nominal_fuel_escalation_annual	22

4.1.4.15 NOx_emissions_intensity_kgL	22
4.1.4.16 NOx_emissions_vec_kg	22
4.1.4.17 PM_emissions_intensity_kgL	22
4.1.4.18 PM_emissions_vec_kg	22
4.1.4.19 real_fuel_escalation_annual	22
4.1.4.20 SOx_emissions_intensity_kgL	23
4.1.4.21 SOx_emissions_vec_kg	23
4.1.4.22 total_emissions	23
4.1.4.23 total_fuel_consumed_L	23
4.1.4.24 type	23
4.2 CombustionInputs Struct Reference	24
4.2.1 Detailed Description	24
4.2.2 Member Data Documentation	24
4.2.2.1 fuel_mode	24
4.2.2.2 nominal_fuel_escalation_annual	25
4.2.2.3 path_2_fuel_interp_data	25
4.2.2.4 production_inputs	25
4.3 Controller Class Reference	25
4.3.1 Detailed Description	26
4.3.2 Constructor & Destructor Documentation	27
4.3.2.1 Controller()	27
4.3.2.2 ~Controller()	27
4.3.3 Member Function Documentation	27
4.3.3.1 __applyCycleChargingControl_CHARGING()	27
4.3.3.2 __applyCycleChargingControl_DISCHARGING()	28
4.3.3.3 __applyLoadFollowingControl_CHARGING()	29
4.3.3.4 __applyLoadFollowingControl_DISCHARGING()	30
4.3.3.5 __computeNetLoad()	31
4.3.3.6 __constructCombustionMap()	32
4.3.3.7 __getRenewableProduction()	33
4.3.3.8 __handleCombustionDispatch()	34
4.3.3.9 __handleStorageCharging() [1/2]	35
4.3.3.10 __handleStorageCharging() [2/2]	37
4.3.3.11 __handleStorageDischarging()	38
4.3.3.12 applyDispatchControl()	39
4.3.3.13 clear()	40
4.3.3.14 init()	40
4.3.3.15 setControlMode()	40
4.3.4 Member Data Documentation	41
4.3.4.1 combustion_map	41
4.3.4.2 control_mode	41
4.3.4.3 control_string	41

4.3.4.4 missed_load_vec_kW	42
4.3.4.5 net_load_vec_kW	42
4.4 Diesel Class Reference	42
4.4.1 Detailed Description	44
4.4.2 Constructor & Destructor Documentation	44
4.4.2.1 Diesel() [1/2]	44
4.4.2.2 Diesel() [2/2]	44
4.4.2.3 ~Diesel()	45
4.4.3 Member Function Documentation	46
4.4.3.1 __checkInputs()	46
4.4.3.2 __getGenericCapitalCost()	47
4.4.3.3 __getGenericFuelIntercept()	48
4.4.3.4 __getGenericFuelSlope()	48
4.4.3.5 __getGenericOpMaintCost()	49
4.4.3.6 __handleStartStop()	49
4.4.3.7 __writeSummary()	50
4.4.3.8 __writeTimeSeries()	52
4.4.3.9 commit()	53
4.4.3.10 handleReplacement()	54
4.4.3.11 requestProductionkW()	54
4.4.4 Member Data Documentation	55
4.4.4.1 minimum_load_ratio	55
4.4.4.2 minimum_runtime_hrs	55
4.4.4.3 time_since_last_start_hrs	55
4.5 DieselInputs Struct Reference	56
4.5.1 Detailed Description	57
4.5.2 Member Data Documentation	57
4.5.2.1 capital_cost	57
4.5.2.2 CH4_emissions_intensity_kgL	57
4.5.2.3 CO2_emissions_intensity_kgL	58
4.5.2.4 CO_emissions_intensity_kgL	58
4.5.2.5 combustion_inputs	58
4.5.2.6 fuel_cost_L	58
4.5.2.7 linear_fuel_intercept_LkWh	58
4.5.2.8 linear_fuel_slope_LkWh	58
4.5.2.9 minimum_load_ratio	59
4.5.2.10 minimum_runtime_hrs	59
4.5.2.11 NOx_emissions_intensity_kgL	59
4.5.2.12 operation_maintenance_cost_kWh	59
4.5.2.13 PM_emissions_intensity_kgL	59
4.5.2.14 replace_running_hrs	59
4.5.2.15 SOx_emissions_intensity_kgL	60

4.6 ElectricalLoad Class Reference	60
4.6.1 Detailed Description	61
4.6.2 Constructor & Destructor Documentation	61
4.6.2.1 ElectricalLoad() [1/2]	61
4.6.2.2 ElectricalLoad() [2/2]	61
4.6.2.3 ~ElectricalLoad()	61
4.6.3 Member Function Documentation	61
4.6.3.1 clear()	62
4.6.3.2 readLoadData()	62
4.6.4 Member Data Documentation	63
4.6.4.1 dt_vec_hrs	63
4.6.4.2 load_vec_kW	63
4.6.4.3 max_load_kW	63
4.6.4.4 mean_load_kW	64
4.6.4.5 min_load_kW	64
4.6.4.6 n_points	64
4.6.4.7 n_years	64
4.6.4.8 path_2_electrical_load_time_series	64
4.6.4.9 time_vec_hrs	64
4.7 Emissions Struct Reference	65
4.7.1 Detailed Description	65
4.7.2 Member Data Documentation	65
4.7.2.1 CH4_kg	65
4.7.2.2 CO2_kg	65
4.7.2.3 CO_kg	66
4.7.2.4 NOx_kg	66
4.7.2.5 PM_kg	66
4.7.2.6 SOx_kg	66
4.8 Interpolator Class Reference	66
4.8.1 Detailed Description	68
4.8.2 Constructor & Destructor Documentation	68
4.8.2.1 Interpolator()	68
4.8.2.2 ~Interpolator()	68
4.8.3 Member Function Documentation	68
4.8.3.1 __checkBounds1D()	68
4.8.3.2 __checkBounds2D()	69
4.8.3.3 __checkDataKey1D()	70
4.8.3.4 __checkDataKey2D()	70
4.8.3.5 __getDataStringMatrix()	71
4.8.3.6 __getInterpolationIndex()	72
4.8.3.7 __isNonNumeric()	72
4.8.3.8 __readData1D()	73

4.8.3.9 __readData2D()	74
4.8.3.10 __splitCommaSeparatedString()	75
4.8.3.11 __throwReadError()	76
4.8.3.12 addData1D()	76
4.8.3.13 addData2D()	77
4.8.3.14 interp1D()	77
4.8.3.15 interp2D()	78
4.8.4 Member Data Documentation	79
4.8.4.1 interp_map_1D	79
4.8.4.2 interp_map_2D	79
4.8.4.3 path_map_1D	79
4.8.4.4 path_map_2D	79
4.9 InterpolatorStruct1D Struct Reference	80
4.9.1 Detailed Description	80
4.9.2 Member Data Documentation	80
4.9.2.1 max_x	80
4.9.2.2 min_x	80
4.9.2.3 n_points	81
4.9.2.4 x_vec	81
4.9.2.5 y_vec	81
4.10 InterpolatorStruct2D Struct Reference	81
4.10.1 Detailed Description	82
4.10.2 Member Data Documentation	82
4.10.2.1 max_x	82
4.10.2.2 max_y	82
4.10.2.3 min_x	82
4.10.2.4 min_y	82
4.10.2.5 n_cols	82
4.10.2.6 n_rows	83
4.10.2.7 x_vec	83
4.10.2.8 y_vec	83
4.10.2.9 z_matrix	83
4.11 Lilon Class Reference	84
4.11.1 Detailed Description	86
4.11.2 Constructor & Destructor Documentation	86
4.11.2.1 Lilon() [1/2]	86
4.11.2.2 Lilon() [2/2]	86
4.11.2.3 ~Lilon()	87
4.11.3 Member Function Documentation	88
4.11.3.1 __checkInputs()	88
4.11.3.2 __getBcal()	90
4.11.3.3 __getEcal()	91

4.11.3.4	__getGenericCapitalCost()	91
4.11.3.5	__getGenericOpMaintCost()	92
4.11.3.6	__handleDegradation()	92
4.11.3.7	__modelDegradation()	92
4.11.3.8	__toggleDepleted()	94
4.11.3.9	__writeSummary()	94
4.11.3.10	__writeTimeSeries()	96
4.11.3.11	commitCharge()	96
4.11.3.12	commitDischarge()	97
4.11.3.13	getAcceptablekW()	98
4.11.3.14	getAvailablekW()	99
4.11.3.15	handleReplacement()	99
4.11.4	Member Data Documentation	100
4.11.4.1	charging_efficiency	100
4.11.4.2	degradation_a_cal	100
4.11.4.3	degradation_alpha	100
4.11.4.4	degradation_B_hat_cal_0	100
4.11.4.5	degradation_beta	101
4.11.4.6	degradation_Ea_cal_0	101
4.11.4.7	degradation_r_cal	101
4.11.4.8	degradation_s_cal	101
4.11.4.9	discharging_efficiency	101
4.11.4.10	dynamic_energy_capacity_kWh	101
4.11.4.11	gas_constant_JmolK	102
4.11.4.12	hysteresis_SOC	102
4.11.4.13	init_SOC	102
4.11.4.14	max_SOC	102
4.11.4.15	min_SOC	102
4.11.4.16	replace_SOH	102
4.11.4.17	SOH	103
4.11.4.18	SOH_vec	103
4.11.4.19	temperature_K	103
4.12	LilonInputs Struct Reference	103
4.12.1	Detailed Description	104
4.12.2	Member Data Documentation	105
4.12.2.1	capital_cost	105
4.12.2.2	charging_efficiency	105
4.12.2.3	degradation_a_cal	105
4.12.2.4	degradation_alpha	105
4.12.2.5	degradation_B_hat_cal_0	105
4.12.2.6	degradation_beta	106
4.12.2.7	degradation_Ea_cal_0	106

4.12.2.8 degradation_r_cal	106
4.12.2.9 degradation_s_cal	106
4.12.2.10 discharging_efficiency	106
4.12.2.11 gas_constant_JmolK	106
4.12.2.12 hysteresis_SOC	107
4.12.2.13 init_SOC	107
4.12.2.14 max_SOC	107
4.12.2.15 min_SOC	107
4.12.2.16 operation_maintenance_cost_kWh	107
4.12.2.17 replace_SOH	107
4.12.2.18 storage_inputs	108
4.12.2.19 temperature_K	108
4.13 Model Class Reference	108
4.13.1 Detailed Description	110
4.13.2 Constructor & Destructor Documentation	110
4.13.2.1 Model() [1/2]	110
4.13.2.2 Model() [2/2]	110
4.13.2.3 ~Model()	111
4.13.3 Member Function Documentation	111
4.13.3.1 __checkInputs()	111
4.13.3.2 __computeEconomics()	112
4.13.3.3 __computeFuelAndEmissions()	112
4.13.3.4 __computeLevellizedCostOfEnergy()	113
4.13.3.5 __computeNetPresentCost()	113
4.13.3.6 __writeSummary()	114
4.13.3.7 __writeTimeSeries()	116
4.13.3.8 addDiesel()	117
4.13.3.9 addLilon()	117
4.13.3.10 addResource()	118
4.13.3.11 addSolar()	118
4.13.3.12 addTidal()	119
4.13.3.13 addWave()	119
4.13.3.14 addWind()	120
4.13.3.15 clear()	120
4.13.3.16 reset()	120
4.13.3.17 run()	121
4.13.3.18 writeResults()	121
4.13.4 Member Data Documentation	122
4.13.4.1 combustion_ptr_vec	123
4.13.4.2 controller	123
4.13.4.3 electrical_load	123
4.13.4.4 levellized_cost_of_energy_kWh	123

4.13.4.5 net_present_cost	123
4.13.4.6 renewable_ptr_vec	123
4.13.4.7 resources	124
4.13.4.8 storage_ptr_vec	124
4.13.4.9 total_dispatch_discharge_kWh	124
4.13.4.10 total_emissions	124
4.13.4.11 total_fuel_consumed_L	124
4.14 ModellInputs Struct Reference	124
4.14.1 Detailed Description	125
4.14.2 Member Data Documentation	125
4.14.2.1 control_mode	125
4.14.2.2 path_2_electrical_load_time_series	125
4.15 Production Class Reference	126
4.15.1 Detailed Description	128
4.15.2 Constructor & Destructor Documentation	128
4.15.2.1 Production() [1/2]	128
4.15.2.2 Production() [2/2]	129
4.15.2.3 ~Production()	129
4.15.3 Member Function Documentation	130
4.15.3.1 __checkInputs()	130
4.15.3.2 commit()	131
4.15.3.3 computeEconomics()	132
4.15.3.4 computeRealDiscountAnnual()	133
4.15.3.5 handleReplacement()	133
4.15.4 Member Data Documentation	133
4.15.4.1 capacity_kW	134
4.15.4.2 capital_cost	134
4.15.4.3 capital_cost_vec	134
4.15.4.4 curtailment_vec_kW	134
4.15.4.5 dispatch_vec_kW	134
4.15.4.6 interpolator	134
4.15.4.7 is_running	135
4.15.4.8 is_running_vec	135
4.15.4.9 is_sunk	135
4.15.4.10 lellized_cost_of_energy_kWh	135
4.15.4.11 n_points	135
4.15.4.12 n_replacements	135
4.15.4.13 n_starts	136
4.15.4.14 n_years	136
4.15.4.15 net_present_cost	136
4.15.4.16 nominal_discount_annual	136
4.15.4.17 nominal_inflation_annual	136

4.15.4.18 operation_maintenance_cost_kWh	136
4.15.4.19 operation_maintenance_cost_vec	137
4.15.4.20 print_flag	137
4.15.4.21 production_vec_kW	137
4.15.4.22 real_discount_annual	137
4.15.4.23 replace_running_hrs	137
4.15.4.24 running_hours	137
4.15.4.25 storage_vec_kW	138
4.15.4.26 total_dispatch_kWh	138
4.15.4.27 type_str	138
4.16 ProductionInputs Struct Reference	138
4.16.1 Detailed Description	139
4.16.2 Member Data Documentation	139
4.16.2.1 capacity_kW	139
4.16.2.2 is_sunk	139
4.16.2.3 nominal_discount_annual	139
4.16.2.4 nominal_inflation_annual	139
4.16.2.5 print_flag	139
4.16.2.6 replace_running_hrs	140
4.17 Renewable Class Reference	140
4.17.1 Detailed Description	142
4.17.2 Constructor & Destructor Documentation	142
4.17.2.1 Renewable() [1/2]	142
4.17.2.2 Renewable() [2/2]	142
4.17.2.3 ~Renewable()	143
4.17.3 Member Function Documentation	143
4.17.3.1 __checkInputs()	143
4.17.3.2 __handleStartStop()	144
4.17.3.3 __writeSummary()	144
4.17.3.4 __writeTimeSeries()	144
4.17.3.5 commit()	144
4.17.3.6 computeEconomics()	145
4.17.3.7 computeProductionkW() [1/2]	145
4.17.3.8 computeProductionkW() [2/2]	146
4.17.3.9 handleReplacement()	146
4.17.3.10 writeResults()	146
4.17.4 Member Data Documentation	147
4.17.4.1 resource_key	147
4.17.4.2 type	148
4.18 RenewableInputs Struct Reference	148
4.18.1 Detailed Description	148
4.18.2 Member Data Documentation	148

4.18.2.1 production_inputs	149
4.19 Resources Class Reference	149
4.19.1 Detailed Description	150
4.19.2 Constructor & Destructor Documentation	150
4.19.2.1 Resources()	150
4.19.2.2 ~Resources()	150
4.19.3 Member Function Documentation	151
4.19.3.1 __checkResourceKey1D()	151
4.19.3.2 __checkResourceKey2D()	151
4.19.3.3 __checkTimePoint()	152
4.19.3.4 __readSolarResource()	153
4.19.3.5 __readTidalResource()	154
4.19.3.6 __readWaveResource()	155
4.19.3.7 __readWindResource()	156
4.19.3.8 __throwLengthError()	156
4.19.3.9 addResource()	157
4.19.3.10 clear()	158
4.19.4 Member Data Documentation	158
4.19.4.1 path_map_1D	159
4.19.4.2 path_map_2D	159
4.19.4.3 resource_map_1D	159
4.19.4.4 resource_map_2D	159
4.19.4.5 string_map_1D	159
4.19.4.6 string_map_2D	159
4.20 Solar Class Reference	160
4.20.1 Detailed Description	161
4.20.2 Constructor & Destructor Documentation	161
4.20.2.1 Solar() [1/2]	162
4.20.2.2 Solar() [2/2]	162
4.20.2.3 ~Solar()	163
4.20.3 Member Function Documentation	163
4.20.3.1 __checkInputs()	163
4.20.3.2 __getGenericCapitalCost()	163
4.20.3.3 __getGenericOpMaintCost()	164
4.20.3.4 __writeSummary()	164
4.20.3.5 __writeTimeSeries()	165
4.20.3.6 commit()	166
4.20.3.7 computeProductionkW()	167
4.20.3.8 handleReplacement()	167
4.20.4 Member Data Documentation	168
4.20.4.1 derating	168
4.21 SolarInputs Struct Reference	168

4.21.1 Detailed Description	169
4.21.2 Member Data Documentation	169
4.21.2.1 capital_cost	169
4.21.2.2 derating	169
4.21.2.3 operation_maintenance_cost_kWh	170
4.21.2.4 renewable_inputs	170
4.21.2.5 resource_key	170
4.22 Storage Class Reference	170
4.22.1 Detailed Description	173
4.22.2 Constructor & Destructor Documentation	173
4.22.2.1 Storage() [1/2]	173
4.22.2.2 Storage() [2/2]	173
4.22.2.3 ~Storage()	174
4.22.3 Member Function Documentation	174
4.22.3.1 __checkInputs()	174
4.22.3.2 __computeRealDiscountAnnual()	175
4.22.3.3 __writeSummary()	176
4.22.3.4 __writeTimeSeries()	176
4.22.3.5 commitCharge()	176
4.22.3.6 commitDischarge()	176
4.22.3.7 computeEconomics()	177
4.22.3.8 getAcceptablekW()	177
4.22.3.9 getAvailablekW()	178
4.22.3.10 handleReplacement()	178
4.22.3.11 writeResults()	178
4.22.4 Member Data Documentation	179
4.22.4.1 capital_cost	179
4.22.4.2 capital_cost_vec	179
4.22.4.3 charge_kWh	180
4.22.4.4 charge_vec_kWh	180
4.22.4.5 charging_power_vec_kW	180
4.22.4.6 discharging_power_vec_kW	180
4.22.4.7 energy_capacity_kWh	180
4.22.4.8 interpolator	180
4.22.4.9 is_depleted	181
4.22.4.10 is_sunk	181
4.22.4.11 levlized_cost_of_energy_kWh	181
4.22.4.12 n_points	181
4.22.4.13 n_replacements	181
4.22.4.14 n_years	181
4.22.4.15 net_present_cost	182
4.22.4.16 nominal_discount_annual	182

4.22.4.17 nominal_inflation_annual	182
4.22.4.18 operation_maintenance_cost_kWh	182
4.22.4.19 operation_maintenance_cost_vec	182
4.22.4.20 power_capacity_kW	182
4.22.4.21 power_kW	183
4.22.4.22 print_flag	183
4.22.4.23 real_discount_annual	183
4.22.4.24 total_discharge_kWh	183
4.22.4.25 type	183
4.22.4.26 type_str	183
4.23 StorageInputs Struct Reference	184
4.23.1 Detailed Description	184
4.23.2 Member Data Documentation	184
4.23.2.1 energy_capacity_kWh	184
4.23.2.2 is_sunk	184
4.23.2.3 nominal_discount_annual	185
4.23.2.4 nominal_inflation_annual	185
4.23.2.5 power_capacity_kW	185
4.23.2.6 print_flag	185
4.24 Tidal Class Reference	186
4.24.1 Detailed Description	187
4.24.2 Constructor & Destructor Documentation	188
4.24.2.1 Tidal() [1/2]	188
4.24.2.2 Tidal() [2/2]	188
4.24.2.3 ~Tidal()	189
4.24.3 Member Function Documentation	189
4.24.3.1 __checkInputs()	189
4.24.3.2 __computeCubicProductionkW()	190
4.24.3.3 __computeExponentialProductionkW()	191
4.24.3.4 __computeLookupProductionkW()	191
4.24.3.5 __getGenericCapitalCost()	192
4.24.3.6 __getGenericOpMaintCost()	192
4.24.3.7 __writeSummary()	192
4.24.3.8 __writeTimeSeries()	194
4.24.3.9 commit()	194
4.24.3.10 computeProductionkW()	195
4.24.3.11 handleReplacement()	196
4.24.4 Member Data Documentation	197
4.24.4.1 design_speed_ms	197
4.24.4.2 power_model	197
4.24.4.3 power_model_string	197
4.25 TidalInputs Struct Reference	197

4.25.1 Detailed Description	198
4.25.2 Member Data Documentation	198
4.25.2.1 capital_cost	198
4.25.2.2 design_speed_ms	198
4.25.2.3 operation_maintenance_cost_kWh	199
4.25.2.4 power_model	199
4.25.2.5 renewable_inputs	199
4.25.2.6 resource_key	199
4.26 Wave Class Reference	200
4.26.1 Detailed Description	202
4.26.2 Constructor & Destructor Documentation	202
4.26.2.1 Wave() [1/2]	202
4.26.2.2 Wave() [2/2]	202
4.26.2.3 ~Wave()	203
4.26.3 Member Function Documentation	203
4.26.3.1 __checkInputs()	204
4.26.3.2 __computeGaussianProductionkW()	204
4.26.3.3 __computeLookupProductionkW()	205
4.26.3.4 __computeParaboloidProductionkW()	206
4.26.3.5 __getGenericCapitalCost()	206
4.26.3.6 __getGenericOpMaintCost()	207
4.26.3.7 __writeSummary()	207
4.26.3.8 __writeTimeSeries()	209
4.26.3.9 commit()	210
4.26.3.10 computeProductionkW()	210
4.26.3.11 handleReplacement()	211
4.26.4 Member Data Documentation	212
4.26.4.1 design_energy_period_s	212
4.26.4.2 design_significant_wave_height_m	212
4.26.4.3 power_model	212
4.26.4.4 power_model_string	212
4.27 WaveInputs Struct Reference	213
4.27.1 Detailed Description	214
4.27.2 Member Data Documentation	214
4.27.2.1 capital_cost	214
4.27.2.2 design_energy_period_s	214
4.27.2.3 design_significant_wave_height_m	214
4.27.2.4 operation_maintenance_cost_kWh	214
4.27.2.5 path_2_normalized_performance_matrix	215
4.27.2.6 power_model	215
4.27.2.7 renewable_inputs	215
4.27.2.8 resource_key	215

4.28 Wind Class Reference	216
4.28.1 Detailed Description	217
4.28.2 Constructor & Destructor Documentation	218
4.28.2.1 Wind() [1/2]	218
4.28.2.2 Wind() [2/2]	218
4.28.2.3 ~Wind()	219
4.28.3 Member Function Documentation	219
4.28.3.1 __checkInputs()	219
4.28.3.2 __computeExponentialProductionkW()	220
4.28.3.3 __computeLookupProductionkW()	220
4.28.3.4 __getGenericCapitalCost()	221
4.28.3.5 __getGenericOpMaintCost()	221
4.28.3.6 __writeSummary()	222
4.28.3.7 __writeTimeSeries()	223
4.28.3.8 commit()	224
4.28.3.9 computeProductionkW()	224
4.28.3.10 handleReplacement()	226
4.28.4 Member Data Documentation	227
4.28.4.1 design_speed_ms	227
4.28.4.2 power_model	227
4.28.4.3 power_model_string	227
4.29 WindInputs Struct Reference	228
4.29.1 Detailed Description	228
4.29.2 Member Data Documentation	229
4.29.2.1 capital_cost	229
4.29.2.2 design_speed_ms	229
4.29.2.3 operation_maintenance_cost_kWh	229
4.29.2.4 power_model	229
4.29.2.5 renewable_inputs	229
4.29.2.6 resource_key	229
5 File Documentation	231
5.1 header/Controller.h File Reference	231
5.1.1 Detailed Description	232
5.1.2 Enumeration Type Documentation	232
5.1.2.1 ControlMode	232
5.2 header/doxygen_cite.h File Reference	233
5.2.1 Detailed Description	233
5.3 header/ElectricalLoad.h File Reference	233
5.3.1 Detailed Description	234
5.4 header/Interpolator.h File Reference	234
5.4.1 Detailed Description	234

5.5 header/Model.h File Reference	235
5.5.1 Detailed Description	236
5.6 header/Production/Combustion/Combustion.h File Reference	236
5.6.1 Detailed Description	237
5.6.2 Enumeration Type Documentation	237
5.6.2.1 CombustionType	237
5.6.2.2 FuelMode	237
5.7 header/Production/Combustion/Diesel.h File Reference	237
5.7.1 Detailed Description	238
5.8 header/Production/Production.h File Reference	238
5.8.1 Detailed Description	239
5.9 header/Production/Renewable/Renewable.h File Reference	239
5.9.1 Detailed Description	240
5.9.2 Enumeration Type Documentation	240
5.9.2.1 RenewableType	240
5.10 header/Production/Renewable/Solar.h File Reference	241
5.10.1 Detailed Description	242
5.11 header/Production/Renewable/Tidal.h File Reference	242
5.11.1 Detailed Description	243
5.11.2 Enumeration Type Documentation	243
5.11.2.1 TidalPowerProductionModel	243
5.12 header/Production/Renewable/Wave.h File Reference	243
5.12.1 Detailed Description	244
5.12.2 Enumeration Type Documentation	244
5.12.2.1 WavePowerProductionModel	244
5.13 header/Production/Renewable/Wind.h File Reference	245
5.13.1 Detailed Description	246
5.13.2 Enumeration Type Documentation	246
5.13.2.1 WindPowerProductionModel	246
5.14 header/Resources.h File Reference	246
5.14.1 Detailed Description	247
5.15 header/std_includes.h File Reference	247
5.15.1 Detailed Description	248
5.16 header/Storage/Lilon.h File Reference	248
5.16.1 Detailed Description	248
5.17 header/Storage/Storage.h File Reference	249
5.17.1 Detailed Description	249
5.17.2 Enumeration Type Documentation	250
5.17.2.1 StorageType	250
5.18 pybindings/PYBIND11_PGM.cpp File Reference	250
5.18.1 Detailed Description	251
5.18.2 Function Documentation	251

5.18.2.1 PYBIND11_MODULE()	251
5.19 pybindings/snippets/Production/Combustion/PYBIND11_Combustion.cpp File Reference	251
5.19.1 Detailed Description	251
5.20 pybindings/snippets/Production/Combustion/PYBIND11_Diesel.cpp File Reference	251
5.20.1 Detailed Description	251
5.21 pybindings/snippets/Production/PYBIND11_Production.cpp File Reference	252
5.21.1 Detailed Description	252
5.22 pybindings/snippets/Production/Renewable/PYBIND11_Renewable.cpp File Reference	252
5.22.1 Detailed Description	252
5.23 pybindings/snippets/Production/Renewable/PYBIND11_Solar.cpp File Reference	252
5.23.1 Detailed Description	252
5.24 pybindings/snippets/Production/Renewable/PYBIND11_Tidal.cpp File Reference	252
5.24.1 Detailed Description	253
5.25 pybindings/snippets/Production/Renewable/PYBIND11_Wave.cpp File Reference	253
5.25.1 Detailed Description	253
5.26 pybindings/snippets/Production/Renewable/PYBIND11_Wind.cpp File Reference	253
5.26.1 Detailed Description	253
5.27 pybindings/snippets/PYBIND11_Controller.cpp File Reference	253
5.27.1 Detailed Description	253
5.28 pybindings/snippets/PYBIND11_ElectricalLoad.cpp File Reference	254
5.28.1 Detailed Description	254
5.29 pybindings/snippets/PYBIND11_Interpolator.cpp File Reference	254
5.29.1 Detailed Description	254
5.30 pybindings/snippets/PYBIND11_Model.cpp File Reference	254
5.30.1 Detailed Description	254
5.31 pybindings/snippets/PYBIND11_Resources.cpp File Reference	254
5.31.1 Detailed Description	254
5.32 pybindings/snippets/Storage/PYBIND11_Lilon.cpp File Reference	255
5.32.1 Detailed Description	255
5.33 pybindings/snippets/Storage/PYBIND11_Storage.cpp File Reference	255
5.33.1 Detailed Description	255
5.34 source/Controller.cpp File Reference	255
5.34.1 Detailed Description	256
5.35 source/ElectricalLoad.cpp File Reference	256
5.35.1 Detailed Description	256
5.36 source/Interpolator.cpp File Reference	256
5.36.1 Detailed Description	257
5.37 source/Model.cpp File Reference	257
5.37.1 Detailed Description	257
5.38 source/Production/Combustion/Combustion.cpp File Reference	257
5.38.1 Detailed Description	258
5.39 source/Production/Combustion/Diesel.cpp File Reference	258

5.39.1 Detailed Description	258
5.40 source/Production/Production.cpp File Reference	259
5.40.1 Detailed Description	259
5.41 source/Production/Renewable/Renewable.cpp File Reference	259
5.41.1 Detailed Description	259
5.42 source/Production/Renewable/Solar.cpp File Reference	260
5.42.1 Detailed Description	260
5.43 source/Production/Renewable/Tidal.cpp File Reference	260
5.43.1 Detailed Description	261
5.44 source/Production/Renewable/Wave.cpp File Reference	261
5.44.1 Detailed Description	261
5.45 source/Production/Renewable/Wind.cpp File Reference	261
5.45.1 Detailed Description	262
5.46 source/Resources.cpp File Reference	262
5.46.1 Detailed Description	262
5.47 source/Storage/Lilon.cpp File Reference	263
5.47.1 Detailed Description	263
5.48 source/Storage/Storage.cpp File Reference	263
5.48.1 Detailed Description	263
5.49 test/source/Production/Combustion/test_Combustion.cpp File Reference	264
5.49.1 Detailed Description	264
5.49.2 Function Documentation	264
5.49.2.1 main()	264
5.50 test/source/Production/Combustion/test_Diesel.cpp File Reference	266
5.50.1 Detailed Description	266
5.50.2 Function Documentation	266
5.50.2.1 main()	267
5.51 test/source/Production/Renewable/test_Renewable.cpp File Reference	272
5.51.1 Detailed Description	272
5.51.2 Function Documentation	273
5.51.2.1 main()	273
5.52 test/source/Production/Renewable/test_Solar.cpp File Reference	273
5.52.1 Detailed Description	274
5.52.2 Function Documentation	274
5.52.2.1 main()	274
5.53 test/source/Production/Renewable/test_Tidal.cpp File Reference	277
5.53.1 Detailed Description	278
5.53.2 Function Documentation	278
5.53.2.1 main()	278
5.54 test/source/Production/Renewable/test_Wave.cpp File Reference	281
5.54.1 Detailed Description	282
5.54.2 Function Documentation	282

5.54.2.1 main()	282
5.55 test/source/Production/Renewable/test_Wind.cpp File Reference	286
5.55.1 Detailed Description	287
5.55.2 Function Documentation	287
5.55.2.1 main()	287
5.56 test/source/Production/test_Production.cpp File Reference	290
5.56.1 Detailed Description	291
5.56.2 Function Documentation	291
5.56.2.1 main()	291
5.57 test/source/Storage/test_Lilon.cpp File Reference	293
5.57.1 Detailed Description	293
5.57.2 Function Documentation	293
5.57.2.1 main()	294
5.58 test/source/Storage/test_Storage.cpp File Reference	296
5.58.1 Detailed Description	296
5.58.2 Function Documentation	296
5.58.2.1 main()	297
5.59 test/source/test_Controller.cpp File Reference	298
5.59.1 Detailed Description	299
5.59.2 Function Documentation	299
5.59.2.1 main()	299
5.60 test/source/test_ElectricalLoad.cpp File Reference	300
5.60.1 Detailed Description	300
5.60.2 Function Documentation	300
5.60.2.1 main()	300
5.61 test/source/test_Interpolator.cpp File Reference	302
5.61.1 Detailed Description	303
5.61.2 Function Documentation	303
5.61.2.1 main()	303
5.62 test/source/test_Model.cpp File Reference	308
5.62.1 Detailed Description	309
5.62.2 Function Documentation	309
5.62.2.1 main()	309
5.63 test/source/test_Resources.cpp File Reference	317
5.63.1 Detailed Description	317
5.63.2 Function Documentation	317
5.63.2.1 main()	318
5.64 test/utlis/testing_utils.cpp File Reference	323
5.64.1 Detailed Description	324
5.64.2 Function Documentation	324
5.64.2.1 expectedErrorNotDetected()	324
5.64.2.2 printGold()	325

5.64.2.3 printGreen()	325
5.64.2.4 printRed()	325
5.64.2.5 testFloatEquals()	326
5.64.2.6 testGreaterThan()	326
5.64.2.7 testGreaterThanOrEqualTo()	327
5.64.2.8 testLessThan()	328
5.64.2.9 testLessThanOrEqualTo()	328
5.64.2.10 testTruth()	329
5.65 test/utls/testing_utils.h File Reference	329
5.65.1 Detailed Description	330
5.65.2 Macro Definition Documentation	331
5.65.2.1 FLOAT_TOLERANCE	331
5.65.3 Function Documentation	331
5.65.3.1 expectedErrorNotDetected()	331
5.65.3.2 printGold()	331
5.65.3.3 printGreen()	332
5.65.3.4 printRed()	332
5.65.3.5 testFloatEquals()	332
5.65.3.6 testGreaterThan()	333
5.65.3.7 testGreaterThanOrEqualTo()	334
5.65.3.8 testLessThan()	334
5.65.3.9 testLessThanOrEqualTo()	335
5.65.3.10 testTruth()	335
Bibliography	338
Index	339

Chapter 1

Hierarchical Index

1.1 Class Hierarchy

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

CombustionInputs	24
Controller	25
DieselInputs	56
ElectricalLoad	60
Emissions	65
Interpolator	66
InterpolatorStruct1D	80
InterpolatorStruct2D	81
LilonInputs	103
Model	108
ModelInputs	124
Production	126
Combustion	9
Diesel	42
Renewable	140
Solar	160
Tidal	186
Wave	200
Wind	216
ProductionInputs	138
RenewableInputs	148
Resources	149
SolarInputs	168
Storage	170
Lilon	84
StorageInputs	184
TidalInputs	197
WaveInputs	213
WindInputs	228

Chapter 2

Class Index

2.1 Class List

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

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	9
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 . . .	24
Controller	A class which contains a various dispatch control logic. Intended to serve as a component class of Model	25
Diesel	A derived class of the Combustion branch of Production which models production using a diesel generator	42
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 . . .	56
ElectricalLoad	A class which contains time and electrical load data. Intended to serve as a component class of Model	60
Emissions	A structure which bundles the emitted masses of various emissions chemistries	65
Interpolator	A class which contains interpolation data and functionality. Intended to serve as a component of the Production and Storage hierarchies	66
InterpolatorStruct1D	A struct which holds two parallel vectors for use in 1D interpolation	80
InterpolatorStruct2D	A struct which holds two parallel vectors and a matrix for use in 2D interpolation	81
Lilon	A derived class of Storage which models energy storage by way of lithium-ion batteries	84
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	103
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	108

ModelInputs	A structure which bundles the necessary inputs for the Model 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)	124
Production	The base class of the Production hierarchy. This hierarchy contains derived classes which model the production of energy, be it renewable or otherwise	126
ProductionInputs	A structure which bundles the necessary inputs for the Production constructor. Provides default values for every necessary input	138
Renewable	The root of the Renewable branch of the Production hierarchy. This branch contains derived classes which model the renewable production of energy	140
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 . . .	148
Resources	A class which contains renewable resource data. Intended to serve as a component class of Model	149
Solar	A derived class of the Renewable branch of Production which models solar production	160
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	168
Storage	The base class of the Storage hierarchy. This hierarchy contains derived classes which model the storage of energy	170
StorageInputs	A structure which bundles the necessary inputs for the Storage constructor. Provides default values for every necessary input	184
Tidal	A derived class of the Renewable branch of Production which models tidal production	186
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	197
Wave	A derived class of the Renewable branch of Production which models wave production	200
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	213
Wind	A derived class of the Renewable branch of Production which models wind production	216
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	228

Chapter 3

File Index

3.1 File List

Here is a list of all files with brief descriptions:

header/ Controller.h	Header file for the Controller class	231
header/ doxygen_cite.h	Header file which simply cites the doxygen tool	233
header/ ElectricalLoad.h	Header file for the ElectricalLoad class	233
header/ Interpolator.h	Header file for the Interpolator class	234
header/ Model.h	Header file for the Model class	235
header/ Resources.h	Header file for the Resources class	246
header/ std_includes.h	Header file which simply batches together some standard includes	247
header/Production/ Production.h	Header file for the Production class	238
header/Production/Combustion/ Combustion.h	Header file for the Combustion class	236
header/Production/Combustion/ Diesel.h	Header file for the Diesel class	237
header/Production/Renewable/ Renewable.h	Header file for the Renewable class	239
header/Production/Renewable/ Solar.h	Header file for the Solar class	241
header/Production/Renewable/ Tidal.h	Header file for the Tidal class	242
header/Production/Renewable/ Wave.h	Header file for the Wave class	243
header/Production/Renewable/ Wind.h	Header file for the Wind class	245
header/Storage/ Lilon.h	Header file for the Lilon class	248
header/Storage/ Storage.h	Header file for the Storage class	249
pybindings/ PYBIND11_PGM.cpp	Bindings file for PGMcpp	250

pybindings/snippets/ PYBIND11_Controller.cpp	
Bindings file for the Controller class. Intended to be #include'd in PYBIND11_PGM.cpp	253
pybindings/snippets/ PYBIND11_ElectricalLoad.cpp	
Bindings file for the ElectricalLoad class. Intended to be #include'd in PYBIND11_PGM.cpp	254
pybindings/snippets/ PYBIND11_Interpolator.cpp	
Bindings file for the Interpolator class. Intended to be #include'd in PYBIND11_PGM.cpp	254
pybindings/snippets/ PYBIND11_Model.cpp	
Bindings file for the Model class. Intended to be #include'd in PYBIND11_PGM.cpp	254
pybindings/snippets/ PYBIND11_Resources.cpp	
Bindings file for the Resources class. Intended to be #include'd in PYBIND11_PGM.cpp	254
pybindings/snippets/Production/ PYBIND11_Production.cpp	
Bindings file for the Production class. Intended to be #include'd in PYBIND11_PGM.cpp	252
pybindings/snippets/Production/Combustion/ PYBIND11_Combustion.cpp	
Bindings file for the Combustion class. Intended to be #include'd in PYBIND11_PGM.cpp	251
pybindings/snippets/Production/Combustion/ PYBIND11_Diesel.cpp	
Bindings file for the Diesel class. Intended to be #include'd in PYBIND11_PGM.cpp	251
pybindings/snippets/Production/Renewable/ PYBIND11_Renewable.cpp	
Bindings file for the Renewable class. Intended to be #include'd in PYBIND11_PGM.cpp	252
pybindings/snippets/Production/Renewable/ PYBIND11_Solar.cpp	
Bindings file for the Solar class. Intended to be #include'd in PYBIND11_PGM.cpp	252
pybindings/snippets/Production/Renewable/ PYBIND11_Tidal.cpp	
Bindings file for the Tidal class. Intended to be #include'd in PYBIND11_PGM.cpp	252
pybindings/snippets/Production/Renewable/ PYBIND11_Wave.cpp	
Bindings file for the Wave class. Intended to be #include'd in PYBIND11_PGM.cpp	253
pybindings/snippets/Production/Renewable/ PYBIND11_Wind.cpp	
Bindings file for the Wind class. Intended to be #include'd in PYBIND11_PGM.cpp	253
pybindings/snippets/Storage/ PYBIND11_Lilon.cpp	
Bindings file for the Lilon class. Intended to be #include'd in PYBIND11_PGM.cpp	255
pybindings/snippets/Storage/ PYBIND11_Storage.cpp	
Bindings file for the Storage class. Intended to be #include'd in PYBIND11_PGM.cpp	255
source/ Controller.cpp	
Implementation file for the Controller class	255
source/ ElectricalLoad.cpp	
Implementation file for the ElectricalLoad class	256
source/ Interpolator.cpp	
Implementation file for the Interpolator class	256
source/ Model.cpp	
Implementation file for the Model class	257
source/ Resources.cpp	
Implementation file for the Resources class	262
source/Production/ Production.cpp	
Implementation file for the Production class	259
source/Production/Combustion/ Combustion.cpp	
Implementation file for the Combustion class	257
source/Production/Combustion/ Diesel.cpp	
Implementation file for the Diesel class	258
source/Production/Renewable/ Renewable.cpp	
Implementation file for the Renewable class	259
source/Production/Renewable/ Solar.cpp	
Implementation file for the Solar class	260
source/Production/Renewable/ Tidal.cpp	
Implementation file for the Tidal class	260
source/Production/Renewable/ Wave.cpp	
Implementation file for the Wave class	261
source/Production/Renewable/ Wind.cpp	
Implementation file for the Wind class	261
source/Storage/ Lilon.cpp	
Implementation file for the Lilon class	263

source/Storage/Storage.cpp	
Implementation file for the Storage class	263
test/source/test_Controller.cpp	
Testing suite for Controller class	298
test/source/test_ElectricalLoad.cpp	
Testing suite for ElectricalLoad class	300
test/source/test_Interpolator.cpp	
Testing suite for Interpolator class	302
test/source/test_Model.cpp	
Testing suite for Model class	308
test/source/test_Resources.cpp	
Testing suite for Resources class	317
test/source/Production/test_Production.cpp	
Testing suite for Production class	290
test/source/Production/Combustion/test_Combustion.cpp	
Testing suite for Combustion class	264
test/source/Production/Combustion/test_Diesel.cpp	
Testing suite for Diesel class	266
test/source/Production/Renewable/test_Renewable.cpp	
Testing suite for Renewable class	272
test/source/Production/Renewable/test_Solar.cpp	
Testing suite for Solar class	273
test/source/Production/Renewable/test_Tidal.cpp	
Testing suite for Tidal class	277
test/source/Production/Renewable/test_Wave.cpp	
Testing suite for Wave class	281
test/source/Production/Renewable/test_Wind.cpp	
Testing suite for Wind class	286
test/source/Storage/test_Lilon.cpp	
Testing suite for Lilon class	293
test/source/Storage/test_Storage.cpp	
Testing suite for Storage class	296
test/utills/testing_utils.cpp	
Header file for various PGMcpp testing utilities	323
test/utills/testing_utils.h	
Header file for various PGMcpp testing utilities	329

Chapter 4

Class Documentation

4.1 Combustion Class Reference

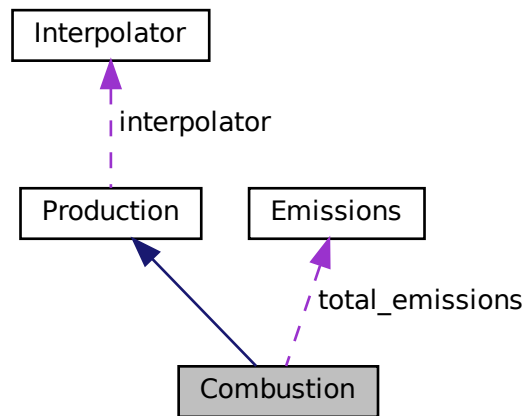
The root of the [Combustion](#) branch of the [Production](#) hierarchy. This branch contains derived classes which model the production of energy by way of combustibles.

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

Inheritance diagram for Combustion:



Collaboration diagram for Combustion:



Public Member Functions

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

Public Attributes

- [CombustionType](#) type
The type (CombustionType) of the asset.
- [FuelMode](#) fuel_mode
The fuel mode to use in modelling fuel consumption.
- [Emissions](#) total_emissions
An [Emissions](#) structure for holding total emissions [kg].
- double [fuel_cost_L](#)
The cost of fuel [1/L] (undefined currency).
- double [nominal_fuel_escalation_annual](#)
The nominal, annual fuel escalation rate to use in computing model economics.
- double [real_fuel_escalation_annual](#)
The real, annual fuel escalation rate used in computing model economics. Is computed from the given nominal inflation and discount rates.
- double [linear_fuel_slope_LkWh](#)
The slope [L/kWh] to use in computing linearized fuel consumption. This is fuel consumption per unit energy produced.
- double [linear_fuel_intercept_LkWh](#)
The intercept [L/kWh] to use in computing linearized fuel consumption. This is fuel consumption per unit energy produced.
- double [CO2_emissions_intensity_kgL](#)
Carbon dioxide (CO2) emissions intensity [kg/L].
- double [CO_emissions_intensity_kgL](#)
Carbon monoxide (CO) emissions intensity [kg/L].
- double [NOx_emissions_intensity_kgL](#)
Nitrogen oxide (NOx) emissions intensity [kg/L].
- double [SOx_emissions_intensity_kgL](#)
Sulfur oxide (SOx) emissions intensity [kg/L].
- double [CH4_emissions_intensity_kgL](#)
Methane (CH4) emissions intensity [kg/L].
- double [PM_emissions_intensity_kgL](#)
Particulate Matter (PM) emissions intensity [kg/L].
- double [total_fuel_consumed_L](#)
The total fuel consumed [L] over a model run.
- std::string [fuel_mode_str](#)
A string describing the fuel mode of the asset.
- std::vector< double > [fuel_consumption_vec_L](#)
A vector of fuel consumed [L] over each modelling time step.
- std::vector< double > [fuel_cost_vec](#)
A vector of fuel costs (undefined currency) incurred over each modelling time step. These costs are not discounted (i.e., these are actual costs).
- std::vector< double > [CO2_emissions_vec_kg](#)
A vector of carbon dioxide (CO2) emitted [kg] over each modelling time step.
- std::vector< double > [CO_emissions_vec_kg](#)
A vector of carbon monoxide (CO) emitted [kg] over each modelling time step.
- std::vector< double > [NOx_emissions_vec_kg](#)
A vector of nitrogen oxide (NOx) emitted [kg] over each modelling time step.
- std::vector< double > [SOx_emissions_vec_kg](#)
A vector of sulfur oxide (SOx) emitted [kg] over each modelling time step.
- std::vector< double > [CH4_emissions_vec_kg](#)
A vector of methane (CH4) emitted [kg] over each modelling time step.
- std::vector< double > [PM_emissions_vec_kg](#)
A vector of particulate matter (PM) emitted [kg] over each modelling time step.

Private Member Functions

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

4.1.1 Detailed Description

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

4.1.2 Constructor & Destructor Documentation

4.1.2.1 `Combustion()` [1/2]

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

Constructor (dummy) for the `Combustion` class.

```
77 {
78     return;
79 } /* Combustion() */
```

4.1.2.2 `Combustion()` [2/2]

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

Constructor (intended) for the `Combustion` class.

Parameters

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

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

```

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

```

4.1.2.3 ~Combustion()

```

Combustion::~Combustion (
    void ) [virtual]

```

Destructor for the [Combustion](#) class.

```

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

```

4.1.3 Member Function Documentation

4.1.3.1 __checkInputs()

```

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

```

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

Parameters

<i>combustion_inputs</i>	A structure of Combustion constructor inputs.
--------------------------	---

```

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

```

4.1.3.2 __writeSummary()

```

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

```

Reimplemented in [Diesel](#).

```

105 {return;}

```

4.1.3.3 `__writeTimeSeries()`

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

Reimplemented in [Diesel](#).

```
110         {return;};
```

4.1.3.4 `commit()`

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

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

Parameters

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

Returns

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

Reimplemented from [Production](#).

Reimplemented in [Diesel](#).

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

```

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

```

4.1.3.5 computeEconomics()

```

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

```

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

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

Parameters

<i>time_vec_hrs_ptr</i>	A pointer to the time_vec_hrs attribute of the ElectricalLoad .
-------------------------	---

Reimplemented from [Production](#).

```

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

```

4.1.3.6 computeFuelAndEmissions()

```

void Combustion::computeFuelAndEmissions (
    void )

```

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

```

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

```

4.1.3.7 getEmissionskg()

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

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

Parameters

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

Returns

A structure containing the mass spectrum of resulting emissions.

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

4.1.3.8 getFuelConsumptionL()

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

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

Parameters

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

Returns

The volume of fuel consumed [L].

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

```

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

```

4.1.3.9 handleReplacement()

```

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

```

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

Parameters

<i>timestep</i>	The current time step of the Model run.
-----------------	---

Reimplemented from [Production](#).

Reimplemented in [Diesel](#).

```

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

```

4.1.3.10 requestProductionkW()

```

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

```

Reimplemented in [Diesel](#).

```

156 {return 0;}

```


4.1.3.11 writeResults()

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

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

Parameters

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

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

4.1.4 Member Data Documentation

4.1.4.1 CH4_emissions_intensity_kgL

```
double Combustion::CH4_emissions_intensity_kgL
```

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

4.1.4.2 CH4_emissions_vec_kg

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

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

4.1.4.3 CO2_emissions_intensity_kgL

```
double Combustion::CO2_emissions_intensity_kgL
```

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

4.1.4.4 CO2_emissions_vec_kg

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

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

4.1.4.5 CO_emissions_intensity_kgL

```
double Combustion::CO_emissions_intensity_kgL
```

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

4.1.4.6 CO_emissions_vec_kg

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

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

4.1.4.7 fuel_consumption_vec_L

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

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

4.1.4.8 fuel_cost_L

```
double Combustion::fuel_cost_L
```

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

4.1.4.9 fuel_cost_vec

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

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

4.1.4.10 fuel_mode

```
FuelMode Combustion::fuel_mode
```

The fuel mode to use in modelling fuel consumption.

4.1.4.11 fuel_mode_str

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

A string describing the fuel mode of the asset.

4.1.4.12 linear_fuel_intercept_LkWh

```
double Combustion::linear_fuel_intercept_LkWh
```

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

4.1.4.13 linear_fuel_slope_LkWh

```
double Combustion::linear_fuel_slope_LkWh
```

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

4.1.4.14 nominal_fuel_escalation_annual

```
double Combustion::nominal_fuel_escalation_annual
```

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

4.1.4.15 NOx_emissions_intensity_kgL

```
double Combustion::NOx_emissions_intensity_kgL
```

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

4.1.4.16 NOx_emissions_vec_kg

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

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

4.1.4.17 PM_emissions_intensity_kgL

```
double Combustion::PM_emissions_intensity_kgL
```

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

4.1.4.18 PM_emissions_vec_kg

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

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

4.1.4.19 real_fuel_escalation_annual

```
double Combustion::real_fuel_escalation_annual
```

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

4.1.4.20 SOx_emissions_intensity_kgL

```
double Combustion::SOx_emissions_intensity_kgL
```

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

4.1.4.21 SOx_emissions_vec_kg

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

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

4.1.4.22 total_emissions

```
Emissions Combustion::total_emissions
```

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

4.1.4.23 total_fuel_consumed_L

```
double Combustion::total_fuel_consumed_L
```

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

4.1.4.24 type

```
CombustionType Combustion::type
```

The type (CombustionType) of the asset.

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

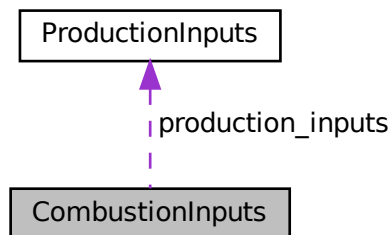
- [header/Production/Combustion/Combustion.h](#)
- [source/Production/Combustion/Combustion.cpp](#)

4.2 CombustionInputs Struct Reference

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

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

Collaboration diagram for CombustionInputs:



Public Attributes

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

4.2.1 Detailed Description

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

4.2.2 Member Data Documentation

4.2.2.1 fuel_mode

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

The fuel mode to use in modelling fuel consumption.

4.2.2.2 nominal_fuel_escalation_annual

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

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

4.2.2.3 path_2_fuel_interp_data

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

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

4.2.2.4 production_inputs

```
ProductionInputs CombustionInputs::production_inputs
```

An encapsulated [ProductionInputs](#) instance.

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

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

4.3 Controller Class Reference

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

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

Public Member Functions

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

Public Attributes

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

Private Member Functions

- `void` `__computeNetLoad` (*ElectricalLoad* *, `std::vector< Renewable * >` *, *Resources* *)
Helper method to compute and populate the net load vector.
- `void` `__constructCombustionMap` (`std::vector< Combustion * >` *)
Helper method to construct a *Combustion* map, for use in determining.
- `void` `__applyLoadFollowingControl_CHARGING` (int, *ElectricalLoad* *, `std::vector< Combustion * >` *, `std::vector< Renewable * >` *, `std::vector< Storage * >` *)
Helper method to apply load following control action for given timestep of the *Model* run when net load ≤ 0 .
- `void` `__applyLoadFollowingControl_DISCHARGING` (int, *ElectricalLoad* *, `std::vector< Combustion * >` *, `std::vector< Renewable * >` *, `std::vector< Storage * >` *)
Helper method to apply load following control action for given timestep of the *Model* run when net load > 0 .
- `void` `__applyCycleChargingControl_CHARGING` (int, *ElectricalLoad* *, `std::vector< Combustion * >` *, `std::vector< Renewable * >` *, `std::vector< Storage * >` *)
Helper method to apply cycle charging control action for given timestep of the *Model* run when net load ≤ 0 . Simply defaults to load following control.
- `void` `__applyCycleChargingControl_DISCHARGING` (int, *ElectricalLoad* *, `std::vector< Combustion * >` *, `std::vector< Renewable * >` *, `std::vector< Storage * >` *)
Helper method to apply cycle charging control action for given timestep of the *Model* run when net load > 0 . Defaults to load following control if no depleted storage assets.
- `void` `__handleStorageCharging` (int, double, `std::list< Storage * >`, `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)
bool is_cycle_charging)
- `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.

```
1000 {
1001     return;
1002 } /* Controller() */
```

4.3.2.2 ~Controller()

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

Destructor for the [Controller](#) class.

```
1229 {
1230     this->clear();
1231
1232     return;
1233 } /* ~Controller() */
```

4.3.3 Member Function Documentation

4.3.3.1 __applyCycleChargingControl_CHARGING()

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

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

Parameters

<i>timestep</i>	The current time step of the Model run.
<i>electrical_load_ptr</i>	A pointer to the ElectricalLoad component of the Model .
<i>combustion_ptr_vec_ptr</i>	A pointer to the Combustion pointer vector of the Model .
<i>renewable_ptr_vec_ptr</i>	A pointer to the Renewable pointer vector of the Model .
<i>storage_ptr_vec_ptr</i>	A pointer to the Storage pointer vector of the Model .

```

403 {
404     // 1. default to load following
405     this->__applyLoadFollowingControl_CHARGING(
406         timestep,
407         electrical_load_ptr,
408         combustion_ptr_vec_ptr,
409         renewable_ptr_vec_ptr,
410         storage_ptr_vec_ptr
411     );
412
413     return;
414 } /* __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 Model run.
<i>electrical_load_ptr</i>	A pointer to the ElectricalLoad component of the Model .
<i>combustion_ptr_vec_ptr</i>	A pointer to the Combustion pointer vector of the Model .
<i>renewable_ptr_vec_ptr</i>	A pointer to the Renewable pointer vector of the Model .
<i>storage_ptr_vec_ptr</i>	A pointer to the Storage pointer vector of the Model .

curtailment

```

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

```

```

486         net_load_kW = this->__handleCombustionDispatch(
487             timestep,
488             dt_hrs,
489             net_load_kW,
490             combustion_ptr_vec_ptr,
491             false // is_cycle_charging
492         );
493     }
494
495     else {
496         net_load_kW = this->__handleCombustionDispatch(
497             timestep,
498             dt_hrs,
499             net_load_kW,
500             combustion_ptr_vec_ptr,
501             true // is_cycle_charging
502         );
503     }
504
505     // 5. attempt to charge depleted Storage assets using any and all available
506     // charge priority is Combustion, then Renewable
507     this->__handleStorageCharging(
508         timestep,
509         dt_hrs,
510         depleted_storage_ptr_list,
511         combustion_ptr_vec_ptr,
512         renewable_ptr_vec_ptr
513     );
514
515     // 6. record any missed load
516     if (net_load_kW > 1e-6) {
517         this->missed_load_vec_kW[timestep] = net_load_kW;
518     }
519
520     return;
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 ≤ 0 ;

Parameters

<i>timestep</i>	The current time step of the Model run.
<i>electrical_load_ptr</i>	A pointer to the ElectricalLoad component of the Model .
<i>combustion_ptr_vec_ptr</i>	A pointer to the Combustion pointer vector of the Model .
<i>renewable_ptr_vec_ptr</i>	A pointer to the Renewable pointer vector of the Model .
<i>storage_ptr_vec_ptr</i>	A pointer to the Storage pointer vector of the Model .

```

246 {
247     // 1. get dt_hrs, set net load
248     double dt_hrs = electrical_load_ptr->dt_vec_hrs[timestep];
249     double net_load_kW = 0;
250
251     // 2. request zero production from all Combustion assets
252     this->__handleCombustionDispatch(
253         timestep,
254         dt_hrs,
255         net_load_kW,
256         combustion_ptr_vec_ptr,
257         false // is_cycle_charging
258     );

```

```

259
260 // 3. attempt to charge all Storage assets using any and all available curtailment
261 // charge priority is Combustion, then Renewable
262 this->__handleStorageCharging(
263     timestep,
264     dt_hrs,
265     storage_ptr_vec_ptr,
266     combustion_ptr_vec_ptr,
267     renewable_ptr_vec_ptr
268 );
269
270 return;
271 } /* __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 Model run.
<i>electrical_load_ptr</i>	A pointer to the ElectricalLoad component of the Model .
<i>combustion_ptr_vec_ptr</i>	A pointer to the Combustion pointer vector of the Model .
<i>renewable_ptr_vec_ptr</i>	A pointer to the Renewable pointer vector of the Model .
<i>storage_ptr_vec_ptr</i>	A pointer to the Storage pointer vector of the Model .

curtailment

```

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

```

```

342         dt_hrs,
343         net_load_kW,
344         combustion_ptr_vec_ptr,
345         false // is_cycle_charging
346     );
347
348     // 5. attempt to charge depleted Storage assets using any and all available
349     // charge priority is Combustion, then Renewable
350     this->__handleStorageCharging(
351         timestep,
352         dt_hrs,
353         depleted_storage_ptr_list,
354         combustion_ptr_vec_ptr,
355         renewable_ptr_vec_ptr
356     );
357
358     // 6. record any missed load
359     if (net_load_kW > 1e-6) {
360         this->missed_load_vec_kW[timestep] = net_load_kW;
361     }
362 }
363
364 return;
365 } /* __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 ElectricalLoad component of the Model .
<i>renewable_ptr_vec_ptr</i>	A pointer to the Renewable pointer vector of the Model .
<i>resources_ptr</i>	A pointer to the Resources component of the Model .

```

57 {
58     // 1. init
59     this->net_load_vec_kW.resize(electrical_load_ptr->n_points, 0);
60     this->missed_load_vec_kW.resize(electrical_load_ptr->n_points, 0);
61
62     // 2. populate net load vector
63     double dt_hrs = 0;
64     double load_kW = 0;
65     double net_load_kW = 0;
66     double production_kW = 0;
67
68     Renewable* renewable_ptr;
69
70     for (int i = 0; i < electrical_load_ptr->n_points; i++) {
71         dt_hrs = electrical_load_ptr->dt_vec_hrs[i];
72         load_kW = electrical_load_ptr->load_vec_kW[i];
73         net_load_kW = load_kW;
74
75         for (size_t j = 0; j < renewable_ptr_vec_ptr->size(); j++) {
76             renewable_ptr = renewable_ptr_vec_ptr->at(j);
77
78             production_kW = this->__getRenewableProduction(
79                 i,
80                 dt_hrs,
81                 renewable_ptr,
82                 resources_ptr
83             );

```

```

84
85         load_kW = renewable_ptr->commit(
86             i,
87             dt_hrs,
88             production_kW,
89             load_kW
90         );
91
92         net_load_kW -= production_kW;
93     }
94
95     this->net_load_vec_kW[i] = net_load_kW;
96 }
97
98 return;
99 } /* __computeNetLoad() */

```

4.3.3.6 __constructCombustionMap()

```

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

```

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

Parameters

<i>combustion_ptr_vec_ptr</i>	A pointer to the Combustion pointer vector of the Model .
-------------------------------	---

```

121 {
122     // 1. get state table dimensions
123     int n_cols = combustion_ptr_vec_ptr->size();
124     int n_rows = pow(2, n_cols);
125
126     // 2. init state table (all possible on/off combinations)
127     std::vector<std::vector<bool>> state_table;
128     state_table.resize(n_rows, {});
129
130     int x = 0;
131     for (int i = 0; i < n_rows; i++) {
132         state_table[i].resize(n_cols, false);
133
134         x = i;
135         for (int j = 0; j < n_cols; j++) {
136             if (x % 2 == 0) {
137                 state_table[i][j] = true;
138             }
139             x /= 2;
140         }
141     }
142
143     // 3. construct combustion map (handle duplicates by keeping rows with minimum
144     //     trues)
145     double total_capacity_kW = 0;
146     int truth_count = 0;
147     int current_truth_count = 0;
148
149     for (int i = 0; i < n_rows; i++) {
150         total_capacity_kW = 0;
151         truth_count = 0;
152         current_truth_count = 0;
153
154         for (int j = 0; j < n_cols; j++) {
155             if (state_table[i][j]) {
156                 total_capacity_kW += combustion_ptr_vec_ptr->at(j)->capacity_kW;
157                 truth_count++;
158             }
159         }
160
161         if (this->combustion_map.count(total_capacity_kW) > 0) {
162             for (int j = 0; j < n_cols; j++) {
163                 if (this->combustion_map[total_capacity_kW][j]) {
164                     current_truth_count++;
165                 }
166             }
167         }

```

```

168         if (truth_count < current_truth_count) {
169             this->combustion_map.erase(total_capacity_kW);
170         }
171     }
172
173     this->combustion_map.insert(
174         std::pair<double, std::vector<bool>> (
175             total_capacity_kW,
176             state_table[i]
177         )
178     );
179 }
180
181 /*
182 // ==== TEST PRINT ==== //
183 std::cout << std::endl;
184
185 std::cout << "\t\t";
186 for (size_t i = 0; i < combustion_ptr_vec_ptr->size(); i++) {
187     std::cout << combustion_ptr_vec_ptr->at(i)->capacity_kW << "\t";
188 }
189 std::cout << std::endl;
190
191 std::map<double, std::vector<bool>::iterator iter;
192 for (
193     iter = this->combustion_map.begin();
194     iter != this->combustion_map.end();
195     iter++
196 ) {
197     std::cout << iter->first << ":\t{\t";
198
199     for (size_t i = 0; i < iter->second.size(); i++) {
200         std::cout << iter->second[i] << "\t";
201     }
202     std::cout << "}" << std::endl;
203 }
204 // ==== END TEST PRINT ==== //
205 /**/
206
207 return;
208 } /* __constructCombustionTable() */

```

4.3.3.7 __getRenewableProduction()

```

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

```

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

Parameters

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

Returns

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

```

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

```

```

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

```

4.3.3.8 __handleCombustionDispatch()

```

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

```

bool is_cycle_charging)

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

Parameters

<i>timestep</i>	The current time step of the Model 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 Combustion pointer vector of the Model .
<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.

```

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

```
560 {
561     double acceptable_kW = 0;
562     double curtailment_kW = 0;
563
564     Storage* storage_ptr;
565     Combustion* combustion_ptr;
566     Renewable* renewable_ptr;
567
568     std::list<Storage*>::iterator iter;
569     for (
570         iter = storage_ptr_list.begin();
571         iter != storage_ptr_list.end();
572         iter++
573     ){
574         storage_ptr = (*iter);
575
576         // 1. attempt to charge from Combustion curtailment first
577         for (size_t i = 0; i < combustion_ptr_vec_ptr->size(); i++) {
578             combustion_ptr = combustion_ptr_vec_ptr->at(i);
579             curtailment_kW = combustion_ptr->curtailment_vec_kW[timestep];
580
581             if (curtailment_kW <= 0) {
582                 continue;
583             }
584
585             acceptable_kW = storage_ptr->getAcceptablekW(dt_hrs);
586
587             if (acceptable_kW > curtailment_kW) {
588                 acceptable_kW = curtailment_kW;
589             }
590
591             combustion_ptr->curtailment_vec_kW[timestep] -= acceptable_kW;
592             combustion_ptr->storage_vec_kW[timestep] += acceptable_kW;
593             storage_ptr->power_kW += acceptable_kW;
594         }
595
596         // 2. attempt to charge from Renewable curtailment second
597         for (size_t i = 0; i < renewable_ptr_vec_ptr->size(); i++) {
598             renewable_ptr = renewable_ptr_vec_ptr->at(i);
599             curtailment_kW = renewable_ptr->curtailment_vec_kW[timestep];
600
601             if (curtailment_kW <= 0) {
602                 continue;
603             }
604
605             acceptable_kW = storage_ptr->getAcceptablekW(dt_hrs);
606
607             if (acceptable_kW > curtailment_kW) {
608                 acceptable_kW = curtailment_kW;
609             }
610
611             renewable_ptr->curtailment_vec_kW[timestep] -= acceptable_kW;
612             renewable_ptr->storage_vec_kW[timestep] += acceptable_kW;
613             storage_ptr->power_kW += acceptable_kW;
614         }
615
616         // 3. commit charge
617         storage_ptr->commitCharge(
618             timestep,
619             dt_hrs,
620             storage_ptr->power_kW
621         );
622     }
623 }
```

```

624     return;
625 } /* __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 Model 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 Storage assets that are to be charged.
<i>combustion_ptr_vec_ptr</i>	A pointer to the Combustion pointer vector of the Model .
<i>renewable_ptr_vec_ptr</i>	A pointer to the Renewable pointer vector of the Model .

```

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

```

```

710         renewable_ptr->storage_vec_kW[timestep] += acceptable_kW;
711         storage_ptr->power_kW += acceptable_kW;
712     }
713
714     // 3. commit charge
715     storage_ptr->commitCharge(
716         timestep,
717         dt_hrs,
718         storage_ptr->power_kW
719     );
720 }
721
722 return;
723 } /* __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 Model 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 Storage assets that are to be discharged.

Returns

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

```

953 {
954     double discharging_kW = 0;
955
956     Storage* storage_ptr;
957
958     std::list<Storage*>::iterator iter;
959     for (
960         iter = storage_ptr_list.begin();
961         iter != storage_ptr_list.end();
962         iter++
963     ){
964         storage_ptr = (*iter);
965
966         discharging_kW = storage_ptr->getAvailablekW(dt_hrs);
967
968         if (discharging_kW > net_load_kW) {
969             discharging_kW = net_load_kW;
970         }
971
972         net_load_kW = storage_ptr->commitDischarge(
973             timestep,
974             dt_hrs,
975             discharging_kW,
976             net_load_kW
977         );
978     }
979
980     return net_load_kW;
981 } /* __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 ElectricalLoad component of the Model .
<i>combustion_ptr_vec_ptr</i>	A pointer to the Combustion pointer vector of the Model .
<i>renewable_ptr_vec_ptr</i>	A pointer to the Renewable pointer vector of the Model .
<i>storage_ptr_vec_ptr</i>	A pointer to the Storage pointer vector of the Model .

```
1124 {
1125     for (int i = 0; i < electrical_load_ptr->n_points; i++) {
1126         switch (this->control_mode) {
1127             case (ControlMode :: LOAD_FOLLOWING): {
1128                 if (this->net_load_vec_kW[i] <= 0) {
1129                     this->__applyLoadFollowingControl_CHARGING(
1130                         i,
1131                         electrical_load_ptr,
1132                         combustion_ptr_vec_ptr,
1133                         renewable_ptr_vec_ptr,
1134                         storage_ptr_vec_ptr
1135                     );
1136                 }
1137             }
1138             else {
1139                 this->__applyLoadFollowingControl_DISCHARGING(
1140                     i,
1141                     electrical_load_ptr,
1142                     combustion_ptr_vec_ptr,
1143                     renewable_ptr_vec_ptr,
1144                     storage_ptr_vec_ptr
1145                 );
1146             }
1147             break;
1148         }
1149     }
1150
1151     case (ControlMode :: CYCLE_CHARGING): {
1152         if (this->net_load_vec_kW[i] <= 0) {
1153             this->__applyCycleChargingControl_CHARGING(
1154                 i,
1155                 electrical_load_ptr,
1156                 combustion_ptr_vec_ptr,
1157                 renewable_ptr_vec_ptr,
1158                 storage_ptr_vec_ptr
1159             );
1160         }
1161     }
1162     else {
1163         this->__applyCycleChargingControl_DISCHARGING(
1164             i,
1165             electrical_load_ptr,
1166             combustion_ptr_vec_ptr,
1167             renewable_ptr_vec_ptr,
1168             storage_ptr_vec_ptr
1169         );
1170     }
1171     break;
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
1185             throw std::runtime_error(error_str);
1186
1187             break;
1188         }
1189     }
1190 }
1191
1192 return;
1193 } /* applyDispatchControl() */

```

4.3.3.13 clear()

```

void Controller::clear (
    void )

```

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

```

1208 {
1209     this->net_load_vec_kW.clear();
1210     this->missed_load_vec_kW.clear();
1211     this->combustion_map.clear();
1212
1213     return;
1214 } /* 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 ElectricalLoad component of the Model .
<i>renewable_ptr_vec_ptr</i>	A pointer to the Renewable pointer vector of the Model .
<i>resources_ptr</i>	A pointer to the Resources component of the Model .
<i>combustion_ptr_vec_ptr</i>	A pointer to the Combustion pointer vector of the Model .

```

1083 {
1084     // 1. compute net load
1085     this->__computeNetLoad(electrical_load_ptr, renewable_ptr_vec_ptr, resources_ptr);
1086
1087     // 2. construct Combustion table
1088     this->__constructCombustionMap(combustion_ptr_vec_ptr);
1089
1090     return;
1091 } /* 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 Controller .
---------------------------	---

```

1017 {
1018     this->control_mode = control_mode;
1019
1020     switch(control_mode) {
1021         case (ControlMode :: LOAD_FOLLOWING): {
1022             this->control_string = "LOAD_FOLLOWING";
1023
1024             break;
1025         }
1026
1027         case (ControlMode :: CYCLE_CHARGING): {
1028             this->control_string = "CYCLE_CHARGING";
1029
1030             break;
1031         }
1032
1033         default: {
1034             std::string error_str = "ERROR: Controller :: setControlMode(): ";
1035             error_str += "control mode ";
1036             error_str += std::to_string(control_mode);
1037             error_str += " not recognized";
1038
1039             #ifdef _WIN32
1040                 std::cout << error_str << std::endl;
1041             #endif
1042
1043             throw std::runtime_error(error_str);
1044
1045             break;
1046         }
1047     }
1048
1049     return;
1050 } /* setControlMode() */

```

4.3.4 Member Data Documentation

4.3.4.1 combustion_map

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

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

4.3.4.2 control_mode

`ControlMode Controller::control_mode`

The ControlMode that is active in the [Model](#).

4.3.4.3 control_string

`std::string Controller::control_string`

A string describing the active ControlMode.

4.3.4.4 missed_load_vec_kW

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

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

4.3.4.5 net_load_vec_kW

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

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

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

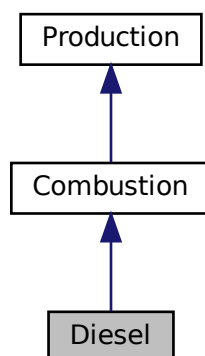
- header/[Controller.h](#)
- source/[Controller.cpp](#)

4.4 Diesel Class Reference

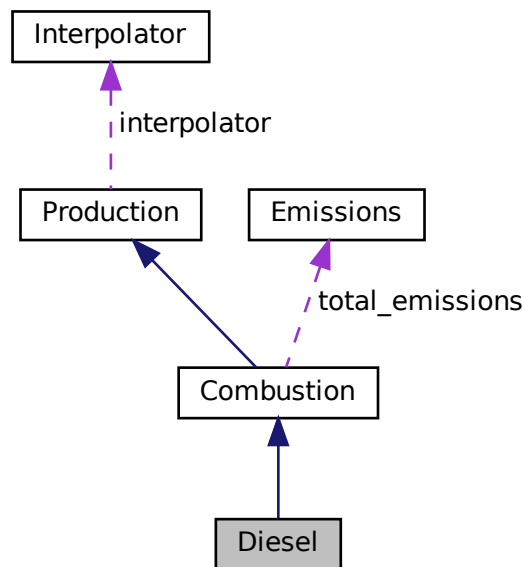
A derived class of the [Combustion](#) branch of [Production](#) which models production using a diesel generator.

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

Inheritance diagram for Diesel:



Collaboration diagram for Diesel:



Public Member Functions

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

Public Attributes

- double [minimum_load_ratio](#)
The minimum load ratio of the asset. That is, when the asset is producing, it must produce at least this ratio of its rated capacity.
- double [minimum_runtime_hrs](#)
The minimum runtime [hrs] of the asset. This is the minimum time that must elapse between successive starts and stops.
- double [time_since_last_start_hrs](#)
The time that has elapsed [hrs] since the last start of the asset.

Private Member Functions

- void `__checkInputs` ([DieselInputs](#))
Helper method to check inputs to the [Diesel](#) constructor.
- void `__handleStartStop` (int, double, double)
Helper method (private) to handle the starting/stopping of the diesel generator. The minimum runtime constraint is enforced in this method.
- double `__getGenericFuelSlope` (void)
Helper method to generate a generic, linearized fuel consumption slope for a diesel generator.
- double `__getGenericFuelIntercept` (void)
Helper method to generate a generic, linearized fuel consumption intercept for a diesel generator.
- double `__getGenericCapitalCost` (void)
Helper method to generate a generic diesel generator capital cost.
- double `__getGenericOpMaintCost` (void)
Helper method (private) to generate a generic diesel generator operation and maintenance cost. This is a cost incurred per unit energy produced.
- void `__writeSummary` (std::string)
Helper method to write summary results for [Diesel](#).
- void `__writeTimeSeries` (std::string, std::vector< double > *, int=-1)
Helper method to write time series results for [Diesel](#).

4.4.1 Detailed Description

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

4.4.2 Constructor & Destructor Documentation

4.4.2.1 `Diesel()` [1/2]

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

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

```
596 {
597     return;
598 } /* Diesel() */
```

4.4.2.2 `Diesel()` [2/2]

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

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

Parameters

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

```

626 :
627 Combustion(
628     n_points,
629     n_years,
630     diesel_inputs.combustion_inputs
631 )
632 {
633     // 1. check inputs
634     this->__checkInputs(diesel_inputs);
635
636     // 2. set attributes
637     this->type = CombustionType :: DIESEL;
638     this->type_str = "DIESEL";
639
640     this->replace_running_hrs = diesel_inputs.replace_running_hrs;
641
642     this->fuel_cost_L = diesel_inputs.fuel_cost_L;
643
644     this->minimum_load_ratio = diesel_inputs.minimum_load_ratio;
645     this->minimum_runtime_hrs = diesel_inputs.minimum_runtime_hrs;
646     this->time_since_last_start_hrs = 0;
647
648     this->CO2_emissions_intensity_kgL = diesel_inputs.CO2_emissions_intensity_kgL;
649     this->CO_emissions_intensity_kgL = diesel_inputs.CO_emissions_intensity_kgL;
650     this->NOx_emissions_intensity_kgL = diesel_inputs.NOx_emissions_intensity_kgL;
651     this->SOx_emissions_intensity_kgL = diesel_inputs.SOx_emissions_intensity_kgL;
652     this->CH4_emissions_intensity_kgL = diesel_inputs.CH4_emissions_intensity_kgL;
653     this->PM_emissions_intensity_kgL = diesel_inputs.PM_emissions_intensity_kgL;
654
655     if (diesel_inputs.linear_fuel_slope_LkWh < 0) {
656         this->linear_fuel_slope_LkWh = this->__getGenericFuelSlope();
657     }
658
659     if (diesel_inputs.linear_fuel_intercept_LkWh < 0) {
660         this->linear_fuel_intercept_LkWh = this->__getGenericFuelIntercept();
661     }
662
663     if (diesel_inputs.capital_cost < 0) {
664         this->capital_cost = this->__getGenericCapitalCost();
665     }
666
667     if (diesel_inputs.operation_maintenance_cost_kWh < 0) {
668         this->operation_maintenance_cost_kWh = this->__getGenericOpMaintCost();
669     }
670
671     if (not this->is_sunk) {
672         this->capital_cost_vec[0] = this->capital_cost;
673     }
674
675     // 3. construction print
676     if (this->print_flag) {
677         std::cout << "Diesel object constructed at " << this << std::endl;
678     }
679
680     return;
681 } /* Diesel() */

```

4.4.2.3 ~Diesel()

```

Diesel::~Diesel (
    void )

```

Destructor for the [Diesel](#) class.

```

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

```

4.4.3 Member Function Documentation

4.4.3.1 `__checkInputs()`

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

Helper method to check inputs to the `Diesel` constructor.

Parameters

<i>diesel_inputs</i>	A structure of <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_kgL
53     if (diesel_inputs.CO2_emissions_intensity_kgL < 0) {
54         std::string error_str = "ERROR: Diesel(): ";
55         error_str += "DieselInputs::CO2_emissions_intensity_kgL must be >= 0";
56
57         #ifdef _WIN32
58             std::cout << error_str << std::endl;
59         #endif
60
61         throw std::invalid_argument(error_str);
62     }
63
64     // 3. check CO_emissions_intensity_kgL
65     if (diesel_inputs.CO_emissions_intensity_kgL < 0) {
66         std::string error_str = "ERROR: Diesel(): ";
67         error_str += "DieselInputs::CO_emissions_intensity_kgL must be >= 0";
68
69         #ifdef _WIN32
70             std::cout << error_str << std::endl;
71         #endif
72
73         throw std::invalid_argument(error_str);
74     }
75
76     // 4. check NOx_emissions_intensity_kgL
77     if (diesel_inputs.NOx_emissions_intensity_kgL < 0) {
78         std::string error_str = "ERROR: Diesel(): ";
79         error_str += "DieselInputs::NOx_emissions_intensity_kgL must be >= 0";
80
81         #ifdef _WIN32
82             std::cout << error_str << std::endl;
83         #endif
84
85         throw std::invalid_argument(error_str);
86     }
87
88     // 5. check SOx_emissions_intensity_kgL
89     if (diesel_inputs.SOx_emissions_intensity_kgL < 0) {
90         std::string error_str = "ERROR: Diesel(): ";
91         error_str += "DieselInputs::SOx_emissions_intensity_kgL must be >= 0";
92
93         #ifdef _WIN32
94             std::cout << error_str << std::endl;
95         #endif
96
97         throw std::invalid_argument(error_str);
98     }
99 }
```

```

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

```

4.4.3.2 __getGenericCapitalCost()

```

double Diesel::__getGenericCapitalCost (
    void ) [private]

```

Helper method to generate a generic diesel generator capital cost.

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

Returns

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

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

4.4.3.3 __getGenericFuelIntercept()

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

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

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

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

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

Returns

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

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

4.4.3.4 __getGenericFuelSlope()

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

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

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

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

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

Returns

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

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

4.4.3.5 `__getGenericOpMaintCost()`

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

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

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

Returns

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

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

4.4.3.6 `__handleStartStop()`

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

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

Parameters

<i>timestep</i>	The current time step of the Model 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): " << this->nominal_fuel_escalation_annual << " \n";
384     ofs << "Real Fuel Escalation Rate (annual): " << this->real_fuel_escalation_annual << " \n";
385     ofs << "\n";
386
387     ofs << "Fuel Mode: " << this->fuel_mode_str << " \n";
388
389     switch (this->fuel_mode) {
390     case (FuelMode :: FUEL_MODE_LINEAR): {
391         ofs << "Linear Fuel Slope: " << this->linear_fuel_slope_LkWh
392             << " L/kWh \n";
393         ofs << "Linear Fuel Intercept Coefficient: "
394             << this->linear_fuel_intercept_LkWh << " L/kWh \n";
395         ofs << "\n";
396     }
397     break;
398 }
399
400

```



```

401         case (FuelMode :: FUEL_MODE_LOOKUP): {
402             ofs << "Fuel Consumption Data: " << this->interpolator.path_map_1D[0]
403                 << " \n";
404
405             break;
406         }
407
408         default: {
409             // write nothing!
410
411             break;
412         }
413     }
414
415     ofs << "Carbon Dioxide (CO2) Emissions Intensity: "
416         << this->CO2_emissions_intensity_kgL << " kg/L \n";
417
418     ofs << "Carbon Monoxide (CO) Emissions Intensity: "
419         << this->CO_emissions_intensity_kgL << " kg/L \n";
420
421     ofs << "Nitrogen Oxides (NOx) Emissions Intensity: "
422         << this->NOx_emissions_intensity_kgL << " kg/L \n";
423
424     ofs << "Sulfur Oxides (SOx) Emissions Intensity: "
425         << this->SOx_emissions_intensity_kgL << " kg/L \n";
426
427     ofs << "Methane (CH4) Emissions Intensity: "
428         << this->CH4_emissions_intensity_kgL << " kg/L \n";
429
430     ofs << "Particulate Matter (PM) Emissions Intensity: "
431         << this->PM_emissions_intensity_kgL << " kg/L \n";
432
433     ofs << "\n-----\n\n";
434
435     // 2.3. Diesel attributes
436     ofs << "## Diesel Attributes\n";
437     ofs << "\n";
438
439     ofs << "Minimum Load Ratio: " << this->minimum_load_ratio << " \n";
440     ofs << "Minimum Runtime: " << this->minimum_runtime_hrs << " hrs \n";
441
442     ofs << "\n-----\n\n";
443
444     // 2.4. Diesel Results
445     ofs << "## Results\n";
446     ofs << "\n";
447
448     ofs << "Net Present Cost: " << this->net_present_cost << " \n";
449     ofs << "\n";
450
451     ofs << "Total Dispatch: " << this->total_dispatch_kWh
452         << " kWh \n";
453
454     ofs << "Levellized Cost of Energy: " << this->levellized_cost_of_energy_kWh
455         << " per kWh dispatched \n";
456     ofs << "\n";
457
458     ofs << "Running Hours: " << this->running_hours << " \n";
459     ofs << "Starts: " << this->n_starts << " \n";
460     ofs << "Replacements: " << this->n_replacements << " \n";
461
462     ofs << "Total Fuel Consumed: " << this->total_fuel_consumed_L << " L "
463         << "(Annual Average: " << this->total_fuel_consumed_L / this->n_years
464         << " L/yr) \n";
465     ofs << "\n";
466
467     ofs << "Total Carbon Dioxide (CO2) Emissions: " <<
468         this->total_emissions.CO2_kg << " kg "
469         << "(Annual Average: " << this->total_emissions.CO2_kg / this->n_years
470         << " kg/yr) \n";
471
472     ofs << "Total Carbon Monoxide (CO) Emissions: " <<
473         this->total_emissions.CO_kg << " kg "
474         << "(Annual Average: " << this->total_emissions.CO_kg / this->n_years
475         << " kg/yr) \n";
476
477     ofs << "Total Nitrogen Oxides (NOx) Emissions: " <<
478         this->total_emissions.NOx_kg << " kg "
479         << "(Annual Average: " << this->total_emissions.NOx_kg / this->n_years
480         << " kg/yr) \n";
481
482     ofs << "Total Sulfur Oxides (SOx) Emissions: " <<
483         this->total_emissions.SOx_kg << " kg "
484         << "(Annual Average: " << this->total_emissions.SOx_kg / this->n_years
485         << " kg/yr) \n";
486
487     ofs << "Total Methane (CH4) Emissions: " << this->total_emissions.CH4_kg << " kg "

```

```

488         « "(Annual Average: " « this->total_emissions.CH4_kg / this->n_years
489         « " kg/yr)  \n";
490
491     ofs « "Total Particulate Matter (PM) Emissions: " «
492     this->total_emissions.PM_kg « " kg "
493     « "(Annual Average: " « this->total_emissions.PM_kg / this->n_years
494     « " kg/yr)  \n";
495
496     ofs « "\n-----\n\n";
497
498     ofs.close();
499     return;
500 } /* __writeSummary() */

```

4.4.3.8 __writeTimeSeries()

```

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

```

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

Parameters

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

Reimplemented from [Combustion](#).

```

530 {
531     // 1. create filestream
532     write_path += "time_series_results.csv";
533     std::ofstream ofs;
534     ofs.open(write_path, std::ofstream::out);
535
536     // 2. write time series results (comma separated value)
537     ofs « "Time (since start of data) [hrs],";
538     ofs « "Production [kW],";
539     ofs « "Dispatch [kW],";
540     ofs « "Storage [kW],";
541     ofs « "Curtailement [kW],";
542     ofs « "Is Running (N = 0 / Y = 1),";
543     ofs « "Fuel Consumption [L],";
544     ofs « "Fuel Cost (actual),";
545     ofs « "Carbon Dioxide (CO2) Emissions [kg],";
546     ofs « "Carbon Monoxide (CO) Emissions [kg],";
547     ofs « "Nitrogen Oxides (NOx) Emissions [kg],";
548     ofs « "Sulfur Oxides (SOx) Emissions [kg],";
549     ofs « "Methane (CH4) Emissions [kg],";
550     ofs « "Particulate Matter (PM) Emissions [kg],";
551     ofs « "Capital Cost (actual),";
552     ofs « "Operation and Maintenance Cost (actual),";
553     ofs « "\n";
554
555     for (int i = 0; i < max_lines; i++) {
556         ofs « time_vec_hrs_ptr->at(i) « ",";
557         ofs « this->production_vec_kW[i] « ",";
558         ofs « this->dispatch_vec_kW[i] « ",";
559         ofs « this->storage_vec_kW[i] « ",";
560         ofs « this->curtailment_vec_kW[i] « ",";
561         ofs « this->is_running_vec[i] « ",";
562         ofs « this->fuel_consumption_vec_L[i] « ",";
563         ofs « this->fuel_cost_vec[i] « ",";
564         ofs « this->CO2_emissions_vec_kg[i] « ",";
565         ofs « this->CO_emissions_vec_kg[i] « ",";
566         ofs « this->NOx_emissions_vec_kg[i] « ",";
567         ofs « this->SOx_emissions_vec_kg[i] « ",";
568         ofs « this->CH4_emissions_vec_kg[i] « ",";

```

```

569         ofs << this->PM_emissions_vec_kg[i] << ", ";
570         ofs << this->capital_cost_vec[i] << ", ";
571         ofs << this->operation_maintenance_cost_vec[i] << ", ";
572         ofs << "\n";
573     }
574
575     ofs.close();
576     return;
577 } /* __writeTimeSeries() */

```

4.4.3.9 commit()

```

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

```

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

Parameters

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

Returns

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

Reimplemented from [Combustion](#).

```

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

```

4.4.3.10 handleReplacement()

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

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

Parameters

<i>timestep</i>	The current time step of the Model run.
-----------------	---

Reimplemented from [Combustion](#).

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

4.4.3.11 requestProductionkW()

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

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

Parameters

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

Returns

The production [kW] delivered by the diesel generator.

Reimplemented from [Combustion](#).

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

```
754         deliver_kW = this->minimum_load_ratio * this->capacity_kW;
755     }
756
757     return deliver_kW;
758 } /* requestProductionkW() */
```

4.4.4 Member Data Documentation

4.4.4.1 minimum_load_ratio

```
double Diesel::minimum_load_ratio
```

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

4.4.4.2 minimum_runtime_hrs

```
double Diesel::minimum_runtime_hrs
```

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

4.4.4.3 time_since_last_start_hrs

```
double Diesel::time_since_last_start_hrs
```

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

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

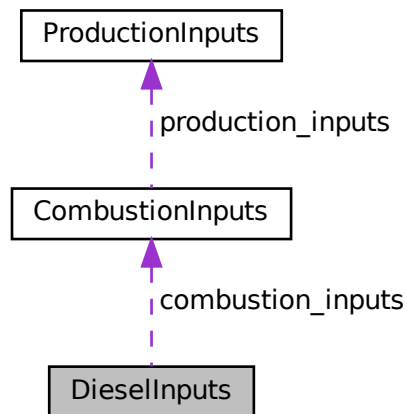
- header/Production/Combustion/[Diesel.h](#)
- source/Production/Combustion/[Diesel.cpp](#)

4.5 DieselInputs Struct Reference

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

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

Collaboration diagram for DieselInputs:



Public Attributes

- [CombustionInputs combustion_inputs](#)
An encapsulated [CombustionInputs](#) instance.
- double [replace_running_hrs](#) = 30000
The number of running hours after which the asset must be replaced. Overwrites the [ProductionInputs](#) attribute.
- double [capital_cost](#) = -1
The capital cost of the asset (undefined currency). -1 is a sentinel value, which triggers a generic cost model on construction (in fact, any negative value here will trigger). Note that the generic cost model is in terms of Canadian dollars [CAD].
- double [operation_maintenance_cost_kWh](#) = -1
The operation and maintenance cost of the asset [1/kWh] (undefined currency). This is a cost incurred per unit of energy produced. -1 is a sentinel value, which triggers a generic cost model on construction (in fact, any negative value here will trigger). Note that the generic cost model is in terms of Canadian dollars [CAD/kWh].
- double [fuel_cost_L](#) = 1.70
The cost of fuel [1/L] (undefined currency).
- double [minimum_load_ratio](#) = 0.2
The minimum load ratio of the asset. That is, when the asset is producing, it must produce at least this ratio of its rated capacity.
- double [minimum_runtime_hrs](#) = 4
The minimum runtime [hrs] of the asset. This is the minimum time that must elapse between successive starts and stops.
- double [linear_fuel_slope_LkWh](#) = -1

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

- double `linear_fuel_intercept_LkWh` = -1

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

- double `CO2_emissions_intensity_kgL` = 2.7
Carbon dioxide (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. Intended to serve as a component of the [Production](#) and [Storage](#) hierarchies.

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


Public Member Functions

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

Public Attributes

- std::map< int, [InterpolatorStruct1D](#) > [interp_map_1D](#)
A map <int, [InterpolatorStruct1D](#)> of given 1D interpolation data.
- std::map< int, std::string > [path_map_1D](#)
A map <int, string> of the paths (either relative or absolute) to the given 1D interpolation data.
- std::map< int, [InterpolatorStruct2D](#) > [interp_map_2D](#)
A map <int, [InterpolatorStruct2D](#)> of given 2D interpolation data.
- std::map< int, std::string > [path_map_2D](#)
A map <int, string> of the paths (either relative or absolute) to the given 2D interpolation data.

Private Member Functions

- void [__checkDataKey1D](#) (int)
Helper method to check if given data key (1D) is already in use.
- void [__checkDataKey2D](#) (int)
Helper method to check if given data key (2D) is already in use.
- void [__checkBounds1D](#) (int, double)
Helper method to check that the given 1D interpolation value is contained within the given corresponding data domain. Also checks that the data key has been registered.
- void [__checkBounds2D](#) (int, double, double)
Helper method to check that the given 2D interpolation value is contained within the given corresponding data domain. Also checks that the data key has been registered.
- void [__throwReadError](#) (std::string, int)
Helper method to throw a read error whenever non-numeric data is encountered where only numeric data should be.
- bool [__isNonNumeric](#) (std::string)
Helper method to determine if given string is non-numeric (i.e., contains.
- int [__getInterpolationIndex](#) (double, std::vector< double > *)
Helper method to get appropriate interpolation index into given vector.
- std::vector< std::string > [__splitCommaSeparatedString](#) (std::string, std::string="|")
Helper method to split a comma-separated string into a vector of substrings.
- std::vector< std::vector< std::string > > [__getDataStringMatrix](#) (std::string)
- void [__readData1D](#) (int, std::string)
Helper method to read the given 1D interpolation data into [Interpolator](#).
- void [__readData2D](#) (int, std::string)
Helper method to read the given 2D interpolation data into [Interpolator](#).

4.8.1 Detailed Description

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

4.8.2 Constructor & Destructor Documentation

4.8.2.1 Interpolator()

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

Constructor for the [Interpolator](#) class.

```
670 {
671     //...
672
673     return;
674 } /* Interpolator() */
```

4.8.2.2 ~Interpolator()

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

Destructor for the [Interpolator](#) class.

```
856 {
857     //...
858
859     return;
860 } /* ~Interpolator() */
```

4.8.3 Member Function Documentation

4.8.3.1 __checkBounds1D()

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

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

Parameters

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

```

108 {
109     // 1. key error
110     if (this->interp_map_1D.count(data_key) == 0) {
111         std::string error_str = "ERROR: Interpolator::interp1D() ";
112         error_str += "data key ";
113         error_str += std::to_string(data_key);
114         error_str += " has not been registered";
115
116         #ifdef _WIN32
117             std::cout << error_str << std::endl;
118         #endif
119
120         throw std::invalid_argument(error_str);
121     }
122
123     // 2. bounds error
124     if (
125         interp_x < this->interp_map_1D[data_key].min_x or
126         interp_x > this->interp_map_1D[data_key].max_x
127     ) {
128         std::string error_str = "ERROR: Interpolator::interp1D() ";
129         error_str += "interpolation value ";
130         error_str += std::to_string(interp_x);
131         error_str += " is outside of the given interpolation data domain";
132
133         #ifdef _WIN32
134             std::cout << error_str << std::endl;
135         #endif
136
137         throw std::invalid_argument(error_str);
138     }
139
140     return;
141 } /* __checkBounds1D() */

```

4.8.3.2 __checkBounds2D()

```

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

```

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

Parameters

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

```

164 {
165     // 1. key error
166     if (this->interp_map_2D.count(data_key) == 0) {
167         std::string error_str = "ERROR: Interpolator::interp2D() ";
168         error_str += "data key ";
169         error_str += std::to_string(data_key);
170         error_str += " has not been registered";
171
172         #ifdef _WIN32
173             std::cout << error_str << std::endl;
174         #endif
175
176         throw std::invalid_argument(error_str);
177     }
178
179     // 2. bounds error (x_interp)
180     if (
181         interp_x < this->interp_map_2D[data_key].min_x or

```

```

182     interp_x > this->interp_map_2D[data_key].max_x
183 ) {
184     std::string error_str = "ERROR: Interpolator::interp2D() ";
185     error_str += "interpolation value interp_x = ";
186     error_str += std::to_string(interp_x);
187     error_str += " is outside of the given interpolation data domain";
188
189     #ifdef _WIN32
190         std::cout << error_str << std::endl;
191     #endif
192
193     throw std::invalid_argument(error_str);
194 }
195
196 // 2. bounds error (y_interp)
197 if (
198     interp_y < this->interp_map_2D[data_key].min_y or
199     interp_y > this->interp_map_2D[data_key].max_y
200 ) {
201     std::string error_str = "ERROR: Interpolator::interp2D() ";
202     error_str += "interpolation value interp_y = ";
203     error_str += std::to_string(interp_y);
204     error_str += " is outside of the given interpolation data domain";
205
206     #ifdef _WIN32
207         std::cout << error_str << std::endl;
208     #endif
209
210     throw std::invalid_argument(error_str);
211 }
212
213 return;
214 } /* __checkBounds2D() */

```

4.8.3.3 __checkDataKey1D()

```

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

```

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

Parameters

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

```

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

```

4.8.3.4 __checkDataKey2D()

```

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

```

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

Parameters

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

```

72 {
73     if (this->interp_map_2D.count(data_key) > 0) {
74         std::string error_str = "ERROR: Interpolator::addData2D() ";
75         error_str += "data key (2D) ";
76         error_str += std::to_string(data_key);
77         error_str += " is already in use";
78
79         #ifdef _WIN32
80             std::cout << error_str << std::endl;
81         #endif
82
83         throw std::invalid_argument(error_str);
84     }
85
86     return;
87 } /* __checkDataKey2D() */

```

4.8.3.5 __getDataStringMatrix()

```

std::vector< std::vector< std::string > > Interpolator::__getDataStringMatrix (
    std::string path_2_data ) [private]
389 {
390     // 1. create input file stream
391     std::ifstream ifs;
392     ifs.open(path_2_data);
393
394     // 2. check that open() worked
395     if (not ifs.is_open()) {
396         std::string error_str = "ERROR: Interpolator::__getDataStringMatrix() ";
397         error_str += " failed to open ";
398         error_str += path_2_data;
399
400         #ifdef _WIN32
401             std::cout << error_str << std::endl;
402         #endif
403
404         throw std::invalid_argument(error_str);
405     }
406
407     // 3. read file line by line
408     bool is_header = true;
409     std::string line;
410     std::vector<std::string> line_split_vec;
411     std::vector<std::vector<std::string>> string_matrix;
412
413     while (not ifs.eof()) {
414         std::getline(ifs, line);
415
416         if (is_header) {
417             is_header = false;
418             continue;
419         }
420
421         line_split_vec = this->__splitCommaSeparatedString(line);
422
423         if (not line_split_vec.empty()) {
424             string_matrix.push_back(line_split_vec);
425         }
426     }
427
428     ifs.close();
429     return string_matrix;
430 } /* __getDataStringMatrix() */

```

4.8.3.6 `__getInterpolationIndex()`

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

Helper method to get appropriate interpolation index into given vector.

Parameters

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

Returns

The appropriate interpolation index into the given vector.

```
306 {
307     int idx = 0;
308     while (
309         not (interp_x >= x_vec_ptr->at(idx) and interp_x <= x_vec_ptr->at(idx + 1))
310     ) {
311         idx++;
312     }
313
314     return idx;
315 } /* __getInterpolationIndex() */
```

4.8.3.7 `__isNonNumeric()`

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

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

Parameters

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

Returns

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

```
271 {
272     for (size_t i = 0; i < str.size(); i++) {;
273         if (isalpha(str[i])) {
274             return true;
275         }
276     }
277
278     return false;
279 } /* __isAlpha() */
```

4.8.3.8 __readData1D()

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

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

Parameters

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

```
450 {
451     // 1. get string matrix
452     std::vector<std::vector<std::string>> string_matrix =
453         this->__getDataStringMatrix(path_2_data);
454
455     // 2. read string matrix contents into 1D interpolation struct
456     InterpolatorStruct1D interp_struct_1D;
457
458     interp_struct_1D.n_points = string_matrix.size();
459     interp_struct_1D.x_vec.resize(interp_struct_1D.n_points, 0);
460     interp_struct_1D.y_vec.resize(interp_struct_1D.n_points, 0);
461
462     for (int i = 0; i < interp_struct_1D.n_points; i++) {
463         try {
464             interp_struct_1D.x_vec[i] = std::stod(string_matrix[i][0]);
465             interp_struct_1D.y_vec[i] = std::stod(string_matrix[i][1]);
466         }
467
468         catch (...) {
469             this->__throwReadError(path_2_data, 1);
470         }
471     }
472
473     interp_struct_1D.min_x = interp_struct_1D.x_vec[0];
474     interp_struct_1D.max_x = interp_struct_1D.x_vec[interp_struct_1D.n_points - 1];
475
476     // 3. write struct to map
477     this->interp_map_1D.insert(
478         std::pair<int, InterpolatorStruct1D>(data_key, interp_struct_1D)
479     );
480
481     /*
482     // ==== TEST PRINT ==== //
483     std::cout << std::endl;
484     std::cout << path_2_data << std::endl;
485     std::cout << "-----" << std::endl;
486
487     std::cout << "n_points: " << this->interp_map_1D[data_key].n_points << std::endl;
488
489     std::cout << "x_vec: [";
490     for (
491         int i = 0;
492         i < this->interp_map_1D[data_key].n_points;
493         i++
494     ) {
495         std::cout << this->interp_map_1D[data_key].x_vec[i] << ", ";
496     }
497     std::cout << "]" << std::endl;
498
499     std::cout << "y_vec: [";
500     for (
501         int i = 0;
502         i < this->interp_map_1D[data_key].n_points;
503         i++
504     ) {
505         std::cout << this->interp_map_1D[data_key].y_vec[i] << ", ";
506     }
507     std::cout << "]" << std::endl;
508
509     std::cout << std::endl;
510     // ==== END TEST PRINT ==== //
511     /**/
512
513     return;
514 } /* __readData1D() */
```

4.8.3.9 __readData2D()

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

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

Parameters

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

```
534 {
535     // 1. get string matrix
536     std::vector<std::vector<std::string>> string_matrix =
537         this->__getDataStringMatrix(path_2_data);
538
539     // 2. read string matrix contents into 2D interpolation map
540     InterpolatorStruct2D interp_struct_2D;
541
542     interp_struct_2D.n_rows = string_matrix.size() - 1;
543     interp_struct_2D.n_cols = string_matrix[0].size() - 1;
544
545     interp_struct_2D.x_vec.resize(interp_struct_2D.n_cols, 0);
546     interp_struct_2D.y_vec.resize(interp_struct_2D.n_rows, 0);
547
548     interp_struct_2D.z_matrix.resize(interp_struct_2D.n_rows, {});
549
550     for (int i = 0; i < interp_struct_2D.n_rows; i++) {
551         interp_struct_2D.z_matrix[i].resize(interp_struct_2D.n_cols, 0);
552     }
553
554     for (size_t i = 1; i < string_matrix[0].size(); i++) {
555         try {
556             interp_struct_2D.x_vec[i - 1] = std::stod(string_matrix[0][i]);
557         }
558         catch (...) {
559             this->__throwReadError(path_2_data, 2);
560         }
561     }
562
563     interp_struct_2D.min_x = interp_struct_2D.x_vec[0];
564     interp_struct_2D.max_x = interp_struct_2D.x_vec[interp_struct_2D.n_cols - 1];
565
566     for (size_t i = 1; i < string_matrix.size(); i++) {
567         try {
568             interp_struct_2D.y_vec[i - 1] = std::stod(string_matrix[i][0]);
569         }
570         catch (...) {
571             this->__throwReadError(path_2_data, 2);
572         }
573     }
574
575     interp_struct_2D.min_y = interp_struct_2D.y_vec[0];
576     interp_struct_2D.max_y = interp_struct_2D.y_vec[interp_struct_2D.n_rows - 1];
577
578     for (size_t i = 1; i < string_matrix.size(); i++) {
579         for (size_t j = 1; j < string_matrix[0].size(); j++) {
580             try {
581                 interp_struct_2D.z_matrix[i - 1][j - 1] = std::stod(string_matrix[i][j]);
582             }
583             catch (...) {
584                 this->__throwReadError(path_2_data, 2);
585             }
586         }
587     }
588
589     // 3. write struct to map
590     this->interp_map_2D.insert(
591         std::pair<int, InterpolatorStruct2D>(data_key, interp_struct_2D)
592     );
593
594     /*
595     // ==== TEST PRINT ==== //
596     std::cout << std::endl;
597     std::cout << path_2_data << std::endl;
598 */
599 }
```



```

601     std::cout << "-----" << std::endl;
602
603     std::cout << "n_rows: " << this->interp_map_2D[data_key].n_rows << std::endl;
604     std::cout << "n_cols: " << this->interp_map_2D[data_key].n_cols << std::endl;
605
606     std::cout << "x_vec: [";
607     for (
608         int i = 0;
609         i < this->interp_map_2D[data_key].n_cols;
610         i++
611     ) {
612         std::cout << this->interp_map_2D[data_key].x_vec[i] << ", ";
613     }
614     std::cout << "]" << std::endl;
615
616     std::cout << "y_vec: [";
617     for (
618         int i = 0;
619         i < this->interp_map_2D[data_key].n_rows;
620         i++
621     ) {
622         std::cout << this->interp_map_2D[data_key].y_vec[i] << ", ";
623     }
624     std::cout << "]" << std::endl;
625
626     std::cout << "z_matrix:" << std::endl;
627     for (
628         int i = 0;
629         i < this->interp_map_2D[data_key].n_rows;
630         i++
631     ) {
632         std::cout << "\t[";
633
634         for (
635             int j = 0;
636             j < this->interp_map_2D[data_key].n_cols;
637             j++
638         ) {
639             std::cout << this->interp_map_2D[data_key].z_matrix[i][j] << ", ";
640         }
641
642         std::cout << "]" << std::endl;
643     }
644     std::cout << std::endl;
645
646     std::cout << std::endl;
647     // ==== END TEST PRINT ==== //
648     /**/
649
650     return;
651 } /* __readData2D() */

```

4.8.3.10 __splitCommaSeparatedString()

```

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

```

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

Parameters

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

Returns

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

```

344 {
345     std::vector<std::string> str_split_vec;
346
347     size_t idx = 0;
348     std::string substr;
349
350     while ((idx = str.find(',')) != std::string::npos) {
351         substr = str.substr(0, idx);
352
353         if (substr == break_str) {
354             break;
355         }
356
357         str_split_vec.push_back(substr);
358
359         str.erase(0, idx + 1);
360     }
361
362     return str_split_vec;
363 } /* __splitCommaSeparatedString() */

```

4.8.3.11 __throwReadError()

```

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

```

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

Parameters

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

```

235 {
236     std::string error_str = "ERROR: Interpolator::addData";
237     error_str += std::to_string(dimensions);
238     error_str += "D() ";
239     error_str += " failed to read ";
240     error_str += path_2_data;
241     error_str += " (this is probably a std::stod() error; is there non-numeric ";
242     error_str += "data where only numeric data should be?)";
243
244     #ifdef _WIN32
245         std::cout << error_str << std::endl;
246     #endif
247
248     throw std::runtime_error(error_str);
249
250     return;
251 } /* __throwReadError() */

```

4.8.3.12 addData1D()

```

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

```

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

Parameters

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

```

694 {
695     // 1. check key
696     this->__checkDataKey1D(data_key);
697
698     // 2. read data into map
699     this->__readData1D(data_key, path_2_data);
700
701     // 3. record path
702     this->path_map_1D.insert(std::pair<int, std::string>(data_key, path_2_data));
703
704     return;
705 } /* addData1D() */

```

4.8.3.13 addData2D()

```

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

```

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

Parameters

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

```

725 {
726     // 1. check key
727     this->__checkDataKey2D(data_key);
728
729     // 2. read data into map
730     this->__readData2D(data_key, path_2_data);
731
732     // 3. record path
733     this->path_map_2D.insert(std::pair<int, std::string>(data_key, path_2_data));
734
735     return;
736 } /* addData2D() */

```

4.8.3.14 interp1D()

```

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

```

Method to perform a 1D interpolation.

Parameters

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

Returns

An interpolation of the given query value.

```

758 {
759     // 1. check bounds
760     this->__checkBounds1D(data_key, interp_x);
761
762     // 2. get interpolation index
763     int idx = this->__getInterpolationIndex(
764         interp_x,
765         &(this->interp_map_1D[data_key].x_vec)
766     );
767
768     // 3. perform interpolation
769     double x_0 = this->interp_map_1D[data_key].x_vec[idx];
770     double x_1 = this->interp_map_1D[data_key].x_vec[idx + 1];
771
772     double y_0 = this->interp_map_1D[data_key].y_vec[idx];
773     double y_1 = this->interp_map_1D[data_key].y_vec[idx + 1];
774
775     double interp_y = ((y_1 - y_0) / (x_1 - x_0)) * (interp_x - x_0) + y_0;
776
777     return interp_y;
778 } /* interp1D() */

```

4.8.3.15 interp2D()

```

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

```

Method to perform a 2D interpolation.

Parameters

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

Returns

An interpolation of the given query values.

```

803 {
804     // 1. check bounds
805     this->__checkBounds2D(data_key, interp_x, interp_y);
806
807     // 2. get interpolation indices
808     int idx_x = this->__getInterpolationIndex(
809         interp_x,
810         &(this->interp_map_2D[data_key].x_vec)
811     );
812
813     int idx_y = this->__getInterpolationIndex(
814         interp_y,
815         &(this->interp_map_2D[data_key].y_vec)
816     );
817
818     // 3. perform first horizontal interpolation
819     double x_0 = this->interp_map_2D[data_key].x_vec[idx_x];
820     double x_1 = this->interp_map_2D[data_key].x_vec[idx_x + 1];
821
822     double z_0 = this->interp_map_2D[data_key].z_matrix[idx_y][idx_x];
823     double z_1 = this->interp_map_2D[data_key].z_matrix[idx_y][idx_x + 1];

```

```

824
825     double interp_z_0 = ((z_1 - z_0) / (x_1 - x_0)) * (interp_x - x_0) + z_0;
826
827     // 4. perform second horizontal interpolation
828     z_0 = this->interp_map_2D[data_key].z_matrix[idx_y + 1][idx_x];
829     z_1 = this->interp_map_2D[data_key].z_matrix[idx_y + 1][idx_x + 1];
830
831     double interp_z_1 = ((z_1 - z_0) / (x_1 - x_0)) * (interp_x - x_0) + z_0;
832
833     // 5. perform vertical interpolation
834     double y_0 = this->interp_map_2D[data_key].y_vec[idx_y];
835     double y_1 = this->interp_map_2D[data_key].y_vec[idx_y + 1];
836
837     double interp_z =
838         ((interp_z_1 - interp_z_0) / (y_1 - y_0)) * (interp_y - y_0) + interp_z_0;
839
840     return interp_z;
841 } /* interp2D() */

```

4.8.4 Member Data Documentation

4.8.4.1 interp_map_1D

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

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

4.8.4.2 interp_map_2D

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

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

4.8.4.3 path_map_1D

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

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

4.8.4.4 path_map_2D

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

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

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

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

4.9 InterpolatorStruct1D Struct Reference

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

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

Public Attributes

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

4.9.1 Detailed Description

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

4.9.2 Member Data Documentation

4.9.2.1 max_x

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

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

4.9.2.2 min_x

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

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

4.9.2.3 n_points

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

The number of data points in each parallel vector.

4.9.2.4 x_vec

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

A vector of independent data.

4.9.2.5 y_vec

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

A vector of dependent data.

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

- header/[Interpolator.h](#)

4.10 InterpolatorStruct2D Struct Reference

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

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

Public Attributes

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

4.10.1 Detailed Description

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

4.10.2 Member Data Documentation

4.10.2.1 max_x

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

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

4.10.2.2 max_y

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

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

4.10.2.3 min_x

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

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

4.10.2.4 min_y

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

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

4.10.2.5 n_cols

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

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

4.10.2.6 n_rows

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

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

4.10.2.7 x_vec

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

A vector of independent data (columns).

4.10.2.8 y_vec

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

A vector of independent data (rows).

4.10.2.9 z_matrix

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

A matrix of dependent data.

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

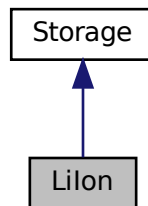
- header/[Interpolator.h](#)

4.11 Lilon Class Reference

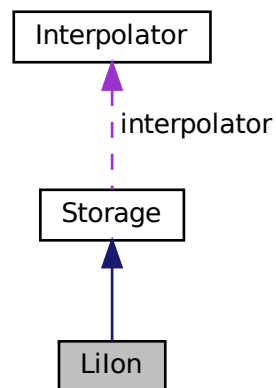
A derived class of [Storage](#) which models energy storage by way of lithium-ion batteries.

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

Inheritance diagram for Lilon:



Collaboration diagram for Lilon:



Public Member Functions

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

- *Method to get the discharge power currently available from the asset.*
double [getAcceptablekW](#) (double)
- *Method to get the charge power currently acceptable by the asset.*
void [commitCharge](#) (int, double, double)
- *Method which takes in the charging power for the current timestep and records.*
double [commitDischarge](#) (int, double, double, double)
- *Method which takes in the discharging power for the current timestep and records. Returns the load remaining after discharge.*
~[Lilon](#) (void)
- *Destructor for the [Lilon](#) class.*

Public Attributes

- double [dynamic_energy_capacity_kWh](#)
The dynamic (i.e. degrading) energy capacity [kWh] of the asset.
- double [SOH](#)
The state of health of the asset.
- double [replace_SOH](#)
The state of health at which the asset is considered "dead" and must be replaced.
- double [degradation_alpha](#)
A dimensionless acceleration coefficient used in modelling energy capacity degradation.
- double [degradation_beta](#)
A dimensionless acceleration exponent used in modelling energy capacity degradation.
- double [degradation_B_hat_cal_0](#)
A reference (or base) pre-exponential factor [1/sqrt(hrs)] used in modelling energy capacity degradation.
- double [degradation_r_cal](#)
A dimensionless constant used in modelling energy capacity degradation.
- double [degradation_Ea_cal_0](#)
A reference (or base) activation energy [J/mol] used in modelling energy capacity degradation.
- double [degradation_a_cal](#)
A pre-exponential factor [J/mol] used in modelling energy capacity degradation.
- double [degradation_s_cal](#)
A dimensionless constant used in modelling energy capacity degradation.
- double [gas_constant_JmolK](#)
The universal gas constant [J/mol.K].
- double [temperature_K](#)
The absolute environmental temperature [K] of the lithium ion battery energy storage system.
- double [init_SOC](#)
The initial state of charge of the asset.
- double [min_SOC](#)
The minimum state of charge of the asset. Will toggle is_depleted when reached.
- double [hysteresis_SOC](#)
The state of charge the asset must achieve to toggle is_depleted.
- double [max_SOC](#)
The maximum state of charge of the asset.
- double [charging_efficiency](#)
The charging efficiency of the asset.
- double [discharging_efficiency](#)
The discharging efficiency of the asset.
- std::vector< double > [SOH_vec](#)
A vector of the state of health of the asset at each point in the modelling time series.

Private Member Functions

- void [__checkInputs](#) ([LilonInputs](#))
Helper method to check inputs to the [Lilon](#) constructor.
- double [__getGenericCapitalCost](#) (void)
Helper method to generate a generic lithium ion battery energy storage system capital cost.
- double [__getGenericOpMaintCost](#) (void)
Helper method to generate a generic lithium ion battery energy storage system operation and maintenance cost. This is a cost incurred per unit energy charged/discharged.
- void [__toggleDepleted](#) (void)
Helper method to toggle the `is_depleted` attribute of [Lilon](#).
- void [__handleDegradation](#) (int, double, double)
Helper method to apply degradation modelling and update attributes.
- void [__modelDegradation](#) (double, double)
Helper method to model energy capacity degradation as a function of operating state.
- double [__getBcal](#) (double)
Helper method to compute and return the base pre-exponential factor for a given state of charge.
- double [__getEacal](#) (double)
Helper method to compute and return the activation energy value for a given state of charge.
- void [__writeSummary](#) (std::string)
Helper method to write summary results for [Lilon](#).
- void [__writeTimeSeries](#) (std::string, std::vector< double > *, int=-1)
Helper method to write time series results for [Lilon](#).

4.11.1 Detailed Description

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

4.11.2 Constructor & Destructor Documentation

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

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

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

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

4.11.2.2 [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>lilion_inputs</i>	A structure of Lilion constructor inputs.

```

676 :
677 Storage(
678     n_points,
679     n_years,
680     lilion_inputs.storage_inputs
681 )
682 {
683     // 1. check inputs
684     this->__checkInputs(lilion_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 = lilion_inputs.replace_SOH;
693
694     this->degradation_alpha = lilion_inputs.degradation_alpha;
695     this->degradation_beta = lilion_inputs.degradation_beta;
696     this->degradation_B_hat_cal_0 = lilion_inputs.degradation_B_hat_cal_0;
697     this->degradation_r_cal = lilion_inputs.degradation_r_cal;
698     this->degradation_Ea_cal_0 = lilion_inputs.degradation_Ea_cal_0;
699     this->degradation_a_cal = lilion_inputs.degradation_a_cal;
700     this->degradation_s_cal = lilion_inputs.degradation_s_cal;
701     this->gas_constant_JmolK = lilion_inputs.gas_constant_JmolK;
702     this->temperature_K = lilion_inputs.temperature_K;
703
704     this->init_SOC = lilion_inputs.init_SOC;
705     this->charge_kWh = this->init_SOC * this->energy_capacity_kWh;
706
707     this->min_SOC = lilion_inputs.min_SOC;
708     this->hysteresis_SOC = lilion_inputs.hysteresis_SOC;
709     this->max_SOC = lilion_inputs.max_SOC;
710
711     this->charging_efficiency = lilion_inputs.charging_efficiency;
712     this->discharging_efficiency = lilion_inputs.discharging_efficiency;
713
714     if (lilion_inputs.capital_cost < 0) {
715         this->capital_cost = this->__getGenericCapitalCost();
716     }
717
718     if (lilion_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() */

```

4.11.2.3 ~Lilion()

```

LiIon::~LiIon (
    void )

```

Destructor for the [Lilion](#) class.

```

990 {
991     // 1. destruction print

```

```

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

```

4.11.3 Member Function Documentation

4.11.3.1 __checkInputs()

```

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

```

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

Parameters

<i>liion_inputs</i>	A structure of Lilon 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 (lilion_inputs.charging_efficiency <= 0 or lilion_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     lilion_inputs.discharging_efficiency <= 0 or
115     lilion_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 (liion_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 (liion_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 (liion_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() */

```

4.11.3.2 __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

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

Returns

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


```

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

```

4.11.3.3 __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() */

```

4.11.3.4 __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() */

```

4.11.3.5 `__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() */
```

4.11.3.6 `__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() */
```

4.11.3.7 `__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() */

```

4.11.3.8 __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() */

```

4.11.3.9 __writeSummary()

```

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

```

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

Parameters

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

Reimplemented from [Storage](#).

```

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

```

```

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

```

4.11.3.10 __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 [LilIon](#).

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 ElectricalLoad .
<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() */

```

4.11.3.11 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() */
```

4.11.3.12 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() */

```

4.11.3.13 getAcceptablekW()

```

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

```

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

Parameters

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

Returns

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

Reimplemented from [Storage](#).

```

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

```



```

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

```

4.11.3.14 getAvailablekW()

```

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

```

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

Parameters

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

Returns

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

Reimplemented from [Storage](#).

```

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

```

4.11.3.15 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 Model 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() */

```

4.11.4 Member Data Documentation

4.11.4.1 charging_efficiency

```
double LiIon::charging_efficiency
```

The charging efficiency of the asset.

4.11.4.2 degradation_a_cal

```
double LiIon::degradation_a_cal
```

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

4.11.4.3 degradation_alpha

```
double LiIon::degradation_alpha
```

A dimensionless acceleration coefficient used in modelling energy capacity degradation.

4.11.4.4 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.

4.11.4.5 degradation_beta

```
double LiIon::degradation_beta
```

A dimensionless acceleration exponent used in modelling energy capacity degradation.

4.11.4.6 degradation_Ea_cal_0

```
double LiIon::degradation_Ea_cal_0
```

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

4.11.4.7 degradation_r_cal

```
double LiIon::degradation_r_cal
```

A dimensionless constant used in modelling energy capacity degradation.

4.11.4.8 degradation_s_cal

```
double LiIon::degradation_s_cal
```

A dimensionless constant used in modelling energy capacity degradation.

4.11.4.9 discharging_efficiency

```
double LiIon::discharging_efficiency
```

The discharging efficiency of the asset.

4.11.4.10 dynamic_energy_capacity_kWh

```
double LiIon::dynamic_energy_capacity_kWh
```

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

4.11.4.11 gas_constant_JmolK

```
double LiIon::gas_constant_JmolK
```

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

4.11.4.12 hysteresis_SOC

```
double LiIon::hysteresis_SOC
```

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

4.11.4.13 init_SOC

```
double LiIon::init_SOC
```

The initial state of charge of the asset.

4.11.4.14 max_SOC

```
double LiIon::max_SOC
```

The maximum state of charge of the asset.

4.11.4.15 min_SOC

```
double LiIon::min_SOC
```

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

4.11.4.16 replace_SOH

```
double LiIon::replace_SOH
```

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

4.11.4.17 SOH

```
double LiIon::SOH
```

The state of health of the asset.

4.11.4.18 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.

4.11.4.19 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:

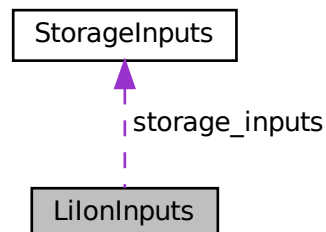
- header/Storage/[Lilon.h](#)
- source/Storage/[Lilon.cpp](#)

4.12 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.

4.12.1 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 \[2023\]](#)

4.12.2 Member Data Documentation

4.12.2.1 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].

4.12.2.2 charging_efficiency

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

The charging efficiency of the asset.

4.12.2.3 degradation_a_cal

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

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

4.12.2.4 degradation_alpha

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

A dimensionless acceleration coefficient used in modelling energy capacity degradation.

4.12.2.5 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.

4.12.2.6 degradation_beta

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

A dimensionless acceleration exponent used in modelling energy capacity degradation.

4.12.2.7 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.

4.12.2.8 degradation_r_cal

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

A dimensionless constant used in modelling energy capacity degradation.

4.12.2.9 degradation_s_cal

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

A dimensionless constant used in modelling energy capacity degradation.

4.12.2.10 discharging_efficiency

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

The discharging efficiency of the asset.

4.12.2.11 gas_constant_JmolK

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

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

4.12.2.12 hysteresis_SOC

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

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

4.12.2.13 init_SOC

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

The initial state of charge of the asset.

4.12.2.14 max_SOC

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

The maximum state of charge of the asset.

4.12.2.15 min_SOC

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

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

4.12.2.16 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].

4.12.2.17 replace_SOH

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

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

4.12.2.18 storage_inputs

```
StorageInputs LiIonInputs::storage_inputs
```

An encapsulated [StorageInputs](#) instance.

4.12.2.19 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:

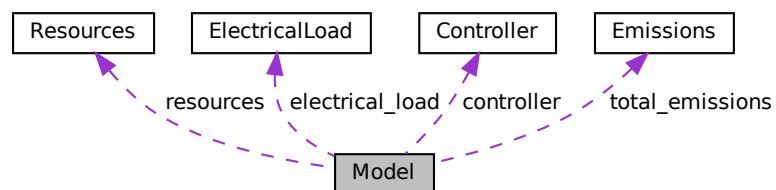
- header/Storage/[Lilon.h](#)

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

4.13.1 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.

4.13.2 Constructor & Destructor Documentation

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

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

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

```
507 {
508     return;
509 } /* Model() */
```

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

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

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

Parameters

<i>model_inputs</i>	A structure of Model constructor inputs.
---------------------	--

```

526 {
527     // 1. check inputs
528     this->__checkInputs(model_inputs);
529
530     // 2. read in electrical load data
531     this->electrical_load.readLoadData(model_inputs.path_2_electrical_load_time_series);
532
533     // 3. set control mode
534     this->controller.setControlMode(model_inputs.control_mode);
535
536     // 4. set public attributes
537     this->total_fuel_consumed_L = 0;
538     this->net_present_cost = 0;
539     this->total_dispatch_discharge_kWh = 0;
540     this->levelized_cost_of_energy_kWh = 0;
541
542     return;
543 } /* Model() */

```

4.13.2.3 ~Model()

```

Model::~~Model (
    void )

```

Destructor for the [Model](#) class.

```

970 {
971     this->clear();
972     return;
973 } /* ~Model() */

```

4.13.3 Member Function Documentation

4.13.3.1 __checkInputs()

```

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

```

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

Parameters

<i>model_inputs</i>	A structure of Model constructor inputs.
---------------------	--

```

40 {
41     // 1. check path_2_electrical_load_time_series
42     if (model_inputs.path_2_electrical_load_time_series.empty()) {
43         std::string error_str = "ERROR: Model() path_2_electrical_load_time_series ";
44         error_str += "cannot be empty";
45
46         #ifdef _WIN32
47             std::cout << error_str << std::endl;
48         #endif
49
50         throw std::invalid_argument(error_str);
51     }

```

```

52
53     return;
54 } /* __checkInputs() */

```

4.13.3.2 __computeEconomics()

```

void Model::__computeEconomics (
    void ) [private]

```

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

```

216 {
217     this->__computeNetPresentCost();
218     this->__computeLevellizedCostOfEnergy();
219
220     return;
221 } /* __computeEconomics() */

```

4.13.3.3 __computeFuelAndEmissions()

```

void Model::__computeFuelAndEmissions (
    void ) [private]

```

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

```

70 {
71     for (size_t i = 0; i < this->combustion_ptr_vec.size(); i++) {
72         this->combustion_ptr_vec[i]->computeFuelAndEmissions();
73
74         this->total_fuel_consumed_L +=
75             this->combustion_ptr_vec[i]->total_fuel_consumed_L;
76
77         this->total_emissions.CO2_kg +=
78             this->combustion_ptr_vec[i]->total_emissions.CO2_kg;
79
80         this->total_emissions.CO_kg +=
81             this->combustion_ptr_vec[i]->total_emissions.CO_kg;
82
83         this->total_emissions.NOx_kg +=
84             this->combustion_ptr_vec[i]->total_emissions.NOx_kg;
85
86         this->total_emissions.SOx_kg +=
87             this->combustion_ptr_vec[i]->total_emissions.SOx_kg;
88
89         this->total_emissions.CH4_kg +=
90             this->combustion_ptr_vec[i]->total_emissions.CH4_kg;
91
92         this->total_emissions.PM_kg +=
93             this->combustion_ptr_vec[i]->total_emissions.PM_kg;
94     }
95
96     return;
97 } /* __computeFuelAndEmissions() */

```

4.13.3.4 __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.

```
170 {
171     // 1. account for Combustion economics in levellized cost of energy
172     for (size_t i = 0; i < this->combustion_ptr_vec.size(); i++) {
173         this->levellized_cost_of_energy_kWh +=
174             (
175                 this->combustion_ptr_vec[i]->levellized_cost_of_energy_kWh *
176                 this->combustion_ptr_vec[i]->total_dispatch_kWh
177             ) / this->total_dispatch_discharge_kWh;
178     }
179
180     // 2. account for Renewable economics in levellized cost of energy
181     for (size_t i = 0; i < this->renewable_ptr_vec.size(); i++) {
182         this->levellized_cost_of_energy_kWh +=
183             (
184                 this->renewable_ptr_vec[i]->levellized_cost_of_energy_kWh *
185                 this->renewable_ptr_vec[i]->total_dispatch_kWh
186             ) / this->total_dispatch_discharge_kWh;
187     }
188
189     // 3. account for Storage economics in levellized cost of energy
190     for (size_t i = 0; i < this->storage_ptr_vec.size(); i++) {
191         /*
192         this->levellized_cost_of_energy_kWh +=
193             (
194                 this->storage_ptr_vec[i]->levellized_cost_of_energy_kWh *
195                 this->storage_ptr_vec[i]->total_discharge_kWh
196             ) / this->total_dispatch_discharge_kWh;
197         */
198     }
199
200     return;
201 } /* __computeLevellizedCostOfEnergy() */
```

4.13.3.5 __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.

```
113 {
114     // 1. account for Combustion economics in net present cost
115     // increment total dispatch
116     for (size_t i = 0; i < this->combustion_ptr_vec.size(); i++) {
117         this->combustion_ptr_vec[i]->computeEconomics(
118             &(this->electrical_load.time_vec_hrs)
119         );
120
121         this->net_present_cost += this->combustion_ptr_vec[i]->net_present_cost;
122
123         this->total_dispatch_discharge_kWh +=
124             this->combustion_ptr_vec[i]->total_dispatch_kWh;
125     }
126
127     // 2. account for Renewable economics in net present cost,
128     // increment total dispatch
129     for (size_t i = 0; i < this->renewable_ptr_vec.size(); i++) {
130         this->renewable_ptr_vec[i]->computeEconomics(
131             &(this->electrical_load.time_vec_hrs)
132         );
133
134         this->net_present_cost += this->renewable_ptr_vec[i]->net_present_cost;
135
136         this->total_dispatch_discharge_kWh +=
137             this->renewable_ptr_vec[i]->total_dispatch_kWh;
138     }
139
140     // 3. account for Storage economics in net present cost
```

```

141 // increment total dispatch
142 for (size_t i = 0; i < this->storage_ptr_vec.size(); i++) {
143     this->storage_ptr_vec[i]->computeEconomics(
144         &(this->electrical_load.time_vec_hrs)
145     );
146
147     this->net_present_cost += this->storage_ptr_vec[i]->net_present_cost;
148
149     this->total_dispatch_discharge_kWh +=
150         this->storage_ptr_vec[i]->total_discharge_kWh;
151 }
152
153 return;
154 } /* __computeNetPresentCost() */

```

4.13.3.6 __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.
-------------------	--

```

239 {
240     // 1. create subdirectory
241     write_path += "Model/";
242     std::filesystem::create_directory(write_path);
243
244     // 2. create filestream
245     write_path += "summary_results.md";
246     std::ofstream ofs;
247     ofs.open(write_path, std::ofstream::out);
248
249     // 3. write summary results (markdown)
250     ofs << "# Model Summary Results\n";
251     ofs << "\n-----\n\n";
252
253     // 3.1. ElectricalLoad
254     ofs << "## Electrical Load\n";
255     ofs << "\n";
256     ofs << "Path: " <<
257         this->electrical_load.path_2_electrical_load_time_series << " \n";
258     ofs << "Data Points: " << this->electrical_load.n_points << " \n";
259     ofs << "Years: " << this->electrical_load.n_years << " \n";
260     ofs << "Min: " << this->electrical_load.min_load_kW << " kW \n";
261     ofs << "Mean: " << this->electrical_load.mean_load_kW << " kW \n";
262     ofs << "Max: " << this->electrical_load.max_load_kW << " kW \n";
263     ofs << "\n-----\n\n";
264
265     // 3.2. Controller
266     ofs << "## Controller\n";
267     ofs << "\n";
268     ofs << "Control Mode: " << this->controller.control_string << " \n";
269     ofs << "\n-----\n\n";
270
271     // 3.3. Resources (1D)
272     ofs << "## 1D Renewable Resources\n";
273     ofs << "\n";
274
275     std::map<int, std::string>::iterator string_map_1D_iter =
276         this->resources.string_map_1D.begin();
277     std::map<int, std::string>::iterator path_map_1D_iter =
278         this->resources.path_map_1D.begin();
279
280     while (
281         string_map_1D_iter != this->resources.string_map_1D.end() and
282         path_map_1D_iter != this->resources.path_map_1D.end()
283     ) {
284         ofs << "Resource Key: " << string_map_1D_iter->first << " \n";
285         ofs << "Type: " << string_map_1D_iter->second << " \n";

```



```

286         ofs << "Path: " << path_map_1D_iter->second << " \n";
287         ofs << "\n";
288
289         string_map_1D_iter++;
290         path_map_1D_iter++;
291     }
292
293     ofs << "\n-----\n\n";
294
295     // 3.4. Resources (2D)
296     ofs << "## 2D Renewable Resources\n";
297     ofs << "\n";
298
299     std::map<int, std::string>::iterator string_map_2D_iter =
300         this->resources.string_map_2D.begin();
301     std::map<int, std::string>::iterator path_map_2D_iter =
302         this->resources.path_map_2D.begin();
303
304     while (
305         string_map_2D_iter != this->resources.string_map_2D.end() and
306         path_map_2D_iter != this->resources.path_map_2D.end()
307     ) {
308         ofs << "Resource Key: " << string_map_2D_iter->first << " \n";
309         ofs << "Type: " << string_map_2D_iter->second << " \n";
310         ofs << "Path: " << path_map_2D_iter->second << " \n";
311         ofs << "\n";
312
313         string_map_2D_iter++;
314         path_map_2D_iter++;
315     }
316
317     ofs << "\n-----\n\n";
318
319     // 3.5. Combustion
320     ofs << "## Combustion Assets\n";
321     ofs << "\n";
322
323     for (size_t i = 0; i < this->combustion_ptr_vec.size(); i++) {
324         ofs << "Asset Index: " << i << " \n";
325         ofs << "Type: " << this->combustion_ptr_vec[i]->type_str << " \n";
326         ofs << "Capacity: " << this->combustion_ptr_vec[i]->capacity_kW << " kW \n";
327         ofs << "\n";
328     }
329
330     ofs << "\n-----\n\n";
331
332     // 3.6. Renewable
333     ofs << "## Renewable Assets\n";
334     ofs << "\n";
335
336     for (size_t i = 0; i < this->renewable_ptr_vec.size(); i++) {
337         ofs << "Asset Index: " << i << " \n";
338         ofs << "Type: " << this->renewable_ptr_vec[i]->type_str << " \n";
339         ofs << "Capacity: " << this->renewable_ptr_vec[i]->capacity_kW << " kW \n";
340         ofs << "\n";
341     }
342
343     ofs << "\n-----\n\n";
344
345     // 3.7. Storage
346     ofs << "## Storage Assets\n";
347     ofs << "\n";
348
349     for (size_t i = 0; i < this->storage_ptr_vec.size(); i++) {
350         //...
351     }
352
353     ofs << "\n-----\n\n";
354
355     // 3.8. Model Results
356     ofs << "## Results\n";
357     ofs << "\n";
358
359     ofs << "Net Present Cost: " << this->net_present_cost << " \n";
360     ofs << "\n";
361
362     ofs << "Total Dispatch + Discharge: " << this->total_dispatch_discharge_kWh
363         << " kWh \n";
364
365     ofs << "Levellized Cost of Energy: " << this->levellized_cost_of_energy_kWh
366         << " per kWh dispatched/discharged \n";
367     ofs << "\n";
368
369     ofs << "Total Fuel Consumed: " << this->total_fuel_consumed_L << " L "
370         << "(Annual Average: " <<
371         this->total_fuel_consumed_L / this->electrical_load.n_years
372         << " L/yr) \n";

```

```

373     ofs << "\n";
374
375     ofs << "Total Carbon Dioxide (CO2) Emissions: " <<
376         this->total_emissions.CO2_kg << " kg "
377         << "(Annual Average: " <<
378             this->total_emissions.CO2_kg / this->electrical_load.n_years
379         << " kg/yr) \n";
380
381     ofs << "Total Carbon Monoxide (CO) Emissions: " <<
382         this->total_emissions.CO_kg << " kg "
383         << "(Annual Average: " <<
384             this->total_emissions.CO_kg / this->electrical_load.n_years
385         << " kg/yr) \n";
386
387     ofs << "Total Nitrogen Oxides (NOx) Emissions: " <<
388         this->total_emissions.NOx_kg << " kg "
389         << "(Annual Average: " <<
390             this->total_emissions.NOx_kg / this->electrical_load.n_years
391         << " kg/yr) \n";
392
393     ofs << "Total Sulfur Oxides (SOx) Emissions: " <<
394         this->total_emissions.SOx_kg << " kg "
395         << "(Annual Average: " <<
396             this->total_emissions.SOx_kg / this->electrical_load.n_years
397         << " kg/yr) \n";
398
399     ofs << "Total Methane (CH4) Emissions: " << this->total_emissions.CH4_kg << " kg "
400         << "(Annual Average: " <<
401             this->total_emissions.CH4_kg / this->electrical_load.n_years
402         << " kg/yr) \n";
403
404     ofs << "Total Particulate Matter (PM) Emissions: " <<
405         this->total_emissions.PM_kg << " kg "
406         << "(Annual Average: " <<
407             this->total_emissions.PM_kg / this->electrical_load.n_years
408         << " kg/yr) \n";
409
410     ofs << "\n-----\n\n";
411
412     ofs.close();
413     return;
414 } /* __writeSummary() */

```

4.13.3.7 __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.

```

434 {
435     // 1. create filestream
436     write_path += "Model/time_series_results.csv";
437     std::ofstream ofs;
438     ofs.open(write_path, std::ofstream::out);
439
440     // 2. write time series results header (comma separated value)
441     ofs << "Time (since start of data) [hrs],";
442     ofs << "Electrical Load [kW],";
443     ofs << "Net Load [kW],";
444     ofs << "Missed Load [kW],";
445
446     for (size_t i = 0; i < this->renewable_ptr_vec.size(); i++) {
447         ofs << this->renewable_ptr_vec[i]->capacity_kW << " kW "
448             << this->renewable_ptr_vec[i]->type_str << " Dispatch [kW],";
449     }

```

```

450
451     for (size_t i = 0; i < this->storage_ptr_vec.size(); i++) {
452         //...
453     }
454
455     for (size_t i = 0; i < this->combustion_ptr_vec.size(); i++) {
456         ofs << this->combustion_ptr_vec[i]->capacity_kW << " kW "
457         << this->combustion_ptr_vec[i]->type_str << " Dispatch [kW], ";
458     }
459
460     ofs << "\n";
461
462     // 3. write time series results values (comma separated value)
463     for (int i = 0; i < max_lines; i++) {
464         // 3.1. load values
465         ofs << this->electrical_load.time_vec_hrs[i] << ", ";
466         ofs << this->electrical_load.load_vec_kW[i] << ", ";
467         ofs << this->controller.net_load_vec_kW[i] << ", ";
468         ofs << this->controller.missed_load_vec_kW[i] << ", ";
469
470         // 3.2. asset-wise dispatch/discharge
471         for (size_t j = 0; j < this->renewable_ptr_vec.size(); j++) {
472             ofs << this->renewable_ptr_vec[j]->dispatch_vec_kW[i] << ", ";
473         }
474
475         for (size_t j = 0; j < this->storage_ptr_vec.size(); j++) {
476             //...
477         }
478
479         for (size_t j = 0; j < this->combustion_ptr_vec.size(); j++) {
480             ofs << this->combustion_ptr_vec[j]->dispatch_vec_kW[i] << ", ";
481         }
482
483         ofs << "\n";
484     }
485
486     ofs.close();
487     return;
488 } /* __writeTimeSeries() */

```

4.13.3.8 addDiesel()

```

void Model::addDiesel (
    DieselInputs diesel_inputs )

```

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

Parameters

<i>diesel_inputs</i>	A structure of Diesel constructor inputs.
----------------------	---

```

560 {
561     Combustion* diesel_ptr = new Diesel(
562         this->electrical_load.n_points,
563         this->electrical_load.n_years,
564         diesel_inputs
565     );
566
567     this->combustion_ptr_vec.push_back(diesel_ptr);
568
569     return;
570 } /* addDiesel() */

```

4.13.3.9 addLiIon()

```

void Model::addLiIon (
    LiIonInputs liion_inputs )

```

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

Parameters

<i>liion_inputs</i>	A structure of Lilon constructor inputs.
---------------------	--

```

733 {
734     Storage* liion_ptr = new Lilon(
735         this->electrical_load.n_points,
736         this->electrical_load.n_years,
737         liion_inputs
738     );
739
740     this->storage_ptr_vec.push_back(liion_ptr);
741
742     return;
743 } /* addLiIon() */

```

4.13.3.10 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 Model .
<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 Resources object, used to associate Renewable assets with the corresponding resource.

```

599 {
600     resources.addResource (
601         renewable_type,
602         path_2_resource_data,
603         resource_key,
604         &(this->electrical_load)
605     );
606
607     return;
608 } /* addResource() */

```

4.13.3.11 addSolar()

```

void Model::addSolar (
    SolarInputs solar_inputs )

```

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

Parameters

<i>solar_inputs</i>	A structure of Solar constructor inputs.
---------------------	--

```

625 {
626     Renewable* solar_ptr = new Solar(

```

```

627         this->electrical_load.n_points,
628         this->electrical_load.n_years,
629         solar_inputs
630     );
631
632     this->renewable_ptr_vec.push_back(solar_ptr);
633
634     return;
635 } /* addSolar() */

```

4.13.3.12 addTidal()

```

void Model::addTidal (
    TidalInputs tidal_inputs )

```

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

Parameters

<i>tidal_inputs</i>	A structure of Tidal constructor inputs.
---------------------	--

```

652 {
653     Renewable* tidal_ptr = new Tidal(
654         this->electrical_load.n_points,
655         this->electrical_load.n_years,
656         tidal_inputs
657     );
658
659     this->renewable_ptr_vec.push_back(tidal_ptr);
660
661     return;
662 } /* addTidal() */

```

4.13.3.13 addWave()

```

void Model::addWave (
    WaveInputs wave_inputs )

```

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

Parameters

<i>wave_inputs</i>	A structure of Wave constructor inputs.
--------------------	---

```

679 {
680     Renewable* wave_ptr = new Wave(
681         this->electrical_load.n_points,
682         this->electrical_load.n_years,
683         wave_inputs
684     );
685
686     this->renewable_ptr_vec.push_back(wave_ptr);
687
688     return;
689 } /* addWave() */

```

4.13.3.14 addWind()

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

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

Parameters

<i>wind_inputs</i>	A structure of Wind constructor inputs.
--------------------	---

```
706 {
707     Renewable* wind_ptr = new Wind(
708         this->electrical_load.n_points,
709         this->electrical_load.n_years,
710         wind_inputs
711     );
712
713     this->renewable_ptr_vec.push_back(wind_ptr);
714
715     return;
716 } /* addWind() */
```

4.13.3.15 clear()

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

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

```
849 {
850     // 1. reset
851     this->reset();
852
853     // 2. clear components
854     controller.clear();
855     electrical_load.clear();
856     resources.clear();
857
858     return;
859 } /* clear() */
```

4.13.3.16 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.

```
800 {
801     // 1. clear combustion_ptr_vec
802     for (size_t i = 0; i < this->combustion_ptr_vec.size(); i++) {
803         delete this->combustion_ptr_vec[i];
804     }
805     this->combustion_ptr_vec.clear();
806
807     // 2. clear renewable_ptr_vec
808     for (size_t i = 0; i < this->renewable_ptr_vec.size(); i++) {
809         delete this->renewable_ptr_vec[i];
810     }
811     this->renewable_ptr_vec.clear();
812 }
```

```

813     // 3. clear storage_ptr_vec
814     for (size_t i = 0; i < this->storage_ptr_vec.size(); i++) {
815         delete this->storage_ptr_vec[i];
816     }
817     this->storage_ptr_vec.clear();
818
819     // 4. reset attributes
820     this->total_fuel_consumed_L = 0;
821
822     this->total_emissions.CO2_kg = 0;
823     this->total_emissions.CO_kg = 0;
824     this->total_emissions.NOx_kg = 0;
825     this->total_emissions.SOx_kg = 0;
826     this->total_emissions.CH4_kg = 0;
827     this->total_emissions.PM_kg = 0;
828
829     this->net_present_cost = 0;
830     this->total_dispatch_discharge_kWh = 0;
831     this->levellized_cost_of_energy_kWh = 0;
832
833     return;
834 } /* reset() */

```

4.13.3.17 run()

```

void Model::run (
    void )

```

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

```

758 {
759     // 1. init Controller
760     this->controller.init(
761         &(this->electrical_load),
762         &(this->renewable_ptr_vec),
763         &(this->resources),
764         &(this->combustion_ptr_vec)
765     );
766
767     // 2. apply dispatch control
768     this->controller.applyDispatchControl(
769         &(this->electrical_load),
770         &(this->combustion_ptr_vec),
771         &(this->renewable_ptr_vec),
772         &(this->storage_ptr_vec)
773     );
774
775     // 3. compute total fuel consumption and emissions
776     this->__computeFuelAndEmissions();
777
778     // 4. compute key economic metrics
779     this->__computeEconomics();
780
781     return;
782 } /* run() */

```

4.13.3.18 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.

```

887 {
888     // 1. handle sentinel
889     if (max_lines < 0) {
890         max_lines = this->electrical_load.n_points;
891     }
892
893     // 2. check for pre-existing, warn (and remove), then create
894     if (write_path.back() != '/') {
895         write_path += '/';
896     }
897
898     if (std::filesystem::is_directory(write_path)) {
899         std::string warning_str = "WARNING: Model::writeResults(): ";
900         warning_str += write_path;
901         warning_str += " already exists, contents will be overwritten!";
902
903         std::cout << warning_str << std::endl;
904
905         std::filesystem::remove_all(write_path);
906     }
907
908     std::filesystem::create_directory(write_path);
909
910     // 3. write summary
911     this->__writeSummary(write_path);
912
913     // 4. write time series
914     if (max_lines > this->electrical_load.n_points) {
915         max_lines = this->electrical_load.n_points;
916     }
917
918     if (max_lines > 0) {
919         this->__writeTimeSeries(write_path, max_lines);
920     }
921
922     // 5. call out to Combustion :: writeResults()
923     for (size_t i = 0; i < this->combustion_ptr_vec.size(); i++) {
924         this->combustion_ptr_vec[i]->writeResults(
925             write_path,
926             &(this->electrical_load.time_vec_hrs),
927             i,
928             max_lines
929         );
930     }
931
932     // 6. call out to Renewable :: writeResults()
933     for (size_t i = 0; i < this->renewable_ptr_vec.size(); i++) {
934         this->renewable_ptr_vec[i]->writeResults(
935             write_path,
936             &(this->electrical_load.time_vec_hrs),
937             &(this->resources.resource_map_1D),
938             &(this->resources.resource_map_2D),
939             i,
940             max_lines
941         );
942     }
943
944     // 7. call out to Storage :: writeResults()
945     for (size_t i = 0; i < this->storage_ptr_vec.size(); i++) {
946         this->storage_ptr_vec[i]->writeResults(
947             write_path,
948             &(this->electrical_load.time_vec_hrs),
949             i,
950             max_lines
951         );
952     }
953
954     return;
955 } /* writeResults() */

```

4.13.4 Member Data Documentation

4.13.4.1 combustion_ptr_vec

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

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

4.13.4.2 controller

```
Controller Model::controller
```

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

4.13.4.3 electrical_load

```
ElectricalLoad Model::electrical_load
```

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

4.13.4.4 levlized_cost_of_energy_kWh

```
double Model::levellized_cost_of_energy_kWh
```

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

4.13.4.5 net_present_cost

```
double Model::net_present_cost
```

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

4.13.4.6 renewable_ptr_vec

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

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

4.13.4.7 resources

[Resources](#) `Model::resources`

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

4.13.4.8 storage_ptr_vec

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

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

4.13.4.9 total_dispatch_discharge_kWh

`double` `Model::total_dispatch_discharge_kWh`

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

4.13.4.10 total_emissions

[Emissions](#) `Model::total_emissions`

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

4.13.4.11 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](#)

4.14 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.

4.14.1 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).

4.14.2 Member Data Documentation

4.14.2.1 control_mode

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

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

4.14.2.2 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:

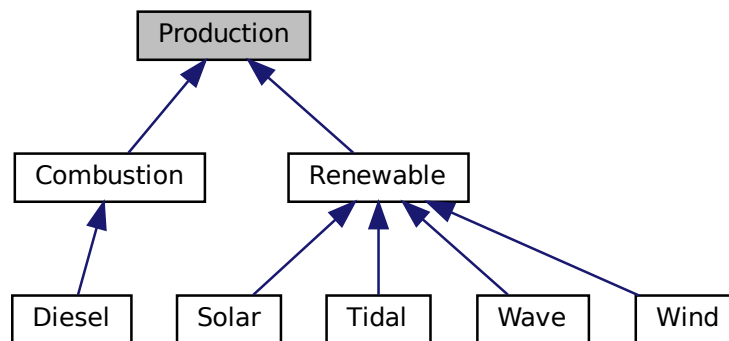
- `header/Model.h`

4.15 Production Class Reference

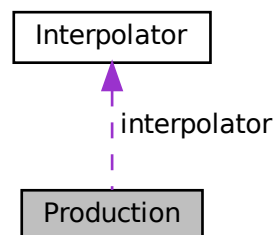
The base class of the [Production](#) hierarchy. This hierarchy contains derived classes which model the production of energy, be it renewable or otherwise.

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

Inheritance diagram for Production:



Collaboration diagram for Production:



Public Member Functions

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

- double `computeRealDiscountAnnual` (double, double)
Method to compute the real, annual discount rate to be used in computing model economics. This enables application of the discount factor approach.
- virtual void `computeEconomics` (std::vector< double > *)
Helper method to compute key economic metrics for the `Model` run.
- virtual double `commit` (int, double, double, double)
Method which takes in production and load for the current timestep, computes and records dispatch and curtailment, and then returns remaining load.
- virtual `~Production` (void)
Destructor for the `Production` class.

Public Attributes

- `Interpolator interpolator`
`Interpolator` component of `Production`.
- bool `print_flag`
A flag which indicates whether or not object construct/destruction should be verbose.
- bool `is_running`
A boolean which indicates whether or not the asset is running.
- bool `is_sunk`
A boolean which indicates whether or not the asset should be considered a sunk cost (i.e., capital cost incurred at the start of the model, or no).
- int `n_points`
The number of points in the modelling time series.
- int `n_starts`
The number of times the asset has been started.
- int `n_replacements`
The number of times the asset has been replaced.
- double `n_years`
The number of years being modelled.
- double `running_hours`
The number of hours for which the asset has been operating.
- double `replace_running_hrs`
The number of running hours after which the asset must be replaced.
- double `capacity_kW`
The rated production capacity [kW] of the asset.
- double `nominal_inflation_annual`
The nominal, annual inflation rate to use in computing model economics.
- double `nominal_discount_annual`
The nominal, annual discount rate to use in computing model economics.
- double `real_discount_annual`
The real, annual discount rate used in computing model economics. Is computed from the given nominal inflation and discount rates.
- double `capital_cost`
The capital cost of the asset (undefined currency).
- double `operation_maintenance_cost_kWh`
The operation and maintenance cost of the asset [1/kWh] (undefined currency). This is a cost incurred per unit of energy produced.
- double `net_present_cost`
The net present cost of this asset.
- double `total_dispatch_kWh`

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

 - double [levellized_cost_of_energy_kWh](#)

The levellized cost of energy [1/kWh] (undefined currency) of this asset. This metric considers only dispatch.
- std::string [type_str](#)

A string describing the type of the asset.
- std::vector< bool > [is_running_vec](#)

A boolean vector for tracking if the asset is running at a particular point in time.
- std::vector< double > [production_vec_kW](#)

A vector of production [kW] at each point in the modelling time series.
- std::vector< double > [dispatch_vec_kW](#)

A vector of dispatch [kW] at each point in the modelling time series. Dispatch is the amount of production that is sent to the grid to satisfy load.
- std::vector< double > [storage_vec_kW](#)

A vector of storage [kW] at each point in the modelling time series. [Storage](#) is the amount of production that is sent to storage.
- std::vector< double > [curtailment_vec_kW](#)

A vector of curtailment [kW] at each point in the modelling time series. Curtailment is the amount of production that can be neither dispatched nor stored, and is hence curtailed.
- std::vector< double > [capital_cost_vec](#)

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

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

Private Member Functions

- void [__checkInputs](#) (int, double, [ProductionInputs](#))

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

4.15.1 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.

4.15.2 Constructor & Destructor Documentation

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

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

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

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

4.15.2.2 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 Production 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() */

```

4.15.2.3 ~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() */

```

4.15.3 Member Function Documentation

4.15.3.1 __checkInputs()

```

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

```

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

Parameters

<i>n_points</i>	The number of points in the modelling time series.
<i>production_inputs</i>	A structure of Production 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() */

```

4.15.3.2 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() */

```

4.15.3.3 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 <code>time_vec_hrs</code> attribute of the ElectricalLoad .
-------------------------	--

1. compute levelized 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->levelized_cost_of_energy_kWh =
311         (n_years * total_annualized_cost) /
312         this->total_dispatch_kWh;
313
314     return;
315 } /* computeEconomics() */

```

4.15.3.4 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() */
```

4.15.3.5 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 Model 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() */
```

4.15.4 Member Data Documentation

4.15.4.1 capacity_kW

```
double Production::capacity_kW
```

The rated production capacity [kW] of the asset.

4.15.4.2 capital_cost

```
double Production::capital_cost
```

The capital cost of the asset (undefined currency).

4.15.4.3 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).

4.15.4.4 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.

4.15.4.5 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.

4.15.4.6 interpolator

```
Interpolator Production::interpolator
```

[Interpolator](#) component of [Production](#).

4.15.4.7 is_running

```
bool Production::is_running
```

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

4.15.4.8 is_running_vec

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

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

4.15.4.9 is_sunk

```
bool Production::is_sunk
```

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

4.15.4.10 levellized_cost_of_energy_kWh

```
double Production::levellized_cost_of_energy_kWh
```

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

4.15.4.11 n_points

```
int Production::n_points
```

The number of points in the modelling time series.

4.15.4.12 n_replacements

```
int Production::n_replacements
```

The number of times the asset has been replaced.

4.15.4.13 n_starts

```
int Production::n_starts
```

The number of times the asset has been started.

4.15.4.14 n_years

```
double Production::n_years
```

The number of years being modelled.

4.15.4.15 net_present_cost

```
double Production::net_present_cost
```

The net present cost of this asset.

4.15.4.16 nominal_discount_annual

```
double Production::nominal_discount_annual
```

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

4.15.4.17 nominal_inflation_annual

```
double Production::nominal_inflation_annual
```

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

4.15.4.18 operation_maintenance_cost_kWh

```
double Production::operation_maintenance_cost_kWh
```

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

4.15.4.19 operation_maintenance_cost_vec

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

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

4.15.4.20 print_flag

```
bool Production::print_flag
```

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

4.15.4.21 production_vec_kW

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

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

4.15.4.22 real_discount_annual

```
double Production::real_discount_annual
```

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

4.15.4.23 replace_running_hrs

```
double Production::replace_running_hrs
```

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

4.15.4.24 running_hours

```
double Production::running_hours
```

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

4.15.4.25 storage_vec_kW

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

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

4.15.4.26 total_dispatch_kWh

```
double Production::total_dispatch_kWh
```

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

4.15.4.27 type_str

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

A string describing the type of the asset.

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

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

4.16 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.

4.16.1 Detailed Description

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

4.16.2 Member Data Documentation

4.16.2.1 capacity_kW

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

The rated production capacity [kW] of the asset.

4.16.2.2 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).

4.16.2.3 nominal_discount_annual

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

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

4.16.2.4 nominal_inflation_annual

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

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

4.16.2.5 print_flag

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

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

4.16.2.6 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:

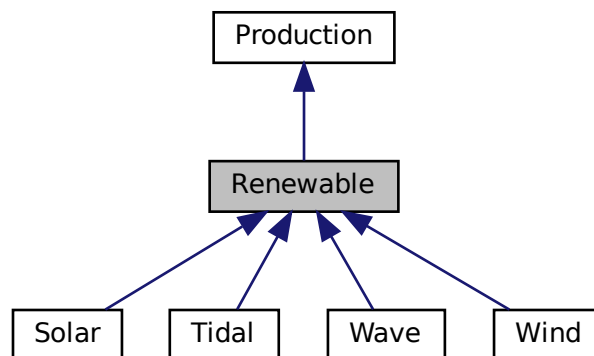
- header/Production/[Production.h](#)

4.17 Renewable Class Reference

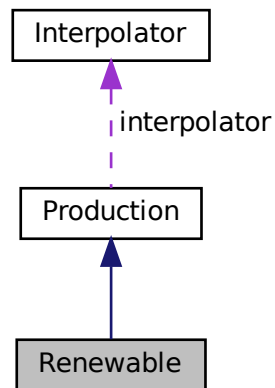
The root of the [Renewable](#) branch of the [Production](#) hierarchy. This branch contains derived classes which model the renewable production of energy.

```
#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)

4.17.1 Detailed Description

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

4.17.2 Constructor & Destructor Documentation

4.17.2.1 `Renewable()` [1/2]

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

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

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

4.17.2.2 `Renewable()` [2/2]

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

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

Parameters

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

```
124 :
125 Production(
126     n_points,
```

```

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

```

4.17.2.3 ~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() */

```

4.17.3 Member Function Documentation

4.17.3.1 __checkInputs()

```

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

```

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

```

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

```

4.17.3.2 __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() */
```

4.17.3.3 __writeSummary()

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

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

```
72 {return;}
```

4.17.3.4 __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;}
```

4.17.3.5 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() */

```

4.17.3.6 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 ElectricalLoad .
-------------------------	--

Reimplemented from [Production](#).

```

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

```

4.17.3.7 computeProductionkW() [1/2]

```

virtual double Renewable::computeProductionkW (
    int ,

```

```
double ,
double ) [inline], [virtual]
```

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

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

4.17.3.8 computeProductionkW() [2/2]

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

Reimplemented in [Wave](#).

```
97 {return 0;}
```

4.17.3.9 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 Model 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() */
```

4.17.3.10 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 ElectricalLoad .
<i>resource_map_1D_ptr</i>	A pointer to the 1D map of Resources .
<i>resource_map_2D_ptr</i>	A pointer to the 2D map of Resources .
<i>renewable_index</i>	An integer which corresponds to the index of the Renewable asset in the Model .
<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() */

```

4.17.4 Member Data Documentation

4.17.4.1 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.

4.17.4.2 type

`RenewableType` `Renewable::type`

The type (`RenewableType`) of the asset.

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

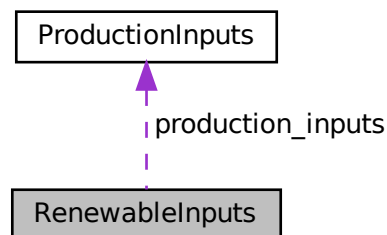
- `header/Production/Renewable/Renewable.h`
- `source/Production/Renewable/Renewable.cpp`

4.18 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.

4.18.1 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`.

4.18.2 Member Data Documentation

4.18.2.1 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](#)

4.19 Resources Class Reference

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

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

Public Member Functions

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

Public Attributes

- std::map< int, std::vector< double > > [resource_map_1D](#)
A map <int, vector<double>> of given 1D renewable resource time series.
- std::map< int, std::string > [string_map_1D](#)
A map <int, string> of descriptors for the type of the given 1D renewable resource time series.
- std::map< int, std::string > [path_map_1D](#)
A map <int, string> of the paths (either relative or absolute) to given 1D renewable resource time series.
- std::map< int, std::vector< std::vector< double > > > [resource_map_2D](#)
A map <int, vector<vector<double>>> of given 2D renewable resource time series.
- std::map< int, std::string > [string_map_2D](#)
A map <int, string> of descriptors for the type of the given 2D renewable resource time series.
- std::map< int, std::string > [path_map_2D](#)
A map <int, string> of the paths (either relative or absolute) to given 2D renewable resource time series.

Private Member Functions

- void `__checkResourceKey1D` (int, [RenewableType](#))
Helper method to check if given resource key (1D) is already in use.
- void `__checkResourceKey2D` (int, [RenewableType](#))
Helper method to check if given resource key (2D) is already in use.
- void `__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](#).

4.19.1 Detailed Description

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

4.19.2 Constructor & Destructor Documentation

4.19.2.1 Resources()

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

Constructor for the [Resources](#) class.

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

4.19.2.2 ~Resources()

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

Destructor for the [Resources](#) class.

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

4.19.3 Member Function Documentation

4.19.3.1 __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() */
```

4.19.3.2 __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() */

```

4.19.3.3 __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 Model's ElectricalLoad object.

```

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

```

```

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

```

4.19.3.4 __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 Model's ElectricalLoad object.

```

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

```

4.19.3.5 __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 Model's ElectricalLoad object.

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


4.19.3.6 `__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

<code>path_2_resource_data</code>	The path (either relative or absolute) to the given resource time series.
<code>resource_key</code>	The key associated with the given renewable resource.
<code>electrical_load_ptr</code>	A pointer to the Model's ElectricalLoad object.

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

4.19.3.7 __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 Model's ElectricalLoad object.

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

4.19.3.8 __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 Model's ElectricalLoad object.

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

4.19.3.9 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 Resources .
<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 Resources object, used to associate Renewable assets with the corresponding resource.
<i>electrical_load_ptr</i>	A pointer to the Model's ElectricalLoad object.

```
616 {
617     switch (renewable_type) {
618         case (RenewableType :: SOLAR): {
619             this->__checkResourceKeyID(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->__checkResourceKeyID(resource_key, renewable_type);
```

```

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

```

4.19.3.10 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() */

```

4.19.4 Member Data Documentation

4.19.4.1 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.

4.19.4.2 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.

4.19.4.3 resource_map_1D

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

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

4.19.4.4 resource_map_2D

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

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

4.19.4.5 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.

4.19.4.6 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:

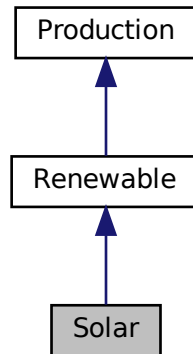
- header/[Resources.h](#)
- source/[Resources.cpp](#)

4.20 Solar Class Reference

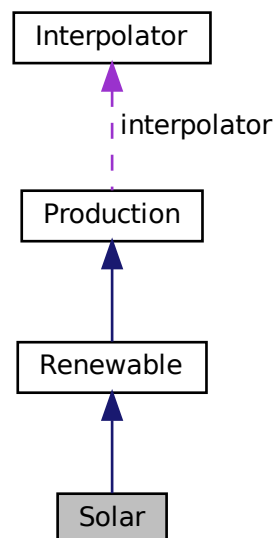
A derived class of the [Renewable](#) branch of [Production](#) which models solar production.

```
#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](#).

4.20.1 Detailed Description

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

4.20.2 Constructor & Destructor Documentation

4.20.2.1 Solar() [1/2]

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

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

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

4.20.2.2 Solar() [2/2]

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

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

Parameters

<i>n_points</i>	The number of points in the modelling time series.
<i>n_years</i>	The number of years being modelled.
<i>solar_inputs</i>	A structure of Solar constructor inputs.

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


4.20.2.3 ~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() */
```

4.20.3 Member Function Documentation

4.20.3.1 __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() */
```

4.20.3.2 __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() */
```

4.20.3.3 `__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() */
```

4.20.3.4 `__writeSummary()`

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

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

Parameters

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

Reimplemented from [Renewable](#).

```
123 {
124     // 1. create filestream
125     write_path += "summary_results.md";
126     std::ofstream ofs;
127     ofs.open(write_path, std::ofstream::out);
128
129     // 2. write summary results (markdown)
130     ofs << "# ";
131     ofs << std::to_string(int(ceil(this->capacity_kW)));
132     ofs << " kW SOLAR Summary Results\n";
133     ofs << "\n-----\n\n";
134
135     // 2.1. Production attributes
136     ofs << "## Production Attributes\n";
137     ofs << "\n";
138
139     ofs << "Capacity: " << this->capacity_kW << "kW \n";
140     ofs << "\n";
141
142     ofs << "Sunk Cost (N = 0 / Y = 1): " << this->is_sunk << " \n";
143     ofs << "Capital Cost: " << this->capital_cost << " \n";
144     ofs << "Operation and Maintenance Cost: " << this->operation_maintenance_cost_kWh
145         << " per kWh produced \n";
146     ofs << "Nominal Inflation Rate (annual): " << this->nominal_inflation_annual
147         << " \n";
148     ofs << "Nominal Discount Rate (annual): " << this->nominal_discount_annual
149         << " \n";
150     ofs << "Real Discount Rate (annual): " << this->real_discount_annual << " \n";
151     ofs << "\n";
152
153     ofs << "Replacement Running Hours: " << this->replace_running_hrs << " \n";
154     ofs << "\n-----\n\n";
```

```

155
156 // 2.2. Renewable attributes
157 ofs << "## Renewable Attributes\n";
158 ofs << "\n";
159
160 ofs << "Resource Key (1D): " << this->resource_key << " \n";
161
162 ofs << "\n-----\n\n";
163
164 // 2.3. Solar attributes
165 ofs << "## Solar Attributes\n";
166 ofs << "\n";
167
168 ofs << "Derating Factor: " << this->derating << " \n";
169
170 ofs << "\n-----\n\n";
171
172 // 2.4. Solar Results
173 ofs << "## Results\n";
174 ofs << "\n";
175
176 ofs << "Net Present Cost: " << this->net_present_cost << " \n";
177 ofs << "\n";
178
179 ofs << "Total Dispatch: " << this->total_dispatch_kWh
180     << " kWh \n";
181
182 ofs << "Levellized Cost of Energy: " << this->levellized_cost_of_energy_kWh
183     << " per kWh dispatched \n";
184 ofs << "\n";
185
186 ofs << "Running Hours: " << this->running_hours << " \n";
187 ofs << "Replacements: " << this->n_replacements << " \n";
188
189 ofs << "\n-----\n\n";
190
191 ofs.close();
192 return;
193 } /* __writeSummary() */

```

4.20.3.5 __writeTimeSeries()

```

void Solar::__writeTimeSeries (
    std::string write_path,
    std::vector< double > * time_vec_hrs_ptr,
    std::map< int, std::vector< double >> * resource_map_1D_ptr,
    std::map< int, std::vector< std::vector< double >>> * resource_map_2D_ptr,
    int max_lines = -1 ) [private], [virtual]

```

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

Parameters

<i>write_path</i>	A path (either relative or absolute) to the directory location where results are to be written. If already exists, will overwrite.
<i>time_vec_hrs_ptr</i>	A pointer to the <code>time_vec_hrs</code> attribute of the ElectricalLoad .
<i>resource_map_1D_ptr</i>	A pointer to the 1D map of Resources .
<i>resource_map_2D_ptr</i>	A pointer to the 2D map of Resources .
<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() */

```

4.20.3.6 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() */

```

4.20.3.7 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>	Solar 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() */
```

4.20.3.8 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 Model 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() */

```

4.20.4 Member Data Documentation

4.20.4.1 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:

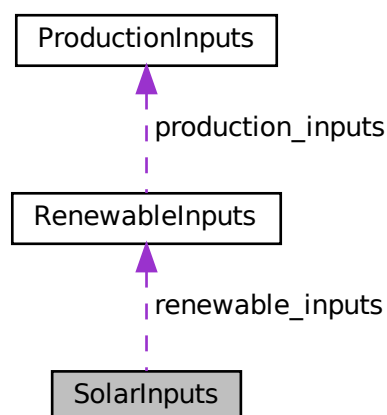
- header/Production/Renewable/[Solar.h](#)
- source/Production/Renewable/[Solar.cpp](#)

4.21 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.).

4.21.1 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](#).

4.21.2 Member Data Documentation

4.21.2.1 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].

4.21.2.2 derating

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

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

4.21.2.3 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].

4.21.2.4 renewable_inputs

```
RenewableInputs SolarInputs::renewable_inputs
```

An encapsulated [RenewableInputs](#) instance.

4.21.2.5 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:

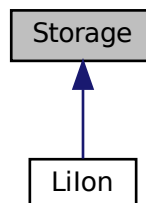
- [header/Production/Renewable/Solar.h](#)

4.22 Storage Class Reference

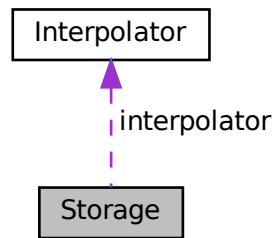
The base class of the [Storage](#) hierarchy. This hierarchy contains derived classes which model the storage of energy.

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

Inheritance diagram for Storage:



Collaboration diagram for Storage:



Public Member Functions

- [Storage](#) (void)
Constructor (dummy) for the [Storage](#) class.
- [Storage](#) (int, double, [StorageInputs](#))
Constructor (intended) for the [Storage](#) class.
- virtual void [handleReplacement](#) (int)
Method to handle asset replacement and capital cost incursion, if applicable.
- void [computeEconomics](#) (std::vector< double > *)
Helper method to compute key economic metrics for the [Model](#) run.
- virtual double [getAvailablekW](#) (double)
- virtual double [getAcceptablekW](#) (double)
- virtual void [commitCharge](#) (int, double, double)
- virtual double [commitDischarge](#) (int, double, double, double)
- void [writeResults](#) (std::string, std::vector< double > *, int, int=-1)
Method which writes [Storage](#) results to an output directory.
- virtual [~Storage](#) (void)
Destructor for the [Storage](#) class.

Public Attributes

- [StorageType](#) type
The type ([StorageType](#)) of the asset.
- [Interpolator](#) interpolator
[Interpolator](#) component of [Storage](#).
- bool [print_flag](#)
A flag which indicates whether or not object construct/destruction should be verbose.
- bool [is_depleted](#)
A boolean which indicates whether or not the asset is currently considered depleted.
- bool [is_sunk](#)
A boolean which indicates whether or not the asset should be considered a sunk cost (i.e., capital cost incurred at the start of the model, or no).
- int [n_points](#)
The number of points in the modelling time series.

- int [n_replacements](#)
The number of times the asset has been replaced.
- double [n_years](#)
The number of years being modelled.
- double [power_capacity_kW](#)
The rated power capacity [kW] of the asset.
- double [energy_capacity_kWh](#)
The rated energy capacity [kWh] of the asset.
- double [charge_kWh](#)
The energy [kWh] stored in the asset.
- double [power_kW](#)
The power [kW] currently being charged/discharged by the asset.
- double [nominal_inflation_annual](#)
The nominal, annual inflation rate to use in computing model economics.
- double [nominal_discount_annual](#)
The nominal, annual discount rate to use in computing model economics.
- double [real_discount_annual](#)
The real, annual discount rate used in computing model economics. Is computed from the given nominal inflation and discount rates.
- double [capital_cost](#)
The capital cost of the asset (undefined currency).
- double [operation_maintenance_cost_kWh](#)
The operation and maintenance cost of the asset [1/kWh] (undefined currency). This is a cost incurred per unit of energy charged/discharged.
- double [net_present_cost](#)
The net present cost of this asset.
- double [total_discharge_kWh](#)
The total energy discharged [kWh] over the [Model](#) run.
- double [levellized_cost_of_energy_kWh](#)
The levellized cost of energy [1/kWh] (undefined currency) of this asset. This metric considers only discharge.
- std::string [type_str](#)
A string describing the type of the asset.
- std::vector< double > [charge_vec_kWh](#)
A vector of the charge state [kWh] at each point in the modelling time series.
- std::vector< double > [charging_power_vec_kW](#)
A vector of the charging power [kW] at each point in the modelling time series.
- std::vector< double > [discharging_power_vec_kW](#)
A vector of the discharging power [kW] at each point in the modelling time series.
- std::vector< double > [capital_cost_vec](#)
A vector of capital costs (undefined currency) incurred over each modelling time step. These costs are not discounted (i.e., these are actual costs).
- std::vector< double > [operation_maintenance_cost_vec](#)
A vector of operation and maintenance costs (undefined currency) incurred over each modelling time step. These costs are not discounted (i.e., these are actual costs).

Private Member Functions

- void [__checkInputs](#) (int, double, [StorageInputs](#))
Helper method to check inputs to the [Storage](#) constructor.
- double [__computeRealDiscountAnnual](#) (double, double)
Helper method to compute the real, annual discount rate to be used in computing model economics. This enables application of the discount factor approach.
- virtual void [__writeSummary](#) (std::string)
- virtual void [__writeTimeSeries](#) (std::string, std::vector< double > *, int=-1)

4.22.1 Detailed Description

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

4.22.2 Constructor & Destructor Documentation

4.22.2.1 Storage() [1/2]

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

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

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

4.22.2.2 Storage() [2/2]

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

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

Parameters

<i>n_points</i>	The number of points in the modelling time series.
<i>n_years</i>	The number of years being modelled.
<i>storage_inputs</i>	A structure of Storage 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() */

```

4.22.2.3 ~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() */

```

4.22.3 Member Function Documentation

4.22.3.1 __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 Storage 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() */

```

4.22.3.2 __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() */
```

4.22.3.3 __writeSummary()

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

Reimplemented in [Lilon](#).

```
79 {return;}
```

4.22.3.4 __writeTimeSeries()

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

Reimplemented in [Lilon](#).

```
80 {return;}
```

4.22.3.5 commitCharge()

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

Reimplemented in [Lilon](#).

```
134 {return;}
```

4.22.3.6 commitDischarge()

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

Reimplemented in [Lilon](#).

```
135 {return 0;}
```

4.22.3.7 computeEconomics()

```
void Storage::computeEconomics (
    std::vector< double > * time_vec_hrs_ptr )
```

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

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

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

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

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

Parameters

<i>time_vec_hrs_ptr</i>	A pointer to the <code>time_vec_hrs</code> attribute of the ElectricalLoad .
-------------------------	--

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() */
```

4.22.3.8 getAcceptablekW()

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

Reimplemented in [Lilon](#).

```
132 {return 0;}
```

4.22.3.9 getAvailablekW()

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

Reimplemented in [Lilon](#).

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

4.22.3.10 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 Model 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() */
```

4.22.3.11 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 ElectricalLoad .
<i>storage_index</i>	An integer which corresponds to the index of the Storage asset in the Model .
<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() */

```

4.22.4 Member Data Documentation

4.22.4.1 capital_cost

double Storage::capital_cost

The capital cost of the asset (undefined currency).

4.22.4.2 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).

4.22.4.3 charge_kWh

```
double Storage::charge_kWh
```

The energy [kWh] stored in the asset.

4.22.4.4 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.

4.22.4.5 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.

4.22.4.6 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.

4.22.4.7 energy_capacity_kWh

```
double Storage::energy_capacity_kWh
```

The rated energy capacity [kWh] of the asset.

4.22.4.8 interpolator

```
Interpolator Storage::interpolator
```

[Interpolator](#) component of [Storage](#).

4.22.4.9 is_depleted

```
bool Storage::is_depleted
```

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

4.22.4.10 is_sunk

```
bool Storage::is_sunk
```

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

4.22.4.11 levellized_cost_of_energy_kWh

```
double Storage::levellized_cost_of_energy_kWh
```

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

4.22.4.12 n_points

```
int Storage::n_points
```

The number of points in the modelling time series.

4.22.4.13 n_replacements

```
int Storage::n_replacements
```

The number of times the asset has been replaced.

4.22.4.14 n_years

```
double Storage::n_years
```

The number of years being modelled.

4.22.4.15 net_present_cost

```
double Storage::net_present_cost
```

The net present cost of this asset.

4.22.4.16 nominal_discount_annual

```
double Storage::nominal_discount_annual
```

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

4.22.4.17 nominal_inflation_annual

```
double Storage::nominal_inflation_annual
```

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

4.22.4.18 operation_maintenance_cost_kWh

```
double Storage::operation_maintenance_cost_kWh
```

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

4.22.4.19 operation_maintenance_cost_vec

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

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

4.22.4.20 power_capacity_kW

```
double Storage::power_capacity_kW
```

The rated power capacity [kW] of the asset.

4.22.4.21 power_kW

```
double Storage::power_kW
```

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

4.22.4.22 print_flag

```
bool Storage::print_flag
```

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

4.22.4.23 real_discount_annual

```
double Storage::real_discount_annual
```

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

4.22.4.24 total_discharge_kWh

```
double Storage::total_discharge_kWh
```

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

4.22.4.25 type

```
StorageType Storage::type
```

The type (StorageType) of the asset.

4.22.4.26 type_str

```
std::string Storage::type_str
```

A string describing the type of the asset.

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

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

4.23 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.

4.23.1 Detailed Description

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

4.23.2 Member Data Documentation

4.23.2.1 [energy_capacity_kWh](#)

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

The rated energy capacity [kWh] of the asset.

4.23.2.2 [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).

4.23.2.3 nominal_discount_annual

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

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

4.23.2.4 nominal_inflation_annual

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

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

4.23.2.5 power_capacity_kW

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

The rated power capacity [kW] of the asset.

4.23.2.6 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:

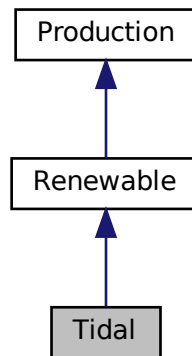
- header/Storage/[Storage.h](#)

4.24 Tidal Class Reference

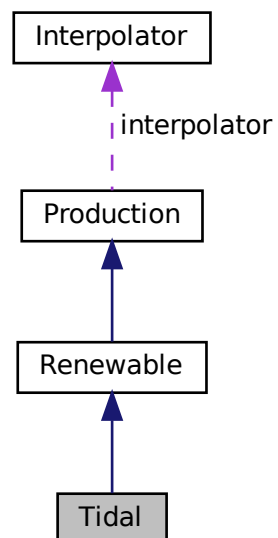
A derived class of the [Renewable](#) branch of [Production](#) which models tidal production.

```
#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](#).

4.24.1 Detailed Description

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

4.24.2 Constructor & Destructor Documentation

4.24.2.1 Tidal() [1/2]

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

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

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

4.24.2.2 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 Tidal constructor inputs.

```
457 :
458 Renewable(
459     n_points,
460     n_years,
461     tidal_inputs.renewable_inputs
462 )
463 {
464     // 1. check inputs
465     this->__checkInputs(tidal_inputs);
466
467     // 2. set attributes
468     this->type = RenewableType :: TIDAL;
469     this->type_str = "TIDAL";
470
471     this->resource_key = tidal_inputs.resource_key;
472
473     this->design_speed_ms = tidal_inputs.design_speed_ms;
474
475     this->power_model = tidal_inputs.power_model;
476
477     switch (this->power_model) {
478         case (TidalPowerProductionModel :: TIDAL_POWER_CUBIC): {
479             this->power_model_string = "CUBIC";
480             break;
481         }
482
483         case (TidalPowerProductionModel :: TIDAL_POWER_EXPONENTIAL): {
484             this->power_model_string = "EXPONENTIAL";
485             break;
486         }
487
488         case (TidalPowerProductionModel :: TIDAL_POWER_LOOKUP): {
```

```

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

```

4.24.2.3 ~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() */

```

4.24.3 Member Function Documentation

4.24.3.1 __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() */

```

4.24.3.2 __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 Model 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() */

```

4.24.3.3 `__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 Model 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() */
```

4.24.3.4 `__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 Model 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() */

```

4.24.3.5 __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() */

```

4.24.3.6 __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() */

```

4.24.3.7 __writeSummary()

```

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

```

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

Parameters

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

Reimplemented from [Renewable](#).

```

268 {
269     // 1. create filestream
270     write_path += "summary_results.md";
271     std::ofstream ofs;
272     ofs.open(write_path, std::ofstream::out);
273
274     // 2. write summary results (markdown)
275     ofs << "# ";
276     ofs << std::to_string(int(ceil(this->capacity_kW)));
277     ofs << " kW TIDAL Summary Results\n";
278     ofs << "\n-----\n\n";
279
280     // 2.1. Production attributes
281     ofs << "## Production Attributes\n";
282     ofs << "\n";
283
284     ofs << "Capacity: " << this->capacity_kW << "kW \n";
285     ofs << "\n";
286
287     ofs << "Sunk Cost (N = 0 / Y = 1): " << this->is_sunk << " \n";
288     ofs << "Capital Cost: " << this->capital_cost << " \n";
289     ofs << "Operation and Maintenance Cost: " << this->operation_maintenance_cost_kWh
290         << " per kWh produced \n";
291     ofs << "Nominal Inflation Rate (annual): " << this->nominal_inflation_annual
292         << " \n";
293     ofs << "Nominal Discount Rate (annual): " << this->nominal_discount_annual
294         << " \n";
295     ofs << "Real Discount Rate (annual): " << this->real_discount_annual << " \n";
296     ofs << "\n";
297
298     ofs << "Replacement Running Hours: " << this->replace_running_hrs << " \n";
299     ofs << "\n-----\n\n";
300
301     // 2.2. Renewable attributes
302     ofs << "## Renewable Attributes\n";
303     ofs << "\n";
304
305     ofs << "Resource Key (ID): " << this->resource_key << " \n";
306
307     ofs << "\n-----\n\n";
308
309     // 2.3. Tidal attributes
310     ofs << "## Tidal Attributes\n";
311     ofs << "\n";
312
313     ofs << "Power Production Model: " << this->power_model_string << " \n";
314     ofs << "Design Speed: " << this->design_speed_ms << " m/s \n";
315
316     ofs << "\n-----\n\n";
317
318     // 2.4. Tidal Results
319     ofs << "## Results\n";
320     ofs << "\n";
321
322     ofs << "Net Present Cost: " << this->net_present_cost << " \n";
323     ofs << "\n";
324
325     ofs << "Total Dispatch: " << this->total_dispatch_kWh
326         << " kWh \n";
327
328     ofs << "Levellized Cost of Energy: " << this->levellized_cost_of_energy_kWh
329         << " per kWh dispatched \n";
330     ofs << "\n";
331
332     ofs << "Running Hours: " << this->running_hours << " \n";
333     ofs << "Replacements: " << this->n_replacements << " \n";
334
335     ofs << "\n-----\n\n";
336
337     ofs.close();
338
339     return;
340 } /* __writeSummary() */

```

4.24.3.8 __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 ElectricalLoad .
<i>resource_map_1D_ptr</i>	A pointer to the 1D map of Resources .
<i>resource_map_2D_ptr</i>	A pointer to the 2D map of Resources .
<i>max_lines</i>	The maximum number of lines of output to write.

Reimplemented from [Renewable](#).

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

4.24.3.9 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() */

```

4.24.3.10 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>	Tidal resource (i.e. tidal stream speed) [m/s].

Returns

The production [kW] of the tidal turbine.

Reimplemented from [Renewable](#).

```

588 {
589     // check if no resource
590     if (tidal_resource_ms <= 0) {
591         return 0;
592     }
593
594     // compute production
595     double production_kW = 0;

```

```

596
597     switch (this->power_model) {
598         case (TidalPowerProductionModel :: TIDAL_POWER_CUBIC): {
599             production_kW = this->__computeCubicProductionkW(
600                 timestep,
601                 dt_hrs,
602                 tidal_resource_ms
603             );
604
605             break;
606         }
607
608         case (TidalPowerProductionModel :: TIDAL_POWER_EXPONENTIAL): {
609             production_kW = this->__computeExponentialProductionkW(
610                 timestep,
611                 dt_hrs,
612                 tidal_resource_ms
613             );
614
615             break;
616         }
617
618         case (TidalPowerProductionModel :: TIDAL_POWER_LOOKUP): {
619             production_kW = this->__computeLookupProductionkW(
620                 timestep,
621                 dt_hrs,
622                 tidal_resource_ms
623             );
624
625             break;
626         }
627
628         default: {
629             std::string error_str = "ERROR: Tidal::computeProductionkW(): ";
630             error_str += "power model ";
631             error_str += std::to_string(this->power_model);
632             error_str += " not recognized";
633
634             #ifdef _WIN32
635                 std::cout << error_str << std::endl;
636             #endif
637
638             throw std::runtime_error(error_str);
639
640             break;
641         }
642     }
643
644     return production_kW;
645 } /* computeProductionkW() */

```

4.24.3.11 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 Model 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() */

```

4.24.4 Member Data Documentation

4.24.4.1 design_speed_ms

```
double Tidal::design_speed_ms
```

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

4.24.4.2 power_model

```
TidalPowerProductionModel Tidal::power_model
```

The tidal power production model to be applied.

4.24.4.3 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:

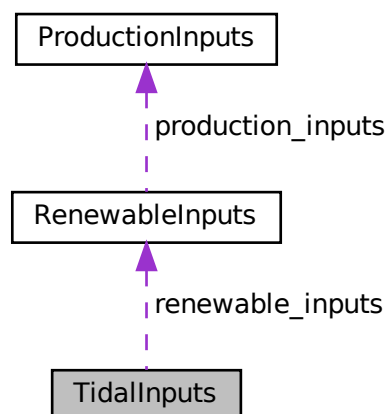
- header/Production/Renewable/[Tidal.h](#)
- source/Production/Renewable/[Tidal.cpp](#)

4.25 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.

4.25.1 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](#).

4.25.2 Member Data Documentation

4.25.2.1 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].

4.25.2.2 design_speed_ms

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

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

4.25.2.3 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].

4.25.2.4 power_model

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

The tidal power production model to be applied.

4.25.2.5 renewable_inputs

```
RenewableInputs TidalInputs::renewable_inputs
```

An encapsulated [RenewableInputs](#) instance.

4.25.2.6 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:

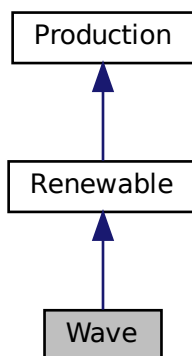
- [header/Production/Renewable/Tidal.h](#)

4.26 Wave Class Reference

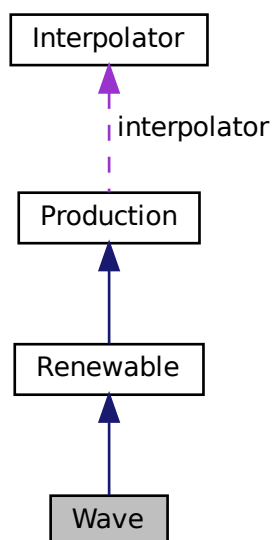
A derived class of the [Renewable](#) branch of [Production](#) which models wave production.

```
#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](#).

4.26.1 Detailed Description

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

4.26.2 Constructor & Destructor Documentation

4.26.2.1 Wave() [1/2]

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

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

```
501 {
502     return;
503 } /* Wave() */
```

4.26.2.2 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 Wave constructor inputs.

```
531 :
532 Renewable(
533     n_points,
534     n_years,
535     wave_inputs.renewable_inputs
536 )
537 {
538     // 1. check inputs
539     this->__checkInputs(wave_inputs);
540
541     // 2. set attributes
542     this->type = RenewableType :: WAVE;
543     this->type_str = "WAVE";
544
545     this->resource_key = wave_inputs.resource_key;
546
547     this->design_significant_wave_height_m =
548         wave_inputs.design_significant_wave_height_m;
549     this->design_energy_period_s = wave_inputs.design_energy_period_s;
550
551     this->power_model = wave_inputs.power_model;
552
553     switch (this->power_model) {
554         case (WavePowerProductionModel :: WAVE_POWER_GAUSSIAN): {
555             this->power_model_string = "GAUSSIAN";
```



```

556
557     break;
558 }
559
560 case (WavePowerProductionModel :: WAVE_POWER_PARABOLOID): {
561     this->power_model_string = "PARABOLOID";
562
563     break;
564 }
565
566 case (WavePowerProductionModel :: WAVE_POWER_LOOKUP): {
567     this->power_model_string = "LOOKUP";
568
569     this->interpolator.addData2D(
570         0,
571         wave_inputs.path_2_normalized_performance_matrix
572     );
573
574     break;
575 }
576
577 default: {
578     std::string error_str = "ERROR: Wave(): ";
579     error_str += "power production model ";
580     error_str += std::to_string(this->power_model);
581     error_str += " not recognized";
582
583     #ifdef _WIN32
584         std::cout << error_str << std::endl;
585     #endif
586
587     throw std::runtime_error(error_str);
588
589     break;
590 }
591 }
592
593 if (wave_inputs.capital_cost < 0) {
594     this->capital_cost = this->__getGenericCapitalCost();
595 }
596
597 if (wave_inputs.operation_maintenance_cost_kWh < 0) {
598     this->operation_maintenance_cost_kWh = this->__getGenericOpMaintCost();
599 }
600
601 if (not this->is_sunk) {
602     this->capital_cost_vec[0] = this->capital_cost;
603 }
604
605 // 3. construction print
606 if (this->print_flag) {
607     std::cout << "Wave object constructed at " << this << std::endl;
608 }
609
610 return;
611 } /* Renewable() */

```

4.26.2.3 ~Wave()

```

Wave::~~Wave (
    void )

```

Destructor for the [Wave](#) class.

```

797 {
798     // 1. destruction print
799     if (this->print_flag) {
800         std::cout << "Wave object at " << this << " destroyed" << std::endl;
801     }
802
803     return;
804 } /* ~Wave() */

```

4.26.3 Member Function Documentation

4.26.3.1 `__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 Wave constructor inputs.
--------------------	---

```
39 {
40     // 1. check design_significant_wave_height_m
41     if (wave_inputs.design_significant_wave_height_m <= 0) {
42         std::string error_str = "ERROR: Wave(): ";
43         error_str += "WaveInputs::design_significant_wave_height_m must be > 0";
44
45         #ifdef _WIN32
46             std::cout << error_str << std::endl;
47         #endif
48
49         throw std::invalid_argument(error_str);
50     }
51
52     // 2. check design_energy_period_s
53     if (wave_inputs.design_energy_period_s <= 0) {
54         std::string error_str = "ERROR: Wave(): ";
55         error_str += "WaveInputs::design_energy_period_s must be > 0";
56
57         #ifdef _WIN32
58             std::cout << error_str << std::endl;
59         #endif
60
61         throw std::invalid_argument(error_str);
62     }
63
64     // 3. if WAVE_POWER_LOOKUP, check that path is given
65     if (
66         wave_inputs.power_model == WavePowerProductionModel::WAVE_POWER_LOOKUP and
67         wave_inputs.path_2_normalized_performance_matrix.empty()
68     ) {
69         std::string error_str = "ERROR: Wave() power model was set to ";
70         error_str += "WavePowerProductionModel::WAVE_POWER_LOOKUP, but no path to a ";
71         error_str += "normalized performance matrix was given";
72
73         #ifdef _WIN32
74             std::cout << error_str << std::endl;
75         #endif
76
77         throw std::invalid_argument(error_str);
78     }
79
80     return;
81 } /* __checkInputs() */
```

4.26.3.2 `__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 Model run.
<i>dt_hrs</i>	The interval of time [hrs] associated with the action.
<i>significant_wave_height_m</i>	The significant wave height [m] in the vicinity of the wave energy converter.
<i>energy_period_s</i>	The energy period [s] in the vicinity of the wave energy converter

Returns

The production [kW] of the wave energy converter, under an exponential model.

```

176 {
177     double H_s_nondim =
178         (significant_wave_height_m - this->design_significant_wave_height_m) /
179         this->design_significant_wave_height_m;
180
181     double T_e_nondim =
182         (energy_period_s - this->design_energy_period_s) /
183         this->design_energy_period_s;
184
185     double production = exp(
186         -2.25119 * pow(T_e_nondim, 2) +
187         3.44570 * T_e_nondim * H_s_nondim -
188         4.01508 * pow(H_s_nondim, 2)
189     );
190
191     return production * this->capacity_kW;
192 } /* __computeGaussianProductionkW() */

```

4.26.3.3 __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 Model run.
<i>dt_hrs</i>	The interval of time [hrs] associated with the action.
<i>significant_wave_height_m</i>	The significant wave height [m] in the vicinity of the wave energy converter.
<i>energy_period_s</i>	The energy period [s] in the vicinity of the wave energy converter

Returns

The interpolated production [kW] of the wave energy converter.

```

293 {
294     double prod = this->interpolator.interp2D(
295         0,
296         significant_wave_height_m,
297         energy_period_s
298     );
299

```

```

300     return prod * this->capacity_kW;
301 } /* __computeLookupProductionkW() */

```

4.26.3.4 __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 Model run.
<i>dt_hrs</i>	The interval of time [hrs] associated with the action.
<i>significant_wave_height_m</i>	The significant wave height [m] in the vicinity of the wave energy converter.
<i>energy_period_s</i>	The energy period [s] in the vicinity of the wave energy converter

Returns

The production [kW] of the wave energy converter, under a paraboloid model.

```

233 {
234     // first, check for idealized wave breaking (deep water)
235     if (significant_wave_height_m >= 0.2184 * pow(energy_period_s, 2)) {
236         return 0;
237     }
238
239     // otherwise, apply generic quadratic performance model
240     // (with outputs bounded to [0, 1])
241     double production =
242         0.289 * significant_wave_height_m -
243         0.00111 * pow(significant_wave_height_m, 2) * energy_period_s -
244         0.0169 * energy_period_s;
245
246     if (production < 0) {
247         production = 0;
248     }
249
250     else if (production > 1) {
251         production = 1;
252     }
253
254     return production * this->capacity_kW;
255 } /* __computeParaboloidProductionkW() */

```

4.26.3.5 __getGenericCapitalCost()

```

double Wave::__getGenericCapitalCost (
    void ) [private]

```

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

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

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

Returns

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

```
103 {
104     double capital_cost_per_kW = 7000 * pow(this->capacity_kW, -0.15) + 5000;
105
106     return capital_cost_per_kW * this->capacity_kW;
107 } /* __getGenericCapitalCost() */
```

4.26.3.6 __getGenericOpMaintCost()

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

Helper method to generate a generic wave energy converter operation and maintenance cost. This is a cost incurred per unit energy produced.

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

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

Returns

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

```
131 {
132     double operation_maintenance_cost_kWh = 0.05 * pow(this->capacity_kW, -0.2) + 0.05;
133
134     return operation_maintenance_cost_kWh;
135 } /* __getGenericOpMaintCost() */
```

4.26.3.7 __writeSummary()

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

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

Parameters

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

Reimplemented from [Renewable](#).

```

319 {
320     // 1. create filestream
321     write_path += "summary_results.md";
322     std::ofstream ofs;
323     ofs.open(write_path, std::ofstream::out);
324
325     // 2. write summary results (markdown)
326     ofs << "# ";
327     ofs << std::to_string(int(ceil(this->capacity_kW)));
328     ofs << " kW WAVE Summary Results\n";
329     ofs << "\n-----\n\n";
330
331     // 2.1. Production attributes
332     ofs << "## Production Attributes\n";
333     ofs << "\n";
334
335     ofs << "Capacity: " << this->capacity_kW << "kW \n";
336     ofs << "\n";
337
338     ofs << "Sunk Cost (N = 0 / Y = 1): " << this->is_sunk << " \n";
339     ofs << "Capital Cost: " << this->capital_cost << " \n";
340     ofs << "Operation and Maintenance Cost: " << this->operation_maintenance_cost_kWh
341         << " per kWh produced \n";
342     ofs << "Nominal Inflation Rate (annual): " << this->nominal_inflation_annual
343         << " \n";
344     ofs << "Nominal Discount Rate (annual): " << this->nominal_discount_annual
345         << " \n";
346     ofs << "Real Discount Rate (annual): " << this->real_discount_annual << " \n";
347     ofs << "\n";
348
349     ofs << "Replacement Running Hours: " << this->replace_running_hrs << " \n";
350     ofs << "\n-----\n\n";
351
352     // 2.2. Renewable attributes
353     ofs << "## Renewable Attributes\n";
354     ofs << "\n";
355
356     ofs << "Resource Key (2D): " << this->resource_key << " \n";
357
358     ofs << "\n-----\n\n";
359
360     // 2.3. Wave attributes
361     ofs << "## Wave Attributes\n";
362     ofs << "\n";
363
364     ofs << "Power Production Model: " << this->power_model_string << " \n";
365     switch (this->power_model) {
366     case (WavePowerProductionModel :: WAVE_POWER_GAUSSIAN): {
367         ofs << "Design Significant Wave Height: "
368             << this->design_significant_wave_height_m << " m \n";
369
370         ofs << "Design Energy Period: " << this->design_energy_period_s << " s \n";
371
372         break;
373     }
374
375     case (WavePowerProductionModel :: WAVE_POWER_LOOKUP): {
376         ofs << "Normalized Performance Matrix: "
377             << this->interpolator.path_map_2D[0] << " \n";
378
379         break;
380     }
381
382     default: {
383         // write nothing!
384
385         break;
386     }
387     }
388
389     ofs << "\n-----\n\n";
390
391     // 2.4. Wave Results
392     ofs << "## Results\n";
393     ofs << "\n";
394
395     ofs << "Net Present Cost: " << this->net_present_cost << " \n";
396     ofs << "\n";
397
398     ofs << "Total Dispatch: " << this->total_dispatch_kWh
399         << " kWh \n";
400
401     ofs << "Levellized Cost of Energy: " << this->levellized_cost_of_energy_kWh
402         << " per kWh dispatched \n";
403     ofs << "\n";
404

```

```

405     ofs << "Running Hours: " << this->running_hours << " \n";
406     ofs << "Replacements: " << this->n_replacements << " \n";
407
408     ofs << "\n-----\n\n";
409
410     ofs.close();
411
412     return;
413 } /* __writeSummary() */

```

4.26.3.8 __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 ElectricalLoad .
<i>resource_map_1D_ptr</i>	A pointer to the 1D map of Resources .
<i>resource_map_2D_ptr</i>	A pointer to the 2D map of Resources .
<i>max_lines</i>	The maximum number of lines of output to write.

Reimplemented from [Renewable](#).

```

451 {
452     // 1. create filestream
453     write_path += "time_series_results.csv";
454     std::ofstream ofs;
455     ofs.open(write_path, std::ofstream::out);
456
457     // 2. write time series results (comma separated value)
458     ofs << "Time (since start of data) [hrs],";
459     ofs << "Significant Wave Height [m],";
460     ofs << "Energy Period [s],";
461     ofs << "Production [kW],";
462     ofs << "Dispatch [kW],";
463     ofs << "Storage [kW],";
464     ofs << "Curtailement [kW],";
465     ofs << "Capital Cost (actual),";
466     ofs << "Operation and Maintenance Cost (actual),";
467     ofs << "\n";
468
469     for (int i = 0; i < max_lines; i++) {
470         ofs << time_vec_hrs_ptr->at(i) << ",";
471         ofs << resource_map_2D_ptr->at(this->resource_key)[i][0] << ",";
472         ofs << resource_map_2D_ptr->at(this->resource_key)[i][1] << ",";
473         ofs << this->production_vec_kW[i] << ",";
474         ofs << this->dispatch_vec_kW[i] << ",";
475         ofs << this->storage_vec_kW[i] << ",";
476         ofs << this->curtailement_vec_kW[i] << ",";
477         ofs << this->capital_cost_vec[i] << ",";
478         ofs << this->operation_maintenance_cost_vec[i] << ",";
479         ofs << "\n";
480     }
481
482     return;
483 } /* __writeTimeSeries() */

```

4.26.3.9 commit()

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

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

Parameters

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

Returns

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

Reimplemented from [Renewable](#).

```
769 {
770     // 1. invoke base class method
771     load_kW = Renewable::commit(
772         timestep,
773         dt_hrs,
774         production_kW,
775         load_kW
776     );
777
778
779     //...
780
781     return load_kW;
782 } /* commit() */
```

4.26.3.10 computeProductionkW()

```
double Wave::computeProductionkW (
    int timestep,
    double dt_hrs,
    double significant_wave_height_m,
    double energy_period_s ) [virtual]
```

Method which takes in the wave resource at a particular point in time, and then returns the wave turbine production at that point in time.

Parameters

<i>timestep</i>	The timestep (i.e., time series index) for the request.
<i>dt_hrs</i>	The interval of time [hrs] associated with the timestep.
<i>signficiant_wave_height_m</i>	The significant wave height (wave statistic) [m].
<i>energy_period_s</i>	The energy period (wave statistic) [s].

Returns

The production [kW] of the wave turbine.

Reimplemented from [Renewable](#).

```

673 {
674     // check if no resource
675     if (significant_wave_height_m <= 0 or energy_period_s <= 0) {
676         return 0;
677     }
678
679     // compute production
680     double production_kW = 0;
681
682     switch (this->power_model) {
683         case (WavePowerProductionModel :: WAVE_POWER_PARABOLOID): {
684             production_kW = this->__computeParaboloidProductionkW(
685                 timestep,
686                 dt_hrs,
687                 significant_wave_height_m,
688                 energy_period_s
689             );
690
691             break;
692         }
693
694         case (WavePowerProductionModel :: WAVE_POWER_GAUSSIAN): {
695             production_kW = this->__computeGaussianProductionkW(
696                 timestep,
697                 dt_hrs,
698                 significant_wave_height_m,
699                 energy_period_s
700             );
701
702             break;
703         }
704
705         case (WavePowerProductionModel :: WAVE_POWER_LOOKUP): {
706             production_kW = this->__computeLookupProductionkW(
707                 timestep,
708                 dt_hrs,
709                 significant_wave_height_m,
710                 energy_period_s
711             );
712
713             break;
714         }
715
716         default: {
717             std::string error_str = "ERROR: Wave::computeProductionkW(): ";
718             error_str += "power model ";
719             error_str += std::to_string(this->power_model);
720             error_str += " not recognized";
721
722             #ifdef _WIN32
723                 std::cout << error_str << std::endl;
724             #endif
725
726             throw std::runtime_error(error_str);
727
728             break;
729         }
730     }
731
732     return production_kW;
733 } /* computeProductionkW() */

```

4.26.3.11 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 Model run.
-----------------	---

Reimplemented from [Renewable](#).

```

629 {
630     // 1. reset attributes
631     //...
632
633     // 2. invoke base class method
634     Renewable :: handleReplacement(timestep);
635
636     return;
637 } /* __handleReplacement() */

```

4.26.4 Member Data Documentation

4.26.4.1 design_energy_period_s

```
double Wave::design_energy_period_s
```

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

4.26.4.2 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.

4.26.4.3 power_model

```
WavePowerProductionModel Wave::power_model
```

The wave power production model to be applied.

4.26.4.4 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:

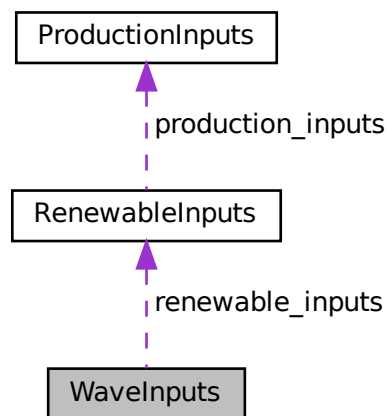
- header/Production/Renewable/[Wave.h](#)
- source/Production/Renewable/[Wave.cpp](#)

4.27 WaveInputs Struct Reference

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

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

Collaboration diagram for WaveInputs:



Public Attributes

- [RenewableInputs](#) `renewable_inputs`
An encapsulated [RenewableInputs](#) instance.
- `int` `resource_key` = 0
A key used to index into the [Resources](#) object, to associate this asset with the appropriate resource time series.
- `double` `capital_cost` = -1
The capital cost of the asset (undefined currency). -1 is a sentinel value, which triggers a generic cost model on construction (in fact, any negative value here will trigger). Note that the generic cost model is in terms of Canadian dollars [CAD].
- `double` `operation_maintenance_cost_kWh` = -1
The operation and maintenance cost of the asset [1/kWh] (undefined currency). This is a cost incurred per unit of energy produced. -1 is a sentinel value, which triggers a generic cost model on construction (in fact, any negative value here will trigger). Note that the generic cost model is in terms of Canadian dollars [CAD/kWh].
- `double` `design_significant_wave_height_m` = 3
The significant wave height [m] at which the wave energy converter achieves its rated capacity.
- `double` `design_energy_period_s` = 10
The energy period [s] at which the wave energy converter achieves its rated capacity.
- [WavePowerProductionModel](#) `power_model` = [WavePowerProductionModel](#) :: [WAVE_POWER_PARABOLOID](#)
The wave power production model to be applied.
- `std::string` `path_2_normalized_performance_matrix` = ""
A path (either relative or absolute) to a normalized performance matrix for the wave energy converter.

4.27.1 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](#).

4.27.2 Member Data Documentation

4.27.2.1 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].

4.27.2.2 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.

4.27.2.3 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.

4.27.2.4 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].

4.27.2.5 path_2_normalized_performance_matrix

```
std::string WaveInputs::path_2_normalized_performance_matrix = ""
```

A path (either relative or absolute) to a normalized performance matrix for the wave energy converter.

4.27.2.6 power_model

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

The wave power production model to be applied.

4.27.2.7 renewable_inputs

```
RenewableInputs WaveInputs::renewable_inputs
```

An encapsulated [RenewableInputs](#) instance.

4.27.2.8 resource_key

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

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

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

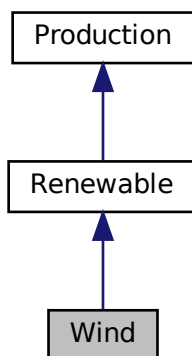
- [header/Production/Renewable/Wave.h](#)

4.28 Wind Class Reference

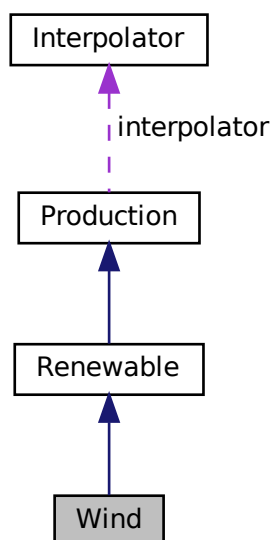
A derived class of the [Renewable](#) branch of [Production](#) which models wind production.

```
#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](#).

4.28.1 Detailed Description

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

4.28.2 Constructor & Destructor Documentation

4.28.2.1 Wind() [1/2]

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

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

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

4.28.2.2 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 Wind constructor inputs.

```
420 :
421 Renewable(
422     n_points,
423     n_years,
424     wind_inputs.renewable_inputs
425 )
426 {
427     // 1. check inputs
428     this->__checkInputs(wind_inputs);
429
430     // 2. set attributes
431     this->type = RenewableType :: WIND;
432     this->type_str = "WIND";
433
434     this->resource_key = wind_inputs.resource_key;
435
436     this->design_speed_ms = wind_inputs.design_speed_ms;
437
438     this->power_model = wind_inputs.power_model;
439
440     switch (this->power_model) {
441         case (WindPowerProductionModel :: WIND_POWER_EXPONENTIAL): {
442             this->power_model_string = "EXPONENTIAL";
443
444             break;
445         }
446
447         case (WindPowerProductionModel :: WIND_POWER_LOOKUP): {
448             this->power_model_string = "LOOKUP";
449
450             break;
451         }
452
453         default: {
```



```

454         std::string error_str = "ERROR: Wind(): ";
455         error_str += "power production model ";
456         error_str += std::to_string(this->power_model);
457         error_str += " not recognized";
458
459         #ifndef _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() */

```

4.28.2.3 ~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() */

```

4.28.3 Member Function Documentation

4.28.3.1 __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 Wind constructor inputs.
--------------------	---

```

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

```

4.28.3.2 __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 Model 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() */

```

4.28.3.3 __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 Model 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() */
```

4.28.3.4 __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() */
```

4.28.3.5 __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() */
```

4.28.3.6 `__writeSummary()`

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

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

Parameters

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

Reimplemented from [Renewable](#).

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

```

278     }
279
280     ofs << "\n-----\n\n";
281
282     // 2.4. Wind Results
283     ofs << "## Results\n";
284     ofs << "\n";
285
286     ofs << "Net Present Cost: " << this->net_present_cost << " \n";
287     ofs << "\n";
288
289     ofs << "Total Dispatch: " << this->total_dispatch_kWh
290         << " kWh \n";
291
292     ofs << "Levellized Cost of Energy: " << this->levellized_cost_of_energy_kWh
293         << " per kWh dispatched \n";
294     ofs << "\n";
295
296     ofs << "Running Hours: " << this->running_hours << " \n";
297     ofs << "Replacements: " << this->n_replacements << " \n";
298
299     ofs << "\n-----\n\n";
300
301     ofs.close();
302
303     return;
304 } /* __writeSummary() */

```

4.28.3.7 __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 ElectricalLoad .
<i>resource_map_1D_ptr</i>	A pointer to the 1D map of Resources .
<i>resource_map_2D_ptr</i>	A pointer to the 2D map of Resources .
<i>max_lines</i>	The maximum number of lines of output to write.

Reimplemented from [Renewable](#).

```

342 {
343     // 1. create filestream
344     write_path += "time_series_results.csv";
345     std::ofstream ofs;
346     ofs.open(write_path, std::ofstream::out);
347
348     // 2. write time series results (comma separated value)
349     ofs << "Time (since start of data) [hrs],";
350     ofs << "Wind Resource [m/s],";
351     ofs << "Production [kW],";
352     ofs << "Dispatch [kW],";
353     ofs << "Storage [kW],";
354     ofs << "Curtailement [kW],";
355     ofs << "Capital Cost (actual),";
356     ofs << "Operation and Maintenance Cost (actual),";
357     ofs << "\n";
358
359     for (int i = 0; i < max_lines; i++) {

```

```

360         ofs « time_vec_hrs_ptr->at(i) « ",";
361         ofs « resource_map_ID_ptr->at(this->resource_key)[i] « ",";
362         ofs « this->production_vec_kW[i] « ",";
363         ofs « this->dispatch_vec_kW[i] « ",";
364         ofs « this->storage_vec_kW[i] « ",";
365         ofs « this->curtailment_vec_kW[i] « ",";
366         ofs « this->capital_cost_vec[i] « ",";
367         ofs « this->operation_maintenance_cost_vec[i] « ",";
368         ofs « "\n";
369     }
370
371     return;
372 } /* __writeTimeSeries() */

```

4.28.3.8 commit()

```

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

```

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

Parameters

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

Returns

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

Reimplemented from [Renewable](#).

```

628 {
629     // 1. invoke base class method
630     load_kW = Renewable::commit(
631         timestep,
632         dt_hrs,
633         production_kW,
634         load_kW
635     );
636
637     //...
638
639     return load_kW;
640 } /* commit() */
641 }

```

4.28.3.9 computeProductionkW()

```

double Wind::computeProductionkW (
    int timestep,

```

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

Method which takes in the wind resource at a particular point in time, and then returns the wind turbine production at that point in time.

Parameters

<i>timestep</i>	The timestep (i.e., time series index) for the request.
<i>dt_hrs</i>	The interval of time [hrs] associated with the timestep.
<i>wind_resource_ms</i>	Wind 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() */

```

4.28.3.10 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 Model 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() */
```

4.28.4 Member Data Documentation

4.28.4.1 design_speed_ms

```
double Wind::design_speed_ms
```

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

4.28.4.2 power_model

```
WindPowerProductionModel Wind::power_model
```

The wind power production model to be applied.

4.28.4.3 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:

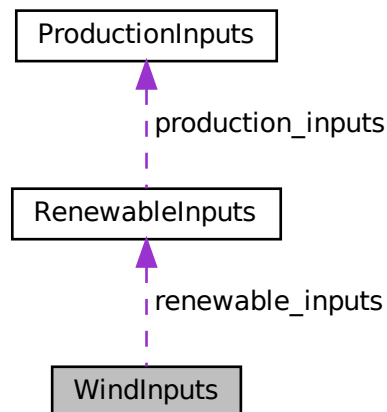
- header/Production/Renewable/[Wind.h](#)
- source/Production/Renewable/[Wind.cpp](#)

4.29 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.

4.29.1 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](#).

4.29.2 Member Data Documentation

4.29.2.1 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].

4.29.2.2 design_speed_ms

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

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

4.29.2.3 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].

4.29.2.4 power_model

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

The wind power production model to be applied.

4.29.2.5 renewable_inputs

```
RenewableInputs WindInputs::renewable_inputs
```

An encapsulated [RenewableInputs](#) instance.

4.29.2.6 resource_key

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

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

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

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

Chapter 5

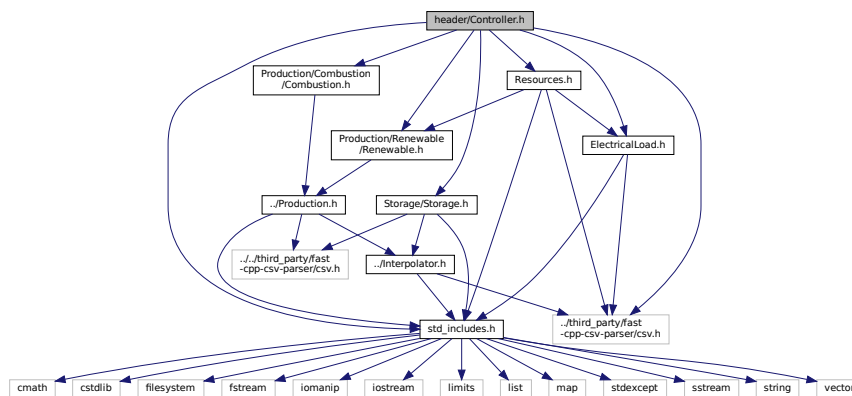
File Documentation

5.1 header/Controller.h File Reference

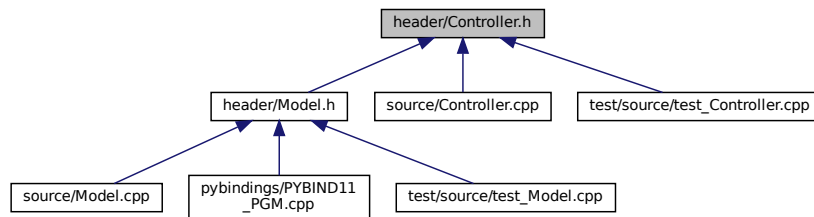
Header file for the [Controller](#) class.

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

Include dependency graph for Controller.h:



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



Classes

- class [Controller](#)

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

Enumerations

- enum [ControlMode](#) { [LOAD_FOLLOWING](#) , [CYCLE_CHARGING](#) , [N_CONTROL_MODES](#) }

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

5.1.1 Detailed Description

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

5.1.2 Enumeration Type Documentation

5.1.2.1 ControlMode

enum [ControlMode](#)

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

Enumerator

LOAD_FOLLOWING	Load following control, with in-order dispatch of non-Combustion assets and optimal dispatch of Combustion assets.
CYCLE_CHARGING	Cycle charging control, with in-order dispatch of non-Combustion assets and optimal dispatch of Combustion assets.
N_CONTROL_MODES	A simple hack to get the number of elements in ControlMode.

```

43     {
44         LOAD\_FOLLOWING,

```

```

45     CYCLE_CHARGING,
46     N_CONTROL_MODES
47 };

```

5.2 header/doxygen_cite.h File Reference

Header file which simply cites the doxygen tool.

5.2.1 Detailed Description

Header file which simply cites the doxygen tool.

Ref: [van Heesch. \[2023\]](#)

5.3 header/ElectricalLoad.h File Reference

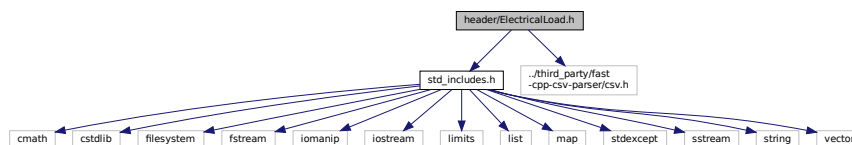
Header file for the [ElectricalLoad](#) class.

```

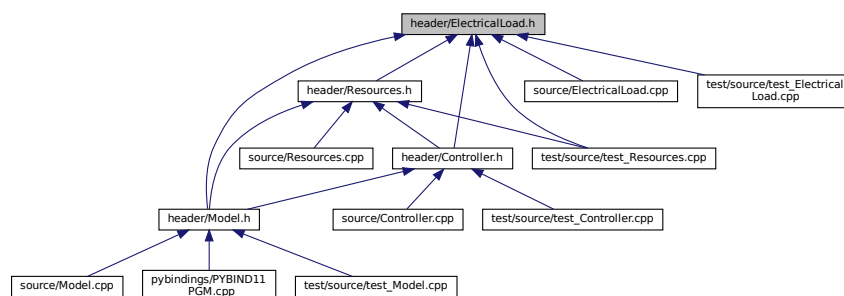
#include "std_includes.h"
#include "../third_party/fast-cpp-csv-parser/csv.h"

```

Include dependency graph for ElectricalLoad.h:



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



Classes

- class [ElectricalLoad](#)

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

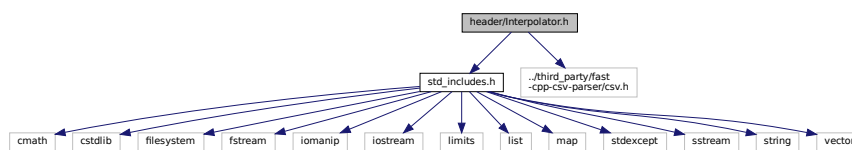
5.3.1 Detailed Description

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

5.4 header/Interpolator.h File Reference

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

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



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



Classes

- struct [InterpolatorStruct1D](#)
A struct which holds two parallel vectors for use in 1D interpolation.
- struct [InterpolatorStruct2D](#)
A struct which holds two parallel vectors and a matrix for use in 2D interpolation.
- class [Interpolator](#)
A class which contains interpolation data and functionality. Intended to serve as a component of the [Production](#) and [Storage](#) hierarchies.

5.4.1 Detailed Description

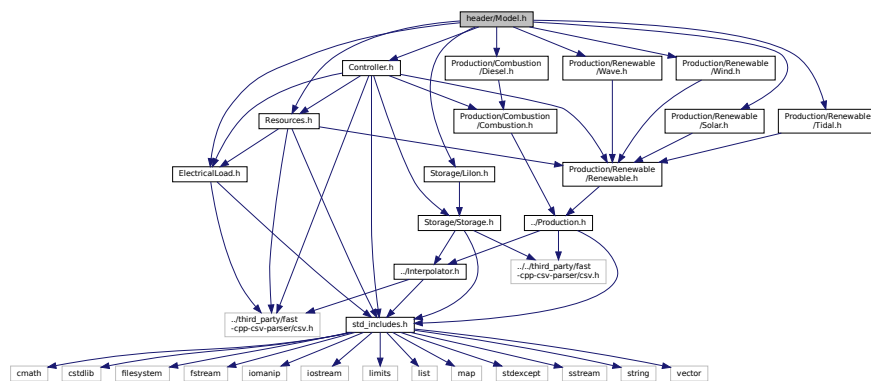
Header file for the [Interpolator](#) class.

5.5 header/Model.h File Reference

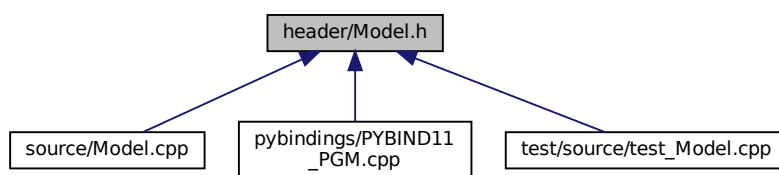
Header file for the [Model](#) class.

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

Include dependency graph for Model.h:



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



Classes

- struct [ModellInputs](#)

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

- class [Model](#)

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

5.5.1 Detailed Description

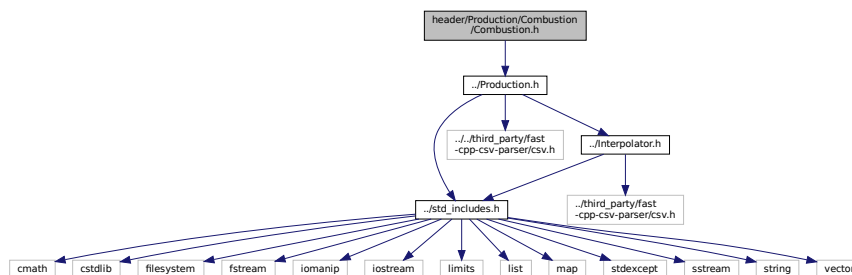
Header file for the [Model](#) class.

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

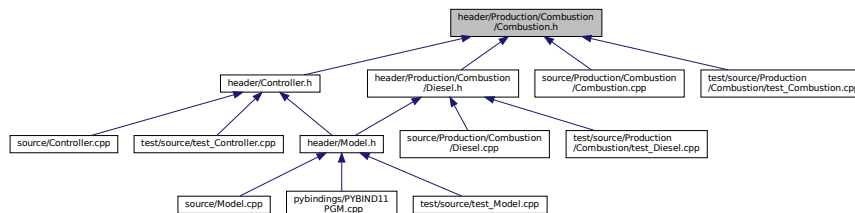
Header file for the [Combustion](#) class.

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

Include dependency graph for Combustion.h:



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



Classes

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

Enumerations

- enum [CombustionType](#) { [DIESEL](#) , [N_COMBUSTION_TYPES](#) }
An enumeration of the types of [Combustion](#) asset supported by PGMcpp.
- enum [FuelMode](#) { [FUEL_MODE_LINEAR](#) , [FUEL_MODE_LOOKUP](#) , [N_FUEL_MODES](#) }
An enumeration of the fuel modes for the [Combustion](#) asset which are supported by PGMcpp.

5.6.1 Detailed Description

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

5.6.2 Enumeration Type Documentation

5.6.2.1 CombustionType

enum [CombustionType](#)

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

Enumerator

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

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

5.6.2.2 FuelMode

enum [FuelMode](#)

An enumeration of the fuel modes for the [Combustion](#) asset which are supported by PGMcpp.

Enumerator

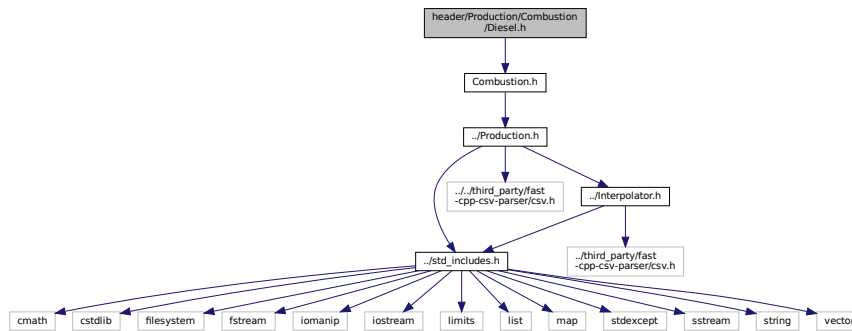
FUEL_MODE_LINEAR	A linearized fuel curve model (i.e., HOMER-like model)
FUEL_MODE_LOOKUP	Interpolating over a given fuel lookup table.
N_FUEL_MODES	A simple hack to get the number of elements in FuelMode.

```
46     {
47     FUEL_MODE_LINEAR,
48     FUEL_MODE_LOOKUP,
49     N_FUEL_MODES
50 };
```

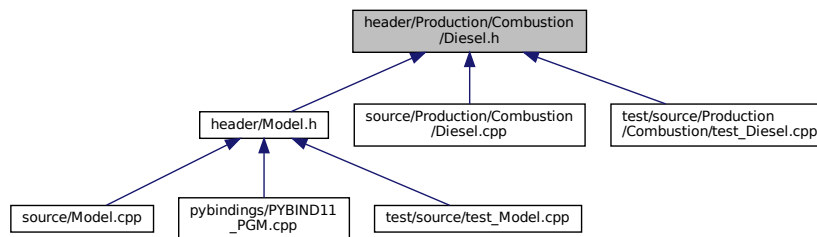
5.7 header/Production/Combustion/Diesel.h File Reference

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

```
#include "Combustion.h"
Include dependency graph for Diesel.h:
```



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



Classes

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

5.7.1 Detailed Description

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

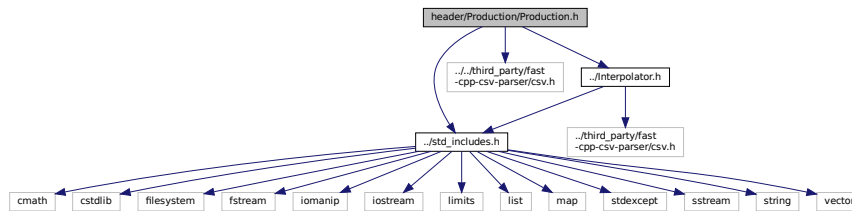
5.8 header/Production/Production.h File Reference

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

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

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

Include dependency graph for Production.h:



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



Classes

- struct [ProductionInputs](#)
A structure which bundles the necessary inputs for the [Production](#) constructor. Provides default values for every necessary input.
- class [Production](#)
The base class of the [Production](#) hierarchy. This hierarchy contains derived classes which model the production of energy, be it renewable or otherwise.

5.8.1 Detailed Description

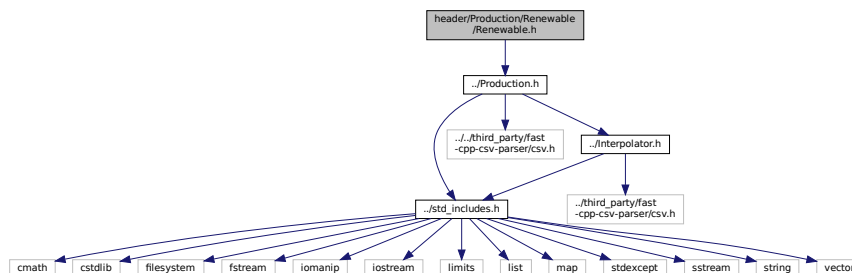
Header file for the [Production](#) class.

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

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

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

Include dependency graph for Renewable.h:




```

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

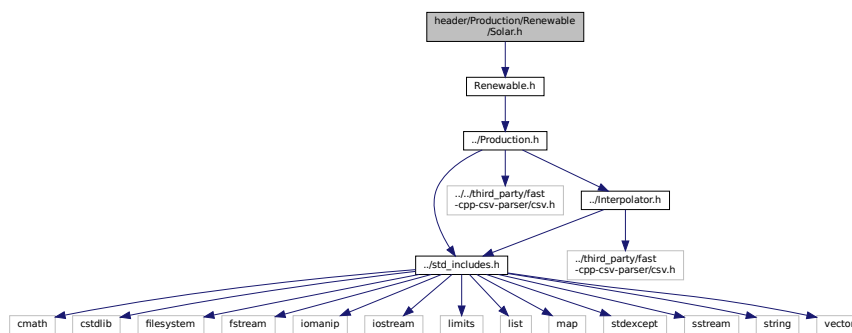
```

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

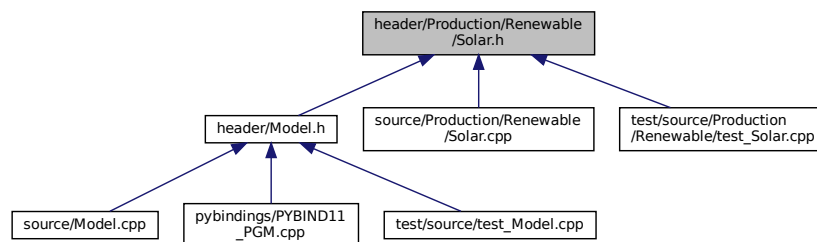
Header file for the [Solar](#) class.

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

Include dependency graph for Solar.h:



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



Classes

- struct [SolarInputs](#)

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

- class [Solar](#)

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

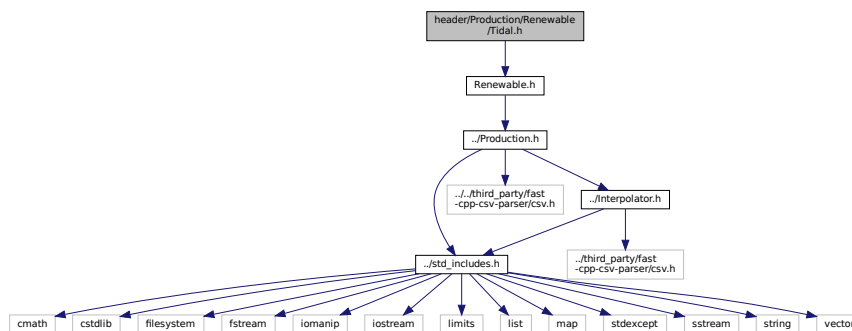
5.10.1 Detailed Description

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

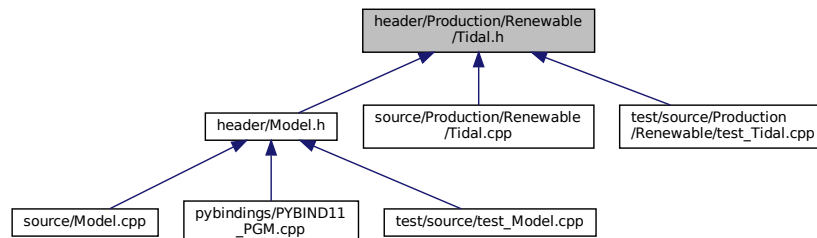
5.11 header/Production/Renewable/Tidal.h File Reference

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

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



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



Classes

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

Enumerations

- enum [TidalPowerProductionModel](#) { [TIDAL_POWER_CUBIC](#) , [TIDAL_POWER_EXPONENTIAL](#) , [TIDAL_POWER_LOOKUP](#) , [N_TIDAL_POWER_PRODUCTION_MODELS](#) }

5.11.1 Detailed Description

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

5.11.2 Enumeration Type Documentation

5.11.2.1 TidalPowerProductionModel

```
enum TidalPowerProductionModel
```

Enumerator

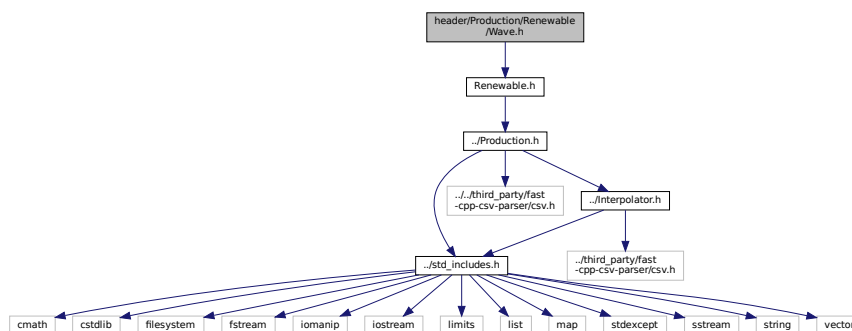
TIDAL_POWER_CUBIC	A cubic power production model.
TIDAL_POWER_EXPONENTIAL	An exponential power production model.
TIDAL_POWER_LOOKUP	Lookup from a given set of power curve data.
N_TIDAL_POWER_PRODUCTION_MODELS	A simple hack to get the number of elements in TidalPowerProductionModel.

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

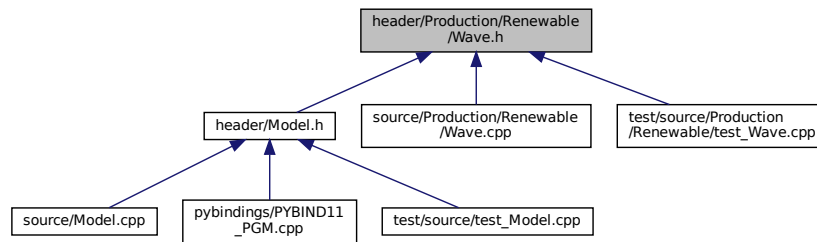
5.12 header/Production/Renewable/Wave.h File Reference

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

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



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



Classes

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

Enumerations

- enum [WavePowerProductionModel](#) { [WAVE_POWER_GAUSSIAN](#) , [WAVE_POWER_PARABOLOID](#) , [WAVE_POWER_LOOKUP](#) , [N_WAVE_POWER_PRODUCTION_MODELS](#) }

5.12.1 Detailed Description

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

5.12.2 Enumeration Type Documentation

5.12.2.1 WavePowerProductionModel

enum [WavePowerProductionModel](#)

Enumerator

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

```

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

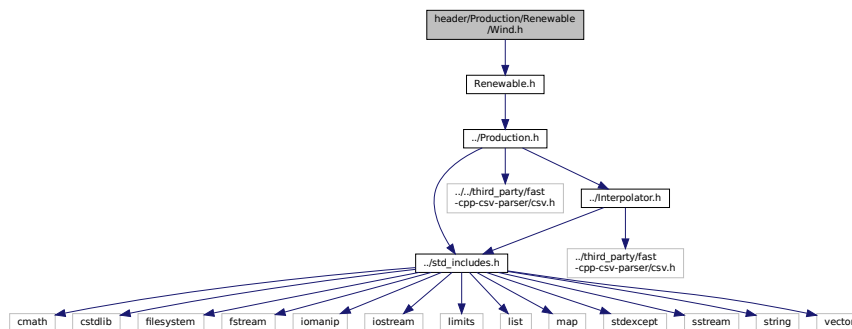
```

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

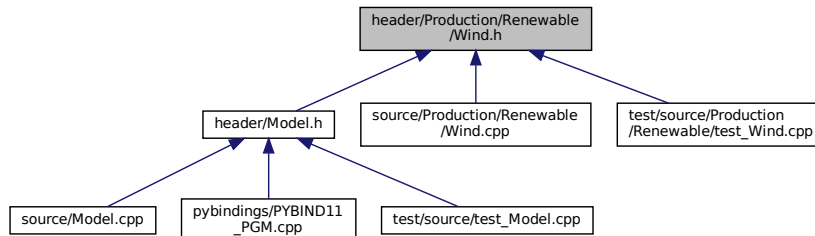
Header file for the [Wind](#) class.

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

Include dependency graph for Wind.h:



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



Classes

- struct [WindInputs](#)

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

- class [Wind](#)

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

Enumerations

- enum [WindPowerProductionModel](#) { [WIND_POWER_EXPONENTIAL](#) , [WIND_POWER_LOOKUP](#) , [N_WIND_POWER_PRODUCTION_MODELS](#) }

5.13.1 Detailed Description

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

5.13.2 Enumeration Type Documentation

5.13.2.1 WindPowerProductionModel

```
enum WindPowerProductionModel
```

Enumerator

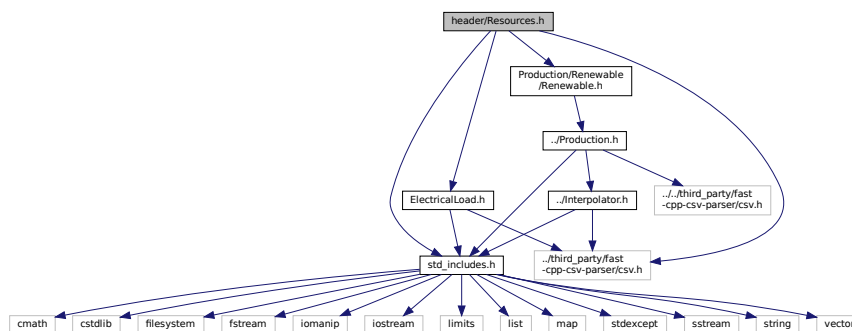
WIND_POWER_EXPONENTIAL	An exponential power production model.
WIND_POWER_LOOKUP	Lookup from a given set of power curve data.
N_WIND_POWER_PRODUCTION_MODELS	A simple hack to get the number of elements in WindPowerProductionModel .

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

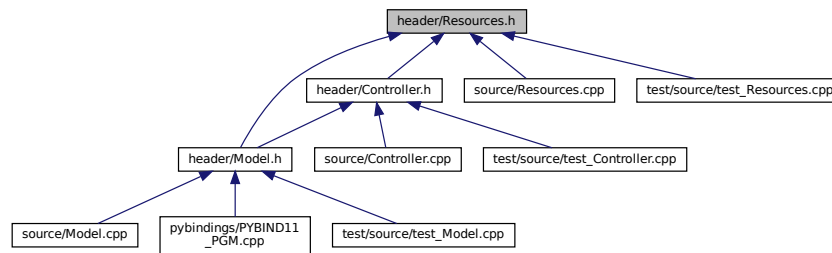
5.14 header/Resources.h File Reference

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

```
#include "std_includes.h"
#include "../third_party/fast-cpp-csv-parser/csv.h"
#include "ElectricalLoad.h"
#include "Production/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](#).

5.14.1 Detailed Description

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

5.15 header/std_includes.h File Reference

Header file which simply batches together some standard includes.

```

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

```

Include dependency graph for std_includes.h:



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



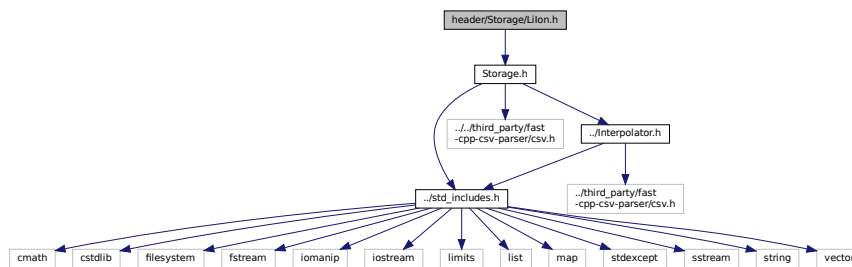
5.15.1 Detailed Description

Header file which simply batches together some standard includes.

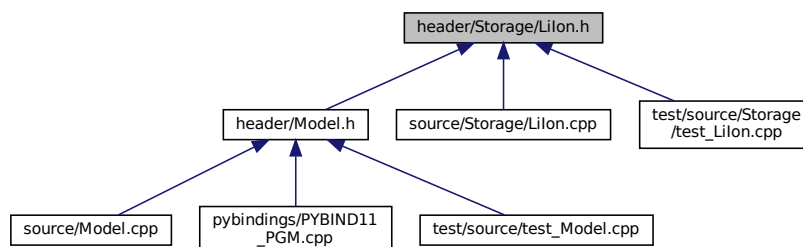
5.16 header/Storage/Lilon.h File Reference

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

```
#include "Storage.h"
Include dependency graph for Lilon.h:
```



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



Classes

- struct [LilonInputs](#)

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

- class [Lilon](#)

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

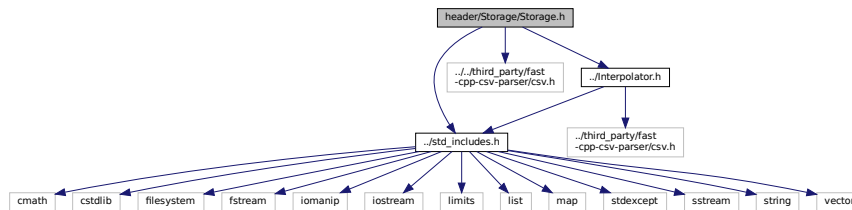
5.16.1 Detailed Description

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

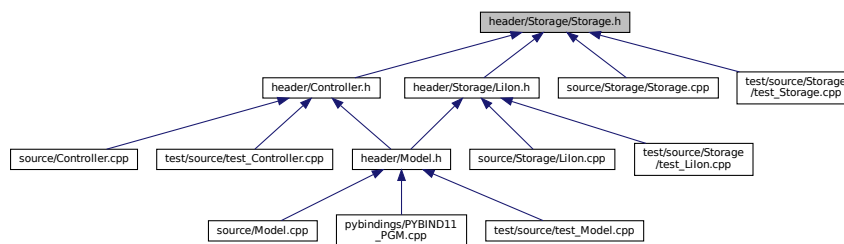
5.17 header/Storage/Storage.h File Reference

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

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



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



Classes

- struct [StorageInputs](#)
A structure which bundles the necessary inputs for the [Storage](#) constructor. Provides default values for every necessary input.
- class [Storage](#)
The base class of the [Storage](#) hierarchy. This hierarchy contains derived classes which model the storage of energy.

Enumerations

- enum [StorageType](#) { [LIION](#) , [N_STORAGE_TYPES](#) }
An enumeration of the types of [Storage](#) asset supported by PGMcpp.

5.17.1 Detailed Description

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

5.17.2 Enumeration Type Documentation

5.17.2.1 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.

```

36         {
37     LIION,
38     N_STORAGE_TYPES
39 };

```

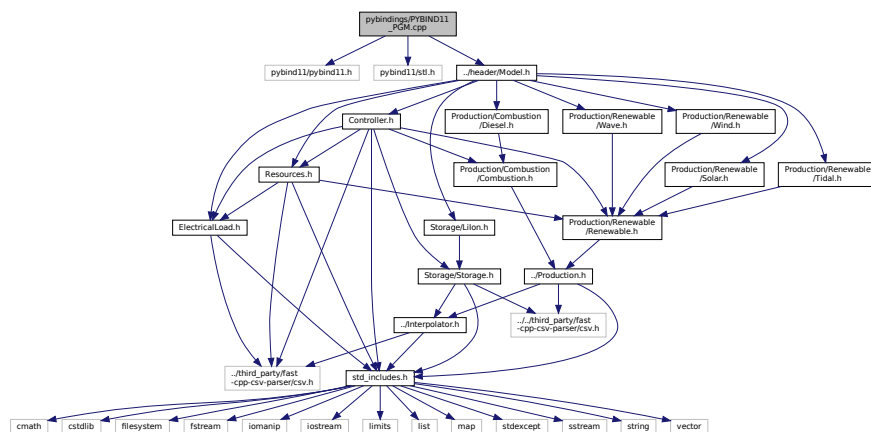
5.18 pybindings/PYBIND11_PGM.cpp File Reference

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)

5.18.1 Detailed Description

Bindings file for PGMcpp.

Ref: [Jakob \[2023\]](#)

A file which instructs pybind11 how to build Python bindings for PGMcpp.

5.18.2 Function Documentation

5.18.2.1 PYBIND11_MODULE()

```
PYBIND11_MODULE (
    PGMcpp ,
    m )
{
30
31
32     // ...
33
34 } /* PYBIND11_MODULE() */
```

5.19 pybindings/snippets/Production/Combustion/PYBIND11_Combustion.cpp File Reference

Bindings file for the [Combustion](#) class. Intended to be #include'd in [PYBIND11_PGM.cpp](#).

5.19.1 Detailed Description

Bindings file for the [Combustion](#) class. Intended to be #include'd in [PYBIND11_PGM.cpp](#).

Ref: [Jakob \[2023\]](#)

A file which instructs pybind11 how to build Python bindings for the [Combustion](#) class.

5.20 pybindings/snippets/Production/Combustion/PYBIND11_Diesel.cpp File Reference

Bindings file for the [Diesel](#) class. Intended to be #include'd in [PYBIND11_PGM.cpp](#).

5.20.1 Detailed Description

Bindings file for the [Diesel](#) class. Intended to be #include'd in [PYBIND11_PGM.cpp](#).

Ref: [Jakob \[2023\]](#)

A file which instructs pybind11 how to build Python bindings for the [Diesel](#) class.

5.21 pybindings/snippets/Production/PYBIND11_Production.cpp File Reference

Bindings file for the [Production](#) class. Intended to be #include'd in [PYBIND11_PGM.cpp](#).

5.21.1 Detailed Description

Bindings file for the [Production](#) class. Intended to be #include'd in [PYBIND11_PGM.cpp](#).

Ref: [Jakob \[2023\]](#)

A file which instructs pybind11 how to build Python bindings for the [Production](#) class.

5.22 pybindings/snippets/Production/Renewable/PYBIND11_↔Renewable.cpp File Reference

Bindings file for the [Renewable](#) class. Intended to be #include'd in [PYBIND11_PGM.cpp](#).

5.22.1 Detailed Description

Bindings file for the [Renewable](#) class. Intended to be #include'd in [PYBIND11_PGM.cpp](#).

Ref: [Jakob \[2023\]](#)

A file which instructs pybind11 how to build Python bindings for the [Renewable](#) class.

5.23 pybindings/snippets/Production/Renewable/PYBIND11_Solar.cpp File Reference

Bindings file for the [Solar](#) class. Intended to be #include'd in [PYBIND11_PGM.cpp](#).

5.23.1 Detailed Description

Bindings file for the [Solar](#) class. Intended to be #include'd in [PYBIND11_PGM.cpp](#).

Ref: [Jakob \[2023\]](#)

A file which instructs pybind11 how to build Python bindings for the [Solar](#) class.

5.24 pybindings/snippets/Production/Renewable/PYBIND11_Tidal.cpp File Reference

Bindings file for the [Tidal](#) class. Intended to be #include'd in [PYBIND11_PGM.cpp](#).

5.24.1 Detailed Description

Bindings file for the [Tidal](#) class. Intended to be #include'd in [PYBIND11_PGM.cpp](#).

Ref: [Jakob \[2023\]](#)

A file which instructs pybind11 how to build Python bindings for the [Tidal](#) class.

5.25 pybindings/snippets/Production/Renewable/PYBIND11_Wave.cpp File Reference

Bindings file for the [Wave](#) class. Intended to be #include'd in [PYBIND11_PGM.cpp](#).

5.25.1 Detailed Description

Bindings file for the [Wave](#) class. Intended to be #include'd in [PYBIND11_PGM.cpp](#).

Ref: [Jakob \[2023\]](#)

A file which instructs pybind11 how to build Python bindings for the [Wave](#) class.

5.26 pybindings/snippets/Production/Renewable/PYBIND11_Wind.cpp File Reference

Bindings file for the [Wind](#) class. Intended to be #include'd in [PYBIND11_PGM.cpp](#).

5.26.1 Detailed Description

Bindings file for the [Wind](#) class. Intended to be #include'd in [PYBIND11_PGM.cpp](#).

Ref: [Jakob \[2023\]](#)

A file which instructs pybind11 how to build Python bindings for the [Wind](#) class.

5.27 pybindings/snippets/PYBIND11_Controller.cpp File Reference

Bindings file for the [Controller](#) class. Intended to be #include'd in [PYBIND11_PGM.cpp](#).

5.27.1 Detailed Description

Bindings file for the [Controller](#) class. Intended to be #include'd in [PYBIND11_PGM.cpp](#).

Ref: [Jakob \[2023\]](#)

A file which instructs pybind11 how to build Python bindings for the [Controller](#) class.

5.28 pybindings/snippets/PYBIND11_ElectricalLoad.cpp File Reference

Bindings file for the [ElectricalLoad](#) class. Intended to be #include'd in [PYBIND11_PGM.cpp](#).

5.28.1 Detailed Description

Bindings file for the [ElectricalLoad](#) class. Intended to be #include'd in [PYBIND11_PGM.cpp](#).

Ref: [Jakob \[2023\]](#)

A file which instructs pybind11 how to build Python bindings for the [ElectricalLoad](#) class.

5.29 pybindings/snippets/PYBIND11_Interpolator.cpp File Reference

Bindings file for the [Interpolator](#) class. Intended to be #include'd in [PYBIND11_PGM.cpp](#).

5.29.1 Detailed Description

Bindings file for the [Interpolator](#) class. Intended to be #include'd in [PYBIND11_PGM.cpp](#).

Ref: [Jakob \[2023\]](#)

A file which instructs pybind11 how to build Python bindings for the [Interpolator](#) class.

5.30 pybindings/snippets/PYBIND11_Model.cpp File Reference

Bindings file for the [Model](#) class. Intended to be #include'd in [PYBIND11_PGM.cpp](#).

5.30.1 Detailed Description

Bindings file for the [Model](#) class. Intended to be #include'd in [PYBIND11_PGM.cpp](#).

Ref: [Jakob \[2023\]](#)

A file which instructs pybind11 how to build Python bindings for the [Model](#) class.

5.31 pybindings/snippets/PYBIND11_Resources.cpp File Reference

Bindings file for the [Resources](#) class. Intended to be #include'd in [PYBIND11_PGM.cpp](#).

5.31.1 Detailed Description

Bindings file for the [Resources](#) class. Intended to be #include'd in [PYBIND11_PGM.cpp](#).

Ref: [Jakob \[2023\]](#)

A file which instructs pybind11 how to build Python bindings for the [Resources](#) class.

5.32 pybindings/snippets/Storage/PYBIND11_Lilon.cpp File Reference

Bindings file for the [Lilon](#) class. Intended to be #include'd in [PYBIND11_PGM.cpp](#).

5.32.1 Detailed Description

Bindings file for the [Lilon](#) class. Intended to be #include'd in [PYBIND11_PGM.cpp](#).

Ref: [Jakob \[2023\]](#)

A file which instructs pybind11 how to build Python bindings for the [Lilon](#) class.

5.33 pybindings/snippets/Storage/PYBIND11_Storage.cpp File Reference

Bindings file for the [Storage](#) class. Intended to be #include'd in [PYBIND11_PGM.cpp](#).

5.33.1 Detailed Description

Bindings file for the [Storage](#) class. Intended to be #include'd in [PYBIND11_PGM.cpp](#).

Ref: [Jakob \[2023\]](#)

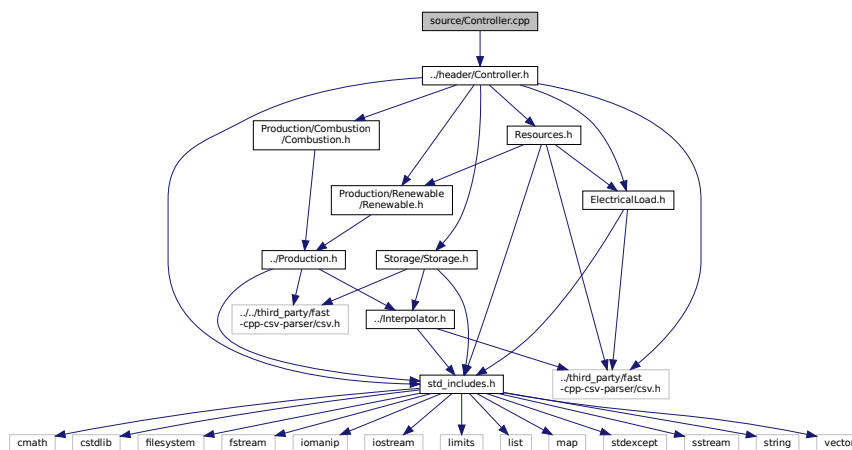
A file which instructs pybind11 how to build Python bindings for the [Storage](#) class.

5.34 source/Controller.cpp File Reference

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

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

Include dependency graph for Controller.cpp:



5.34.1 Detailed Description

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

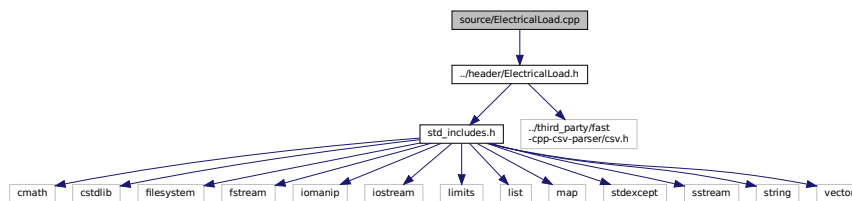
A class which contains a various dispatch control logic. Intended to serve as a component class of [Controller](#).

5.35 source/ElectricalLoad.cpp File Reference

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

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

Include dependency graph for ElectricalLoad.cpp:



5.35.1 Detailed Description

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

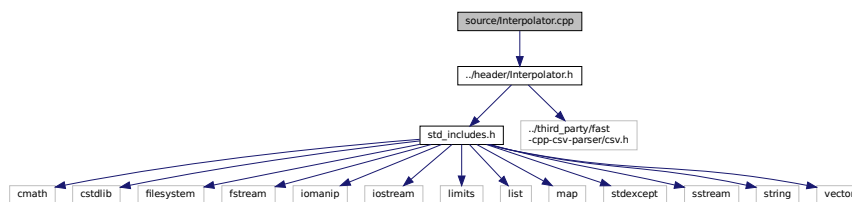
A class which contains time and electrical load data. Intended to serve as a component class of [Model](#).

5.36 source/Interpolator.cpp File Reference

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

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

Include dependency graph for Interpolator.cpp:



5.36.1 Detailed Description

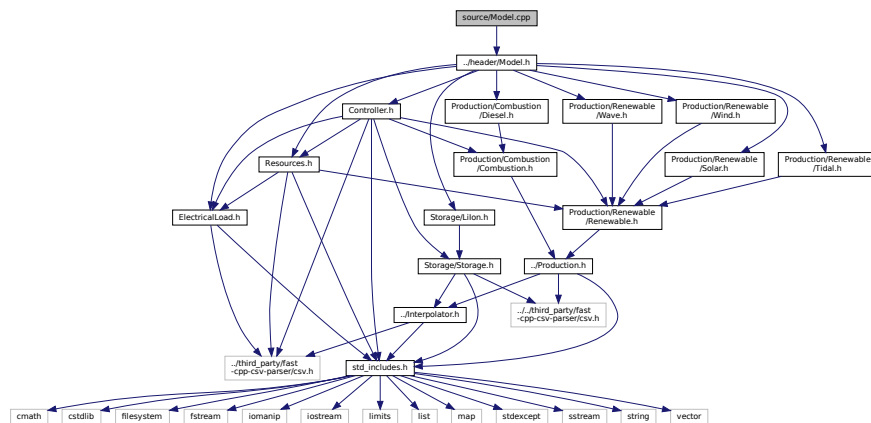
Implementation file for the [Interpolator](#) class.

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

5.37 source/Model.cpp File Reference

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

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



5.37.1 Detailed Description

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

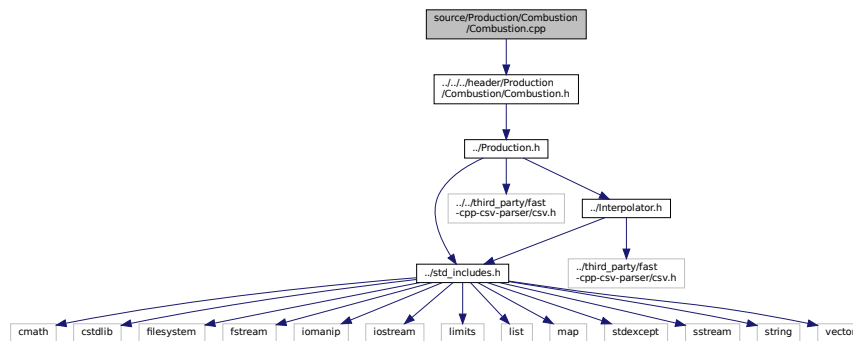
A container class which forms the centre of PGMcpp. The [Model](#) class is intended to serve as the primary user interface with the functionality of PGMcpp, and as such it contains all other classes.

5.38 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:



5.38.1 Detailed Description

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

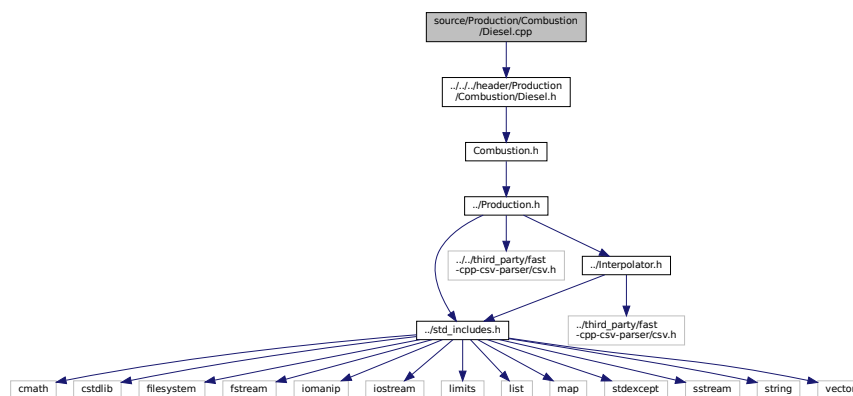
The root of the [Combustion](#) branch of the [Production](#) hierarchy. This branch contains derived classes which model the production of energy by way of combustibles.

5.39 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:



5.39.1 Detailed Description

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

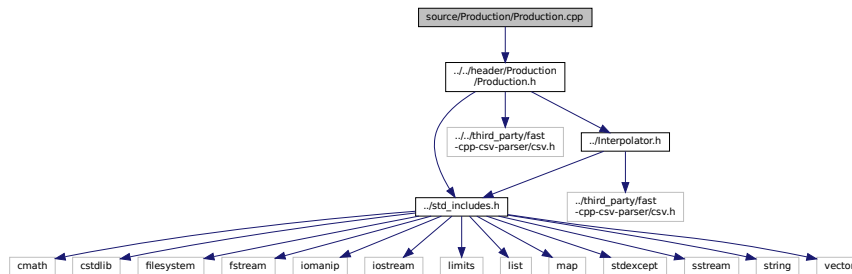
A derived class of the [Combustion](#) branch of [Production](#) which models production using a diesel generator.

5.40 source/Production/Production.cpp File Reference

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

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

Include dependency graph for Production.cpp:



5.40.1 Detailed Description

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

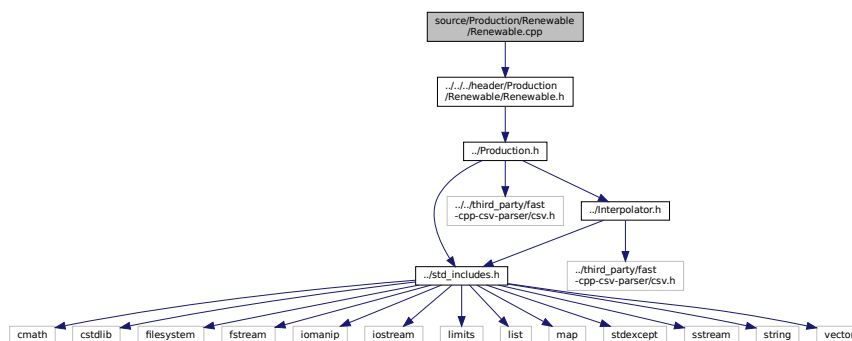
The base class of the [Production](#) hierarchy. This hierarchy contains derived classes which model the production of energy, be it renewable or otherwise.

5.41 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:



5.41.1 Detailed Description

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

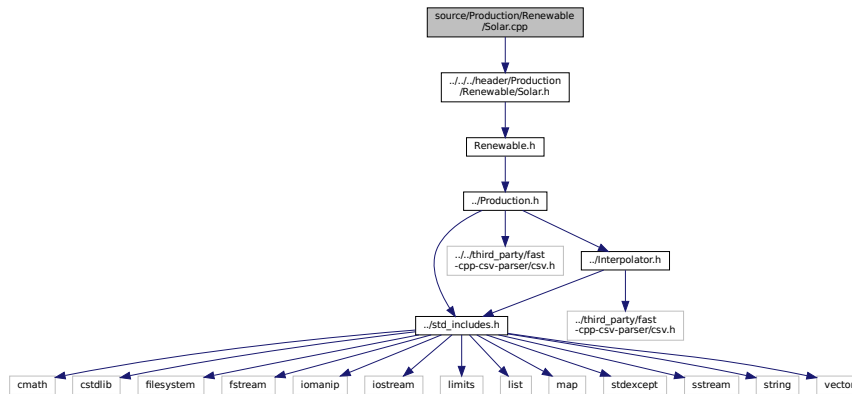
The root of the [Renewable](#) branch of the [Production](#) hierarchy. This branch contains derived classes which model the renewable production of energy.

5.42 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:



5.42.1 Detailed Description

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

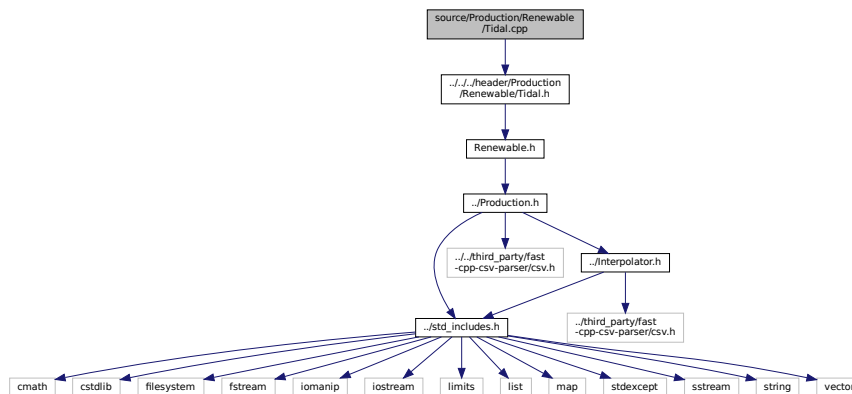
A derived class of the [Renewable](#) branch of [Production](#) which models solar production.

5.43 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:



5.43.1 Detailed Description

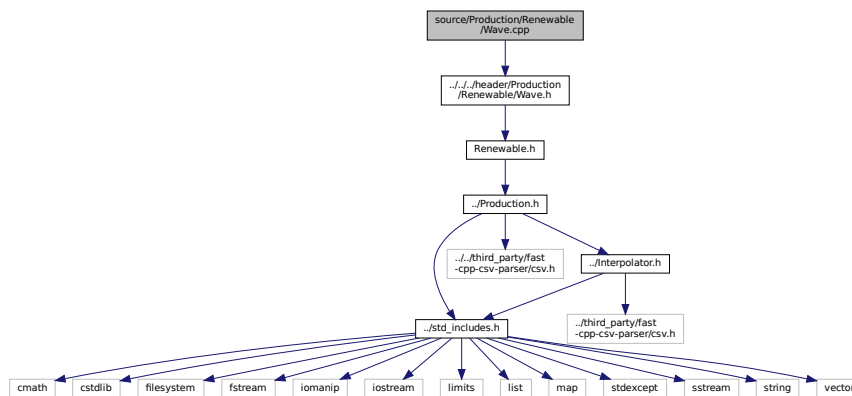
Implementation file for the [Tidal](#) class.

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

5.44 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:
```



5.44.1 Detailed Description

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

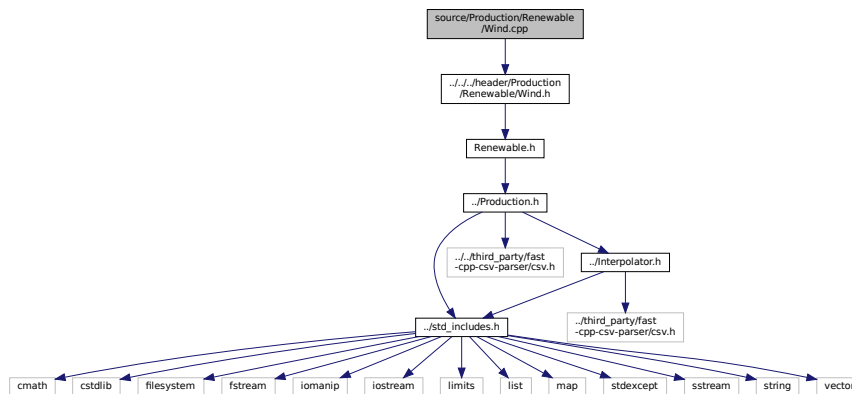
A derived class of the [Renewable](#) branch of [Production](#) which models wave production.

5.45 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:



5.45.1 Detailed Description

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

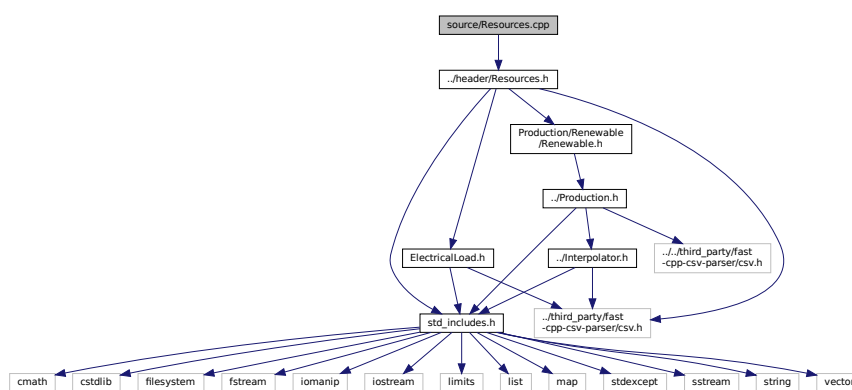
A derived class of the [Renewable](#) branch of [Production](#) which models wind production.

5.46 source/Resources.cpp File Reference

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

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

Include dependency graph for Resources.cpp:



5.46.1 Detailed Description

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

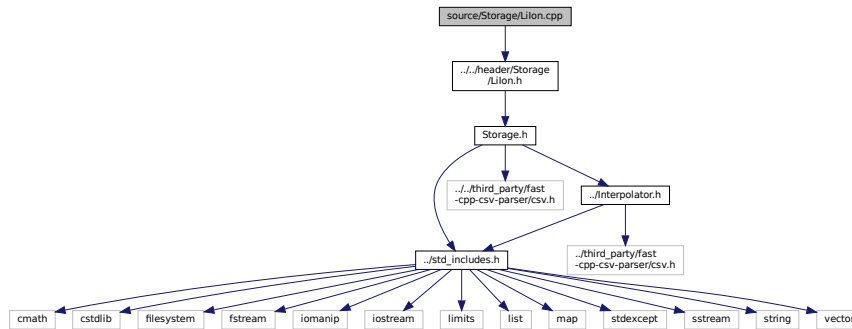
A class which contains renewable resource data. Intended to serve as a component class of [Model](#).

5.47 source/Storage/Lilon.cpp File Reference

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

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

Include dependency graph for Lilon.cpp:



5.47.1 Detailed Description

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

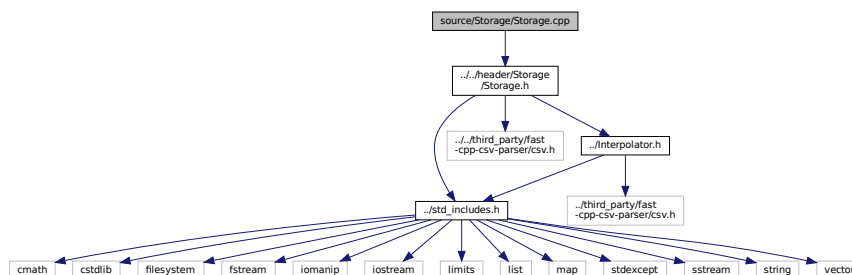
A derived class of [Storage](#) which models energy storage by way of lithium-ion batteries.

5.48 source/Storage/Storage.cpp File Reference

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

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

Include dependency graph for Storage.cpp:



5.48.1 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.

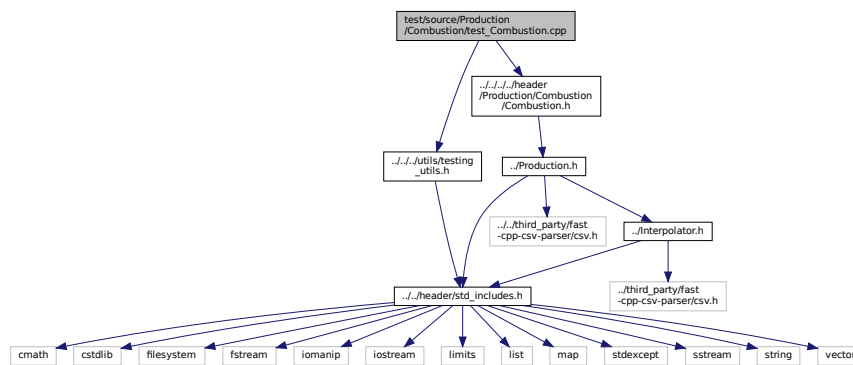
5.49 test/source/Production/Combustion/test_Combustion.cpp File Reference

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)

5.49.1 Detailed Description

Testing suite for [Combustion](#) class.

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

5.49.2 Function Documentation

5.49.2.1 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;

```


5.50.2.1 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     Combustion* test_diesel_ptr;
37
38     try {
39 // ===== CONSTRUCTION ===== //
40
41 bool error_flag = true;
42
43     try {
44         DieselInputs bad_diesel_inputs;
45         bad_diesel_inputs.fuel_cost_L = -1;
46
47         Diesel bad_diesel(8760, 1, bad_diesel_inputs);
48
49         error_flag = false;
50     } catch (...) {
51         // Task failed successfully! =P
52     }
53
54     if (not error_flag) {
55         expectedErrorNotDetected(__FILE__, __LINE__);
56     }
57
58     DieselInputs diesel_inputs;
59
60     test_diesel_ptr = new Diesel(8760, 1, diesel_inputs);
61
62
63     diesel_inputs.combustion_inputs.fuel_mode = FuelMode :: FUEL_MODE_LOOKUP;
64     diesel_inputs.combustion_inputs.path_2_fuel_interp_data =
65         "data/test/interpolation/diesel_fuel_curve.csv";
66
67     Diesel test_diesel_lookup(8760, 1, diesel_inputs);
68
69
70 // ===== END CONSTRUCTION ===== //
71
72
73
74
75 // ===== ATTRIBUTES ===== //
76
77 testTruth(
78     not diesel_inputs.combustion_inputs.production_inputs.print_flag,
79     __FILE__,
80     __LINE__
81 );
82
83 testFloatEquals(
84     test_diesel_ptr->type,
85     CombustionType :: DIESEL,
86     __FILE__,
87     __LINE__
88 );
89
90 testTruth(
91     test_diesel_ptr->type_str == "DIESEL",
92     __FILE__,
93     __LINE__
94 );
95
96 testFloatEquals(
97     test_diesel_ptr->linear_fuel_slope_LkWh,
98     0.265675,
99     __FILE__,
100    __LINE__
101 );
102
103 testFloatEquals(
104     test_diesel_ptr->linear_fuel_intercept_LkWh,
105     0.026676,
106     __FILE__,

```

```

107     __LINE__
108 );
109
110 testFloatEquals(
111     test_diesel_ptr->capital_cost,
112     94125.375446,
113     __FILE__,
114     __LINE__
115 );
116
117 testFloatEquals(
118     test_diesel_ptr->operation_maintenance_cost_kWh,
119     0.069905,
120     __FILE__,
121     __LINE__
122 );
123
124 testFloatEquals(
125     ((Diesel*)test_diesel_ptr)->minimum_load_ratio,
126     0.2,
127     __FILE__,
128     __LINE__
129 );
130
131 testFloatEquals(
132     ((Diesel*)test_diesel_ptr)->minimum_runtime_hrs,
133     4,
134     __FILE__,
135     __LINE__
136 );
137
138 testFloatEquals(
139     test_diesel_ptr->replace_running_hrs,
140     30000,
141     __FILE__,
142     __LINE__
143 );
144
145 // ===== END ATTRIBUTES ===== //
146
147
148
149 // ===== METHODS ===== //
150
151 // test capacity constraint
152 testFloatEquals(
153     test_diesel_ptr->requestProductionkW(0, 1, 2 * test_diesel_ptr->capacity_kW),
154     test_diesel_ptr->capacity_kW,
155     __FILE__,
156     __LINE__
157 );
158
159 // test minimum load ratio constraint
160 testFloatEquals(
161     test_diesel_ptr->requestProductionkW(
162         0,
163         1,
164         0.5 * ((Diesel*)test_diesel_ptr)->minimum_load_ratio *
165             test_diesel_ptr->capacity_kW
166     ),
167     ((Diesel*)test_diesel_ptr)->minimum_load_ratio * test_diesel_ptr->capacity_kW,
168     __FILE__,
169     __LINE__
170 );
171
172 // test commit()
173 std::vector<double> dt_vec_hrs (48, 1);
174
175 std::vector<double> load_vec_kW = {
176     1, 1, 0, 1, 0, 0, 1, 1, 1, 0, 1, 1,
177     1, 1, 1, 0, 0, 0, 0, 0, 0, 1, 1, 0,
178     1, 1, 1, 1, 1, 0, 1, 1, 1, 1, 0, 1,
179     1, 0, 0, 0, 1, 1, 1, 0, 1, 1, 0, 0
180 };
181
182 std::vector<bool> expected_is_running_vec = {
183     1, 1, 1, 1, 0, 0, 1, 1, 1, 1, 1, 1,
184     1, 1, 1, 0, 0, 0, 0, 0, 0, 1, 1, 1,
185     1, 1, 1, 1, 1, 0, 1, 1, 1, 1, 0, 1,
186     1, 1, 1, 0, 1, 1, 1, 1, 1, 1, 0, 0
187 };
188
189 double load_kW = 0;
190 double production_kW = 0;
191 double roll = 0;
192
193 for (int i = 0; i < 48; i++) {

```

```

194     roll = (double)rand() / RAND_MAX;
195
196     if (roll >= 0.95) {
197         roll = 1.25;
198     }
199
200     load_vec_kW[i] *= roll * test_diesel_ptr->capacity_kW;
201     load_kW = load_vec_kW[i];
202
203     production_kW = test_diesel_ptr->requestProductionkW(
204         i,
205         dt_vec_hrs[i],
206         load_kW
207     );
208
209     load_kW = test_diesel_ptr->commit(
210         i,
211         dt_vec_hrs[i],
212         production_kW,
213         load_kW
214     );
215
216     // load_kW <= load_vec_kW (i.e., after vs before)
217     testLessThanOrEqualTo(
218         load_kW,
219         load_vec_kW[i],
220         __FILE__,
221         __LINE__
222     );
223
224     // production = dispatch + storage + curtailment
225     testFloatEquals(
226         test_diesel_ptr->production_vec_kW[i] -
227         test_diesel_ptr->dispatch_vec_kW[i] -
228         test_diesel_ptr->storage_vec_kW[i] -
229         test_diesel_ptr->curtailment_vec_kW[i],
230         0,
231         __FILE__,
232         __LINE__
233     );
234
235     // capacity constraint
236     if (load_vec_kW[i] > test_diesel_ptr->capacity_kW) {
237         testFloatEquals(
238             test_diesel_ptr->production_vec_kW[i],
239             test_diesel_ptr->capacity_kW,
240             __FILE__,
241             __LINE__
242         );
243     }
244
245     // minimum load ratio constraint
246     else if (
247         test_diesel_ptr->is_running and
248         test_diesel_ptr->production_vec_kW[i] > 0 and
249         load_vec_kW[i] <
250         ((Diesel*)test_diesel_ptr)->minimum_load_ratio * test_diesel_ptr->capacity_kW
251     ) {
252         testFloatEquals(
253             test_diesel_ptr->production_vec_kW[i],
254             ((Diesel*)test_diesel_ptr)->minimum_load_ratio *
255             test_diesel_ptr->capacity_kW,
256             __FILE__,
257             __LINE__
258         );
259     }
260
261     // minimum runtime constraint
262     testFloatEquals(
263         test_diesel_ptr->is_running_vec[i],
264         expected_is_running_vec[i],
265         __FILE__,
266         __LINE__
267     );
268
269     // O&M, fuel consumption, and emissions > 0 whenever diesel is running
270     if (test_diesel_ptr->is_running) {
271         testGreaterThan(
272             test_diesel_ptr->operation_maintenance_cost_vec[i],
273             0,
274             __FILE__,
275             __LINE__
276         );
277
278         testGreaterThan(
279             test_diesel_ptr->fuel_consumption_vec_L[i],
280             0,

```

```

281         __FILE__,
282         __LINE__
283     );
284
285     testGreaterThan(
286         test_diesel_ptr->fuel_cost_vec[i],
287         0,
288         __FILE__,
289         __LINE__
290     );
291
292     testGreaterThan(
293         test_diesel_ptr->CO2_emissions_vec_kg[i],
294         0,
295         __FILE__,
296         __LINE__
297     );
298
299     testGreaterThan(
300         test_diesel_ptr->CO_emissions_vec_kg[i],
301         0,
302         __FILE__,
303         __LINE__
304     );
305
306     testGreaterThan(
307         test_diesel_ptr->NOx_emissions_vec_kg[i],
308         0,
309         __FILE__,
310         __LINE__
311     );
312
313     testGreaterThan(
314         test_diesel_ptr->SOx_emissions_vec_kg[i],
315         0,
316         __FILE__,
317         __LINE__
318     );
319
320     testGreaterThan(
321         test_diesel_ptr->CH4_emissions_vec_kg[i],
322         0,
323         __FILE__,
324         __LINE__
325     );
326
327     testGreaterThan(
328         test_diesel_ptr->PM_emissions_vec_kg[i],
329         0,
330         __FILE__,
331         __LINE__
332     );
333 }
334
335 // O&M, fuel consumption, and emissions = 0 whenever diesel is not running
336 else {
337     testFloatEquals(
338         test_diesel_ptr->operation_maintenance_cost_vec[i],
339         0,
340         __FILE__,
341         __LINE__
342     );
343
344     testFloatEquals(
345         test_diesel_ptr->fuel_consumption_vec_L[i],
346         0,
347         __FILE__,
348         __LINE__
349     );
350
351     testFloatEquals(
352         test_diesel_ptr->fuel_cost_vec[i],
353         0,
354         __FILE__,
355         __LINE__
356     );
357
358     testFloatEquals(
359         test_diesel_ptr->CO2_emissions_vec_kg[i],
360         0,
361         __FILE__,
362         __LINE__
363     );
364
365     testFloatEquals(
366         test_diesel_ptr->CO_emissions_vec_kg[i],
367         0,

```

```

368         __FILE__,
369         __LINE__
370     );
371
372     testFloatEquals(
373         test_diesel_ptr->NOx_emissions_vec_kg[i],
374         0,
375         __FILE__,
376         __LINE__
377     );
378
379     testFloatEquals(
380         test_diesel_ptr->SOx_emissions_vec_kg[i],
381         0,
382         __FILE__,
383         __LINE__
384     );
385
386     testFloatEquals(
387         test_diesel_ptr->CH4_emissions_vec_kg[i],
388         0,
389         __FILE__,
390         __LINE__
391     );
392
393     testFloatEquals(
394         test_diesel_ptr->PM_emissions_vec_kg[i],
395         0,
396         __FILE__,
397         __LINE__
398     );
399 }
400 }
401
402 std::vector<double> load_ratio_vec = {
403     0,
404     0.170812859791767,
405     0.322739274162545,
406     0.369750203682042,
407     0.443532869135929,
408     0.471567864244626,
409     0.536513734479662,
410     0.586125806988674,
411     0.601101175455075,
412     0.658356862575221,
413     0.70576929893201,
414     0.784069734739331,
415     0.805765927542453,
416     0.884747873186048,
417     0.930870496062112,
418     0.979415217694769,
419     1
420 };
421
422 std::vector<double> expected_fuel_consumption_vec_L = {
423     4.68079520372916,
424     8.35159603357656,
425     11.7422361561399,
426     12.9931187917615,
427     14.8786636301325,
428     15.5746957307243,
429     17.1419229487141,
430     18.3041866133728,
431     18.6530540913696,
432     19.9569217633299,
433     21.012354614584,
434     22.7142305879957,
435     23.1916726441968,
436     24.8602332554707,
437     25.8172124624032,
438     26.8256741279932,
439     27.254952
440 };
441
442 for (size_t i = 0; i < load_ratio_vec.size(); i++) {
443     testFloatEquals(
444         test_diesel_lookup.getFuelConsumptionL(
445             1, load_ratio_vec[i] * test_diesel_lookup.capacity_kW
446         ),
447         expected_fuel_consumption_vec_L[i],
448         __FILE__,
449         __LINE__
450     );
451 }
452
453 // ===== END METHODS ===== //
454

```

```

455 }    /* try */
456
457
458 catch (...) {
459     delete test_diesel_ptr;
460
461     printGold(" ... ");
462     printRed("FAIL");
463     std::cout << std::endl;
464     throw;
465 }
466
467
468 delete test_diesel_ptr;
469
470 printGold(" ... ");
471 printGreen("PASS");
472 std::cout << std::endl;
473 return 0;
474
475 }    /* main() */

```

5.51 test/source/Production/Renewable/test_Renewable.cpp File Reference

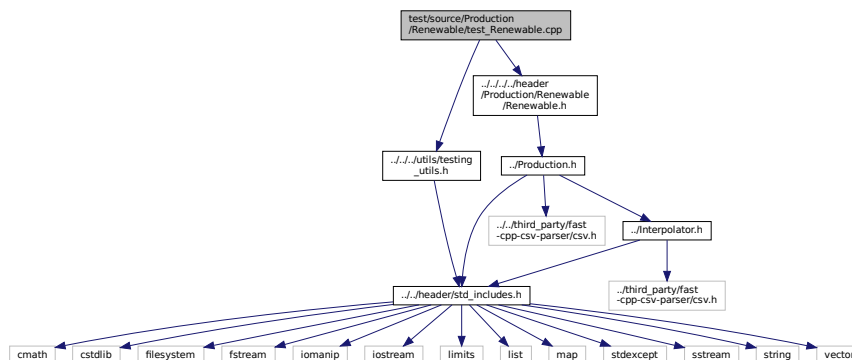
Testing suite for [Renewable](#) class.

```

#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)

5.51.1 Detailed Description

Testing suite for [Renewable](#) class.

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

5.51.2 Function Documentation

5.51.2.1 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() */

```

5.52 test/source/Production/Renewable/test_Solar.cpp File Reference

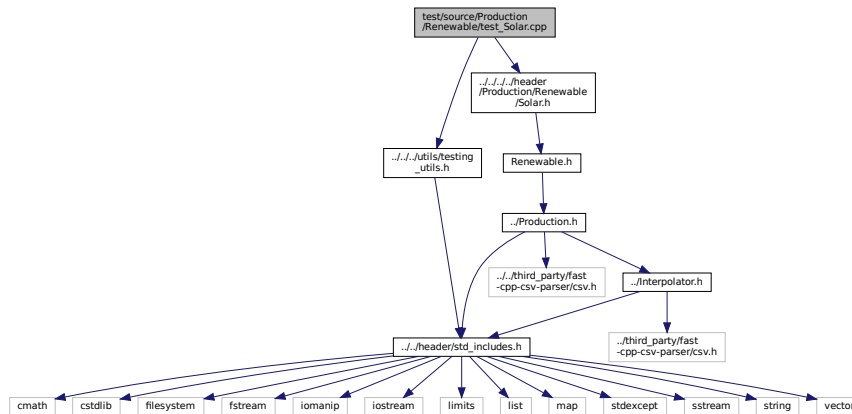
Testing suite for [Solar](#) class.

```

#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)

5.52.1 Detailed Description

Testing suite for [Solar](#) class.

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

5.52.2 Function Documentation

5.52.2.1 main()

```

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

```



```

47
48     Solar bad_solar(8760, 1, bad_solar_inputs);
49
50     error_flag = false;
51 } catch (...) {
52     // Task failed successfully! =P
53 }
54 if (not error_flag) {
55     expectedErrorNotDetected(__FILE__, __LINE__);
56 }
57
58 SolarInputs solar_inputs;
59
60 test_solar_ptr = new Solar(8760, 1, solar_inputs);
61
62 // ===== END CONSTRUCTION ===== //
63
64
65
66 // ===== ATTRIBUTES ===== //
67
68 testTruth(
69     not solar_inputs.renewable_inputs.production_inputs.print_flag,
70     __FILE__,
71     __LINE__
72 );
73
74 testFloatEquals(
75     test_solar_ptr->type,
76     RenewableType :: SOLAR,
77     __FILE__,
78     __LINE__
79 );
80
81 testTruth(
82     test_solar_ptr->type_str == "SOLAR",
83     __FILE__,
84     __LINE__
85 );
86
87 testFloatEquals(
88     test_solar_ptr->capital_cost,
89     350118.723363,
90     __FILE__,
91     __LINE__
92 );
93
94 testFloatEquals(
95     test_solar_ptr->operation_maintenance_cost_kWh,
96     0.01,
97     __FILE__,
98     __LINE__
99 );
100
101 // ===== END ATTRIBUTES ===== //
102
103
104
105 // ===== METHODS ===== //
106
107 // test production constraints
108 testFloatEquals(
109     test_solar_ptr->computeProductionkW(0, 1, 2),
110     100,
111     __FILE__,
112     __LINE__
113 );
114
115 testFloatEquals(
116     test_solar_ptr->computeProductionkW(0, 1, -1),
117     0,
118     __FILE__,
119     __LINE__
120 );
121
122 // test commit()
123 std::vector<double> dt_vec_hrs (48, 1);
124
125 std::vector<double> load_vec_kW = {
126     1, 1, 0, 1, 0, 0, 1, 1, 1, 0, 1, 1,
127     1, 1, 1, 0, 0, 0, 0, 0, 0, 1, 1, 0,
128     1, 1, 1, 1, 1, 0, 1, 1, 1, 1, 0, 1,
129     1, 0, 0, 0, 1, 1, 1, 0, 1, 1, 0, 0
130 };
131
132 double load_kW = 0;
133 double production_kW = 0;

```

```

134 double roll = 0;
135 double solar_resource_kWm2 = 0;
136
137 for (int i = 0; i < 48; i++) {
138     roll = (double)rand() / RAND_MAX;
139
140     solar_resource_kWm2 = roll;
141
142     roll = (double)rand() / RAND_MAX;
143
144     if (roll <= 0.1) {
145         solar_resource_kWm2 = 0;
146     }
147
148     else if (roll >= 0.95) {
149         solar_resource_kWm2 = 1.25;
150     }
151
152     roll = (double)rand() / RAND_MAX;
153
154     if (roll >= 0.95) {
155         roll = 1.25;
156     }
157
158     load_vec_kW[i] *= roll * test_solar_ptr->capacity_kW;
159     load_kW = load_vec_kW[i];
160
161     production_kW = test_solar_ptr->computeProductionkW(
162         i,
163         dt_vec_hrs[i],
164         solar_resource_kWm2
165     );
166
167     load_kW = test_solar_ptr->commit(
168         i,
169         dt_vec_hrs[i],
170         production_kW,
171         load_kW
172     );
173
174     // is running (or not) as expected
175     if (solar_resource_kWm2 > 0) {
176         testTruth(
177             test_solar_ptr->is_running,
178             __FILE__,
179             __LINE__
180         );
181     }
182
183     else {
184         testTruth(
185             not test_solar_ptr->is_running,
186             __FILE__,
187             __LINE__
188         );
189     }
190
191     // load_kW <= load_vec_kW (i.e., after vs before)
192     testLessThanOrEqualTo(
193         load_kW,
194         load_vec_kW[i],
195         __FILE__,
196         __LINE__
197     );
198
199     // production = dispatch + storage + curtailment
200     testFloatEquals(
201         test_solar_ptr->production_vec_kW[i] -
202         test_solar_ptr->dispatch_vec_kW[i] -
203         test_solar_ptr->storage_vec_kW[i] -
204         test_solar_ptr->curtailment_vec_kW[i],
205         0,
206         __FILE__,
207         __LINE__
208     );
209
210     // capacity constraint
211     if (solar_resource_kWm2 > 1) {
212         testFloatEquals(
213             test_solar_ptr->production_vec_kW[i],
214             test_solar_ptr->capacity_kW,
215             __FILE__,
216             __LINE__
217         );
218     }
219
220     // resource, O&M > 0 whenever solar is running (i.e., producing)

```

```

221     if (test_solar_ptr->is_running) {
222         testGreaterThan(
223             solar_resource_kWm2,
224             0,
225             __FILE__,
226             __LINE__
227         );
228
229         testGreaterThan(
230             test_solar_ptr->operation_maintenance_cost_vec[i],
231             0,
232             __FILE__,
233             __LINE__
234         );
235     }
236
237     // resource, O&M = 0 whenever solar is not running (i.e., not producing)
238     else {
239         testFloatEquals(
240             solar_resource_kWm2,
241             0,
242             __FILE__,
243             __LINE__
244         );
245
246         testFloatEquals(
247             test_solar_ptr->operation_maintenance_cost_vec[i],
248             0,
249             __FILE__,
250             __LINE__
251         );
252     }
253 }
254
255 // ===== END METHODS ===== //
256
257 /* try */
258
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() */

```

5.53 test/source/Production/Renewable/test_Tidal.cpp File Reference

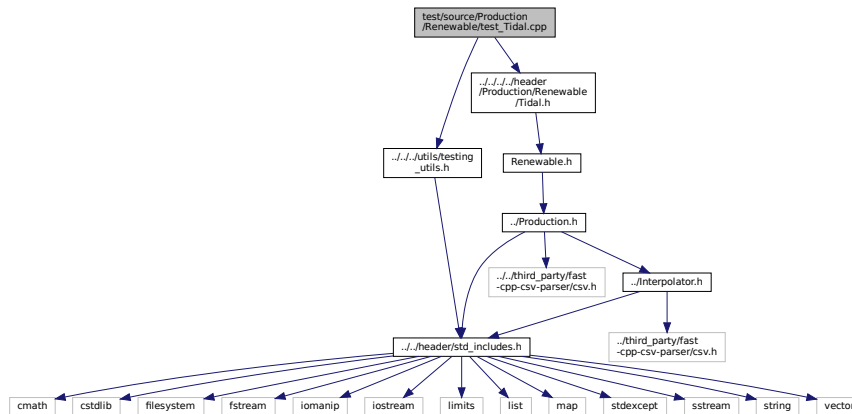
Testing suite for [Tidal](#) class.

```

#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)

5.53.1 Detailed Description

Testing suite for [Tidal](#) class.

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

5.53.2 Function Documentation

5.53.2.1 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, 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() */

```

5.54 test/source/Production/Renewable/test_Wave.cpp File Reference

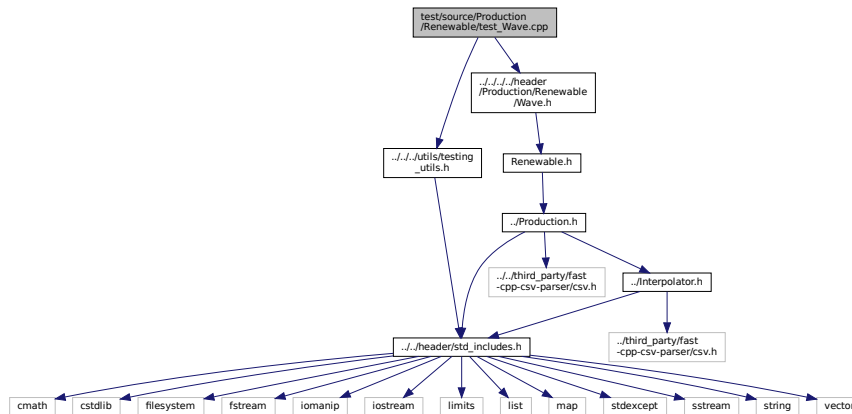
Testing suite for [Wave](#) class.

```

#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)

5.54.1 Detailed Description

Testing suite for [Wave](#) class.

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

5.54.2 Function Documentation

5.54.2.1 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
63 wave_inputs.power_model = WavePowerProductionModel :: WAVE_POWER_LOOKUP;
64 wave_inputs.path_2_normalized_performance_matrix =
65     "data/test/interpolation/wave_energy_converter_normalized_performance_matrix.csv";
66
67 Wave test_wave_lookup(8760, 1, wave_inputs);
68
69 // ===== END CONSTRUCTION ===== //
70
71
72
73 // ===== ATTRIBUTES ===== //
74
75 testTruth(
76     not wave_inputs.renewable_inputs.production_inputs.print_flag,
77     __FILE__,
78     __LINE__
79 );
80
81 testFloatEquals(
82     test_wave_ptr->type,
83     RenewableType :: WAVE,
84     __FILE__,
85     __LINE__
86 );
87
88 testTruth(
89     test_wave_ptr->type_str == "WAVE",
90     __FILE__,
91     __LINE__
92 );
93
94 testFloatEquals(
95     test_wave_ptr->capital_cost,
96     850831.063539,
97     __FILE__,
98     __LINE__
99 );
100
101 testFloatEquals(
102     test_wave_ptr->operation_maintenance_cost_kWh,
103     0.069905,
104     __FILE__,
105     __LINE__
106 );
107
108 // ===== END ATTRIBUTES ===== //
109
110
111
112 // ===== METHODS ===== //
113
114 // test production constraints
115 testFloatEquals(
116     test_wave_ptr->computeProductionkW(0, 1, 0, rand()),
117     0,
118     __FILE__,
119     __LINE__
120 );
121
122 testFloatEquals(
123     test_wave_ptr->computeProductionkW(0, 1, rand(), 0),
124     0,
125     __FILE__,
126     __LINE__
127 );
128
129 // test commit()
130 std::vector<double> dt_vec_hrs (48, 1);
131
132 std::vector<double> load_vec_kW = {
133     1, 1, 0, 1, 0, 0, 1, 1, 1, 0, 1, 1,

```

```

134     1, 1, 1, 0, 0, 0, 0, 0, 0, 1, 1, 0,
135     1, 1, 1, 1, 1, 0, 1, 1, 1, 1, 0, 1,
136     1, 0, 0, 0, 1, 1, 1, 0, 1, 1, 0, 0
137 };
138
139 double load_kW = 0;
140 double production_kW = 0;
141 double roll = 0;
142 double significant_wave_height_m = 0;
143 double energy_period_s = 0;
144
145 for (int i = 0; i < 48; i++) {
146     roll = (double)rand() / RAND_MAX;
147
148     if (roll <= 0.05) {
149         roll = 0;
150     }
151
152     significant_wave_height_m = roll *
153         ((Wave*)test_wave_ptr)->design_significant_wave_height_m;
154
155     roll = (double)rand() / RAND_MAX;
156
157     if (roll <= 0.05) {
158         roll = 0;
159     }
160
161     energy_period_s = roll * ((Wave*)test_wave_ptr)->design_energy_period_s;
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_wave_ptr->capacity_kW;
170     load_kW = load_vec_kW[i];
171
172     production_kW = test_wave_ptr->computeProductionkW(
173         i,
174         dt_vec_hrs[i],
175         significant_wave_height_m,
176         energy_period_s
177     );
178
179     load_kW = test_wave_ptr->commit(
180         i,
181         dt_vec_hrs[i],
182         production_kW,
183         load_kW
184     );
185
186     // is running (or not) as expected
187     if (production_kW > 0) {
188         testTruth(
189             test_wave_ptr->is_running,
190             __FILE__,
191             __LINE__
192         );
193     }
194
195     else {
196         testTruth(
197             not test_wave_ptr->is_running,
198             __FILE__,
199             __LINE__
200         );
201     }
202
203     // load_kW <= load_vec_kW (i.e., after vs before)
204     testLessThanOrEqualTo(
205         load_kW,
206         load_vec_kW[i],
207         __FILE__,
208         __LINE__
209     );
210
211     // production = dispatch + storage + curtailment
212     testFloatEquals(
213         test_wave_ptr->production_vec_kW[i] -
214         test_wave_ptr->dispatch_vec_kW[i] -
215         test_wave_ptr->storage_vec_kW[i] -
216         test_wave_ptr->curtailment_vec_kW[i],
217         0,
218         __FILE__,
219         __LINE__
220     );

```

```

221
222 // resource, O&M > 0 whenever wave is running (i.e., producing)
223 if (test_wave_ptr->is_running) {
224     testGreaterThan(
225         significant_wave_height_m,
226         0,
227         __FILE__,
228         __LINE__
229     );
230
231     testGreaterThan(
232         energy_period_s,
233         0,
234         __FILE__,
235         __LINE__
236     );
237
238     testGreaterThan(
239         test_wave_ptr->operation_maintenance_cost_vec[i],
240         0,
241         __FILE__,
242         __LINE__
243     );
244 }
245
246 // O&M = 0 whenever wave is not running (i.e., not producing)
247 else {
248     testFloatEquals(
249         test_wave_ptr->operation_maintenance_cost_vec[i],
250         0,
251         __FILE__,
252         __LINE__
253     );
254 }
255 }
256
257 std::vector<double> significant_wave_height_vec_m = {
258     0.389211848822208,
259     0.836477431896843,
260     1.52738334015579,
261     1.92640601114508,
262     2.27297317532019,
263     2.87416589636605,
264     3.72275770908175,
265     3.95063175885536,
266     4.68097139867404,
267     4.97775020449812,
268     5.55184219980547,
269     6.06566629451658,
270     6.27927876785062,
271     6.96218133671013,
272     7.51754442460228
273 };
274
275 std::vector<double> energy_period_vec_s = {
276     5.45741899698926,
277     6.00101329139007,
278     7.50567689404182,
279     8.77681262912881,
280     9.45143678206774,
281     10.7767876462885,
282     11.4795760857165,
283     12.9430684577599,
284     13.303544885703,
285     14.5069863517863,
286     15.1487890438045,
287     16.086524049077,
288     17.176609978648,
289     18.4155153740256,
290     19.1704554940162
291 };
292
293 std::vector<std::vector<double>> expected_normalized_performance_matrix = {
294     {0.0337204906738533,0.145056406036013,0.334677248806653,0.441674658936075,0.533295755691263,0.68807895676592,0.8996148
295     {0.0310681846933292,0.135425896595439,0.324045598153363,0.430214268249038,0.520985043044784,0.673879556322479,0.882058
296     {0.0237266281076604,0.108768742207538,0.294617294841705,0.398492020763049,0.486909112828702,0.63457575706117,0.8334608
297     {0.0175245009938255,0.0862488504001753,0.269756343931147,0.371693152028768,0.458121859300634,0.601372013927032,0.79240
298     {0.0142328739589644,0.0742969694833995,0.256562003243255,0.357470308928265,0.442843729679424,0.583749940636223,0.77061
299     {0.0077662203173173,0.0508165832074184,0.230640709501637,0.329528443353471,0.41282867283787,0.549130026772199,0.727811
300     {0.00433717405958826,0.0383657337957315,0.21689552996585,0.314711823368423,0.396912710109449,0.530772265145106,0.70511

```

```

301 {0.000102358416923608,0.0210697053701168,0.188272456115393,0.283857573197153,0.363769179652786,0.492543912767949,0.657
302 {0,0.0196038727057393,0.18122235960193,0.276257786480759,0.355605514643888,0.483127792688125,0.646203044346932,0.6855
303 {0,0.0157252942367668,0.157685253727545,0.250886090139653,0.328351324840186,0.451692313207986,0.607334650020078,0.6442
304 {0,0.0136568246246201,0.145132837191606,0.23735520935175,0.313816498778623,0.43492757979648,0.586605897674033,0.622265
305 {0,0.0106345930466366,0.12679255826648,0.217585300741544,0.292579730277991,0.410432703770651,0.556319211544087,0.59010
306 {0,0.00712134879261874,0.10547259059088,0.194603435839713,0.267892689267542,0.381958220518761,0.52111194060085,0.55272
307 {0,0.00312847342058727,0.0812420026472571,0.168484067035528,0.239835352250276,0.349596376397684,0.481098142839729,0.51
308 {0,0.00103256269522045,0.0673448574082101,0.152567953107312,0.222738316872545,0.329876344040866,0.456715311514779,0.48
309 };
310
311 for (size_t i = 0; i < energy_period_vec_s.size(); i++) {
312     for (size_t j = 0; j < significant_wave_height_vec_m.size(); j++) {
313         testFloatEquals(
314             test_wave_lookup.computeProductionkW(
315                 0,
316                 1,
317                 significant_wave_height_vec_m[j],
318                 energy_period_vec_s[i]
319             ),
320             expected_normalized_performance_matrix[i][j] *
321             test_wave_lookup.capacity_kW,
322             __FILE__,
323             __LINE__
324         );
325     }
326 }
327
328 // ===== END METHODS ===== //
329
330 } /* try */
331
332
333 catch (...) {
334     delete test_wave_ptr;
335
336     printGold(" ..... ");
337     printRed("FAIL");
338     std::cout << std::endl;
339     throw;
340 }
341
342 delete test_wave_ptr;
343
344 printGold(" ..... ");
345 printGreen("PASS");
346 std::cout << std::endl;
347 return 0;
348 } /* main() */

```

5.55 test/source/Production/Renewable/test_Wind.cpp File Reference

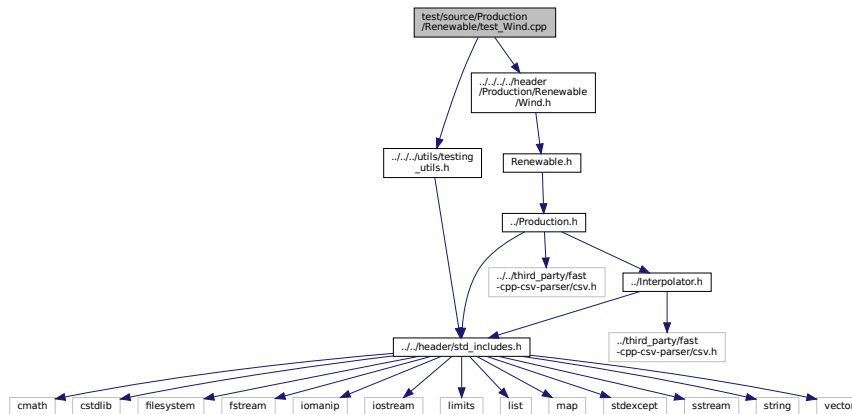
Testing suite for [Wind](#) class.

```

#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)`

5.55.1 Detailed Description

Testing suite for `Wind` class.

A suite of tests for the `Wind` class.

5.55.2 Function Documentation

5.55.2.1 main()

```

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

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

    srand(time(NULL));

    Renewable* test_wind_ptr;

    try {
        // ===== CONSTRUCTION =====
        bool error_flag = true;

        try {
            WindInputs bad_wind_inputs;
            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 delete test_wind_ptr;
265
266 printGold(" ..... ");
267 printGreen("PASS");
268 std::cout << std::endl;
269 return 0;
270 } /* main() */

```

5.56 test/source/Production/test_Production.cpp File Reference

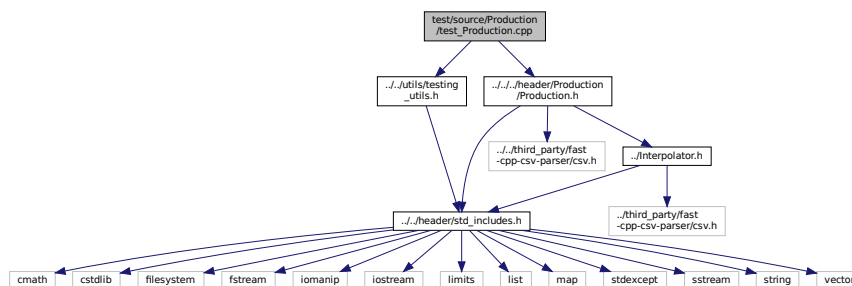
Testing suite for [Production](#) class.

```

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

```

Include dependency graph for test_Production.cpp:



Functions

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

5.56.1 Detailed Description

Testing suite for [Production](#) class.

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

5.56.2 Function Documentation

5.56.2.1 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
154 catch (...) {
155     //...
156
157     printGold(" ..... ");
158     printRed("FAIL");
159     std::cout << std::endl;
160     throw;
161 }
162
163
164 printGold(" ..... ");

```

```

165 printGreen("PASS");
166 std::cout << std::endl;
167 return 0;
168
169 } /* main() */

```

5.57 test/source/Storage/test_Lilon.cpp File Reference

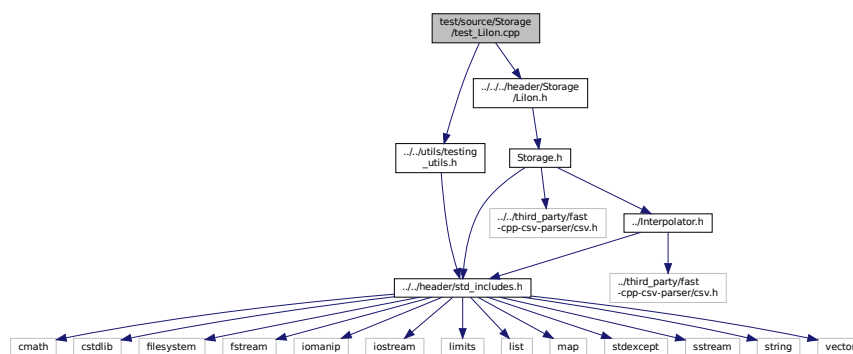
Testing suite for [Lilon](#) class.

```

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

```

Include dependency graph for test_Lilon.cpp:



Functions

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

5.57.1 Detailed Description

Testing suite for [Lilon](#) class.

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

5.57.2 Function Documentation

5.57.2.1 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() */

```

5.58 test/source/Storage/test_Storage.cpp File Reference

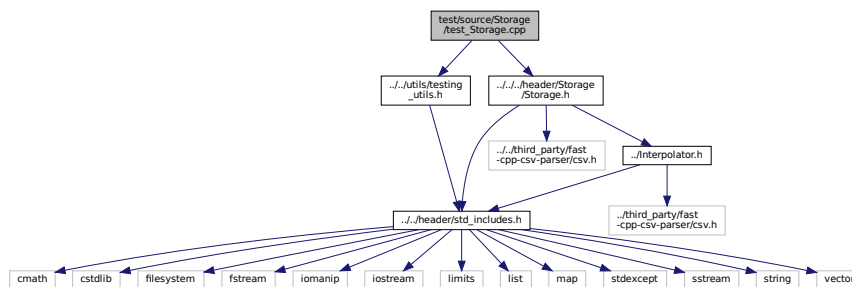
Testing suite for [Storage](#) class.

```

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

```

Include dependency graph for test_Storage.cpp:



Functions

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

5.58.1 Detailed Description

Testing suite for [Storage](#) class.

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

5.58.2 Function Documentation

5.58.2.1 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() */

```

5.59 test/source/test_Controller.cpp File Reference

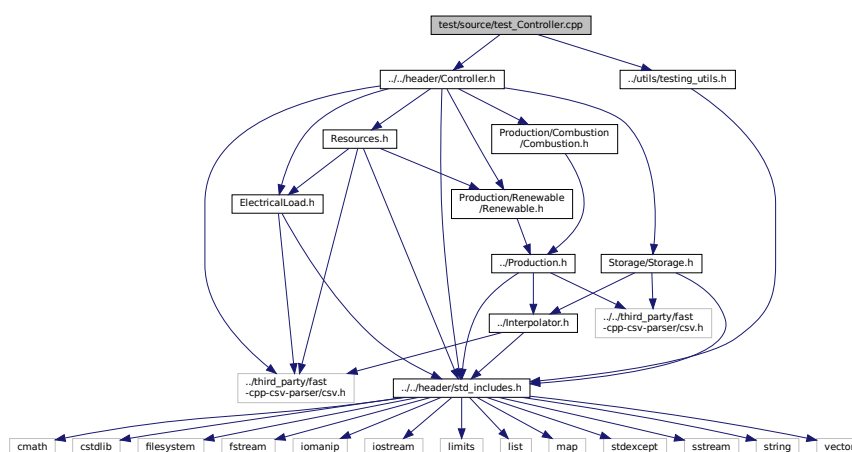
Testing suite for [Controller](#) class.

```

#include "../utils/testing_utils.h"
#include "../../header/Controller.h"

```

Include dependency graph for test_Controller.cpp:



Functions

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

5.59.1 Detailed Description

Testing suite for [Controller](#) class.

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

5.59.2 Function Documentation

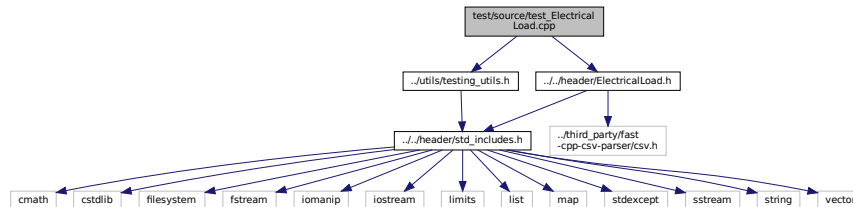
5.59.2.1 main()

```
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() */
```

5.60 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)

5.60.1 Detailed Description

Testing suite for [ElectricalLoad](#) class.

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

5.60.2 Function Documentation

5.60.2.1 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/electrical_load_generic_peak-500kW_1yr_dt-1hr.csv";
    43
    44         ElectricalLoad test_electrical_load(path_2_electrical_load_time_series);
    45
    46     }
```

```

46 // ===== END CONSTRUCTION ===== //
47
48
49
50 // ===== ATTRIBUTES ===== //
51
52 testTruth(
53     test_electrical_load.path_2_electrical_load_time_series ==
54     path_2_electrical_load_time_series,
55     __FILE__,
56     __LINE__
57 );
58
59 testFloatEquals(
60     test_electrical_load.n_points,
61     8760,
62     __FILE__,
63     __LINE__
64 );
65
66 testFloatEquals(
67     test_electrical_load.n_years,
68     0.999886,
69     __FILE__,
70     __LINE__
71 );
72
73 testFloatEquals(
74     test_electrical_load.min_load_kW,
75     82.1211213927802,
76     __FILE__,
77     __LINE__
78 );
79
80 testFloatEquals(
81     test_electrical_load.mean_load_kW,
82     258.373472633202,
83     __FILE__,
84     __LINE__
85 );
86
87
88 testFloatEquals(
89     test_electrical_load.max_load_kW,
90     500,
91     __FILE__,
92     __LINE__
93 );
94
95
96 std::vector<double> expected_dt_vec_hrs (48, 1);
97
98 std::vector<double> expected_time_vec_hrs = {
99     0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11,
100    12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23,
101    24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35,
102    36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47
103 };
104
105 std::vector<double> expected_load_vec_kW = {
106    360.253836463674,
107    355.171277826775,
108    353.776453532298,
109    353.75405737934,
110    346.592867404975,
111    340.132411175118,
112    337.354867340578,
113    340.644115618736,
114    363.639028500678,
115    378.787797779238,
116    372.215798201712,
117    395.093925731298,
118    402.325427142659,
119    386.907725462306,
120    380.709170928091,
121    372.062070914977,
122    372.328646856954,
123    391.841444284136,
124    394.029351759596,
125    383.369407765254,
126    381.093099675206,
127    382.604158946193,
128    390.744843709034,
129    383.13949492437,
130    368.150393976985,
131    364.629744480226,
132    363.572736804082,

```

```

133     359.854924202248,
134     355.207590170267,
135     349.094656012401,
136     354.365935871597,
137     343.380608328546,
138     404.673065729266,
139     486.296896820126,
140     480.225974100847,
141     457.318764401085,
142     418.177339948609,
143     414.399018364126,
144     409.678420185754,
145     404.768766016563,
146     401.699589920585,
147     402.44339040654,
148     398.138372541906,
149     396.010498627646,
150     390.165117432277,
151     375.850429417013,
152     365.567100746484,
153     365.429624610923
154 };
155
156 for (int i = 0; i < 48; i++) {
157     testFloatEquals(
158         test_electrical_load.dt_vec_hrs[i],
159         expected_dt_vec_hrs[i],
160         __FILE__,
161         __LINE__
162     );
163
164     testFloatEquals(
165         test_electrical_load.time_vec_hrs[i],
166         expected_time_vec_hrs[i],
167         __FILE__,
168         __LINE__
169     );
170
171     testFloatEquals(
172         test_electrical_load.load_vec_kW[i],
173         expected_load_vec_kW[i],
174         __FILE__,
175         __LINE__
176     );
177 }
178
179 // ===== END ATTRIBUTES ===== //
180
181 } /* try */
182
183
184 catch (...) {
185     //...
186
187     printGold(" ..... ");
188     printRed("FAIL");
189     std::cout << std::endl;
190     throw;
191 }
192
193
194 printGold(" ..... ");
195 printGreen("PASS");
196 std::cout << std::endl;
197 return 0;
198 } /* main() */

```

5.61 test/source/test_Interpolator.cpp File Reference

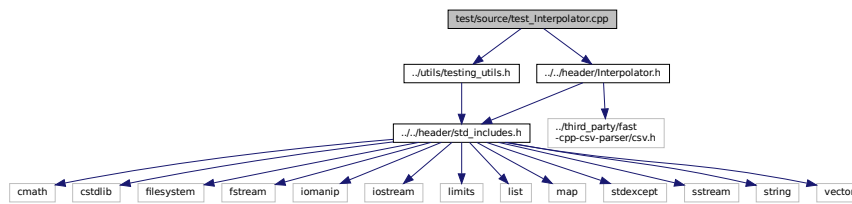
Testing suite for [Interpolator](#) class.

```

#include "../utils/testing_utils.h"
#include "../header/Interpolator.h"

```

Include dependency graph for test_Interpolator.cpp:



Functions

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

5.61.1 Detailed Description

Testing suite for [Interpolator](#) class.

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

5.61.2 Function Documentation

5.61.2.1 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         Interpolator test_interpolator;
    42
    43         // ===== END CONSTRUCTION =====//
    44
    45
    46
    47         // ===== ATTRIBUTES ===== //
    48
    49         //...
    50
    51         // ===== END ATTRIBUTES ===== //
    52
    53
    54
    55         // ===== METHODS ===== //
    56

```

```

57 // 1. 1D interpolation
58
59 int data_key = 1;
60 std::string path_2_data = "data/test/interpolation/diesel_fuel_curve.csv";
61
62 test_interpolator.addData1D(data_key, path_2_data);
63
64 testTruth(
65     test_interpolator.path_map_1D[data_key] == path_2_data,
66     __FILE__,
67     __LINE__
68 );
69
70 testFloatEquals(
71     test_interpolator.interp_map_1D[data_key].n_points,
72     16,
73     __FILE__,
74     __LINE__
75 );
76
77 testFloatEquals(
78     test_interpolator.interp_map_1D[data_key].x_vec.size(),
79     16,
80     __FILE__,
81     __LINE__
82 );
83
84 std::vector<double> expected_x_vec = {
85     0,
86     0.3,
87     0.35,
88     0.4,
89     0.45,
90     0.5,
91     0.55,
92     0.6,
93     0.65,
94     0.7,
95     0.75,
96     0.8,
97     0.85,
98     0.9,
99     0.95,
100    1
101 };
102
103 std::vector<double> expected_y_vec = {
104     4.68079520372916,
105     11.1278522361839,
106     12.4787834830748,
107     13.7808847600209,
108     15.0417468303382,
109     16.277263,
110     17.4612831516442,
111     18.6279054806525,
112     19.7698039220515,
113     20.8893499214868,
114     21.955378,
115     23.0690535155297,
116     24.1323614374927,
117     25.1797231192866,
118     26.2122451458747,
119     27.254952
120 };
121
122 for (int i = 0; i < test_interpolator.interp_map_1D[data_key].n_points; i++) {
123     testFloatEquals(
124         test_interpolator.interp_map_1D[data_key].x_vec[i],
125         expected_x_vec[i],
126         __FILE__,
127         __LINE__
128     );
129
130     testFloatEquals(
131         test_interpolator.interp_map_1D[data_key].y_vec[i],
132         expected_y_vec[i],
133         __FILE__,
134         __LINE__
135     );
136 }
137
138 testFloatEquals(
139     test_interpolator.interp_map_1D[data_key].min_x,
140     expected_x_vec[0],
141     __FILE__,
142     __LINE__
143 );

```

```

144
145 testFloatEquals(
146     test_interpolator.interp_map_1D[data_key].max_x,
147     expected_x_vec[expected_x_vec.size() - 1],
148     __FILE__,
149     __LINE__
150 );
151
152 std::vector<double> interp_x_vec = {
153     0,
154     0.170812859791767,
155     0.322739274162545,
156     0.369750203682042,
157     0.443532869135929,
158     0.471567864244626,
159     0.536513734479662,
160     0.586125806988674,
161     0.601101175455075,
162     0.658356862575221,
163     0.70576929893201,
164     0.784069734739331,
165     0.805765927542453,
166     0.884747873186048,
167     0.930870496062112,
168     0.979415217694769,
169     1
170 };
171
172 std::vector<double> expected_interp_y_vec = {
173     4.68079520372916,
174     8.35159603357656,
175     11.7422361561399,
176     12.9931187917615,
177     14.8786636301325,
178     15.5746957307243,
179     17.1419229487141,
180     18.3041866133728,
181     18.6530540913696,
182     19.9569217633299,
183     21.012354614584,
184     22.7142305879957,
185     23.1916726441968,
186     24.8602332554707,
187     25.8172124624032,
188     26.8256741279932,
189     27.254952
190 };
191
192 for (size_t i = 0; i < interp_x_vec.size(); i++) {
193     testFloatEquals(
194         test_interpolator.interp1D(data_key, interp_x_vec[i]),
195         expected_interp_y_vec[i],
196         __FILE__,
197         __LINE__
198     );
199 }
200
201
202 // 2. 2D interpolation
203
204 data_key = 2;
205 path_2_data =
206     "data/test/interpolation/wave_energy_converter_normalized_performance_matrix.csv";
207
208 test_interpolator.addData2D(data_key, path_2_data);
209
210 testTruth(
211     test_interpolator.path_map_2D[data_key] == path_2_data,
212     __FILE__,
213     __LINE__
214 );
215
216 testFloatEquals(
217     test_interpolator.interp_map_2D[data_key].n_rows,
218     16,
219     __FILE__,
220     __LINE__
221 );
222
223 testFloatEquals(
224     test_interpolator.interp_map_2D[data_key].n_cols,
225     16,
226     __FILE__,
227     __LINE__
228 );
229
230 testFloatEquals(

```

```

231     test_interpolator.interp_map_2D[data_key].x_vec.size(),
232     16,
233     __FILE__,
234     __LINE__
235 );
236
237 testFloatEquals(
238     test_interpolator.interp_map_2D[data_key].y_vec.size(),
239     16,
240     __FILE__,
241     __LINE__
242 );
243
244 testFloatEquals(
245     test_interpolator.interp_map_2D[data_key].z_matrix.size(),
246     16,
247     __FILE__,
248     __LINE__
249 );
250
251 testFloatEquals(
252     test_interpolator.interp_map_2D[data_key].z_matrix[0].size(),
253     16,
254     __FILE__,
255     __LINE__
256 );
257
258 expected_x_vec = {
259     0.25, 0.75, 1.25, 1.75, 2.25, 2.75, 3.25, 3.75, 4.25, 4.75, 5.25, 5.75, 6.25, 6.75, 7.25, 7.75
260 };
261
262 expected_y_vec = {
263     5,
264     6,
265     7,
266     8,
267     9,
268     10,
269     11,
270     12,
271     13,
272     14,
273     15,
274     16,
275     17,
276     18,
277     19,
278     20
279 };
280
281 for (int i = 0; i < test_interpolator.interp_map_2D[data_key].n_cols; i++) {
282     testFloatEquals(
283         test_interpolator.interp_map_2D[data_key].x_vec[i],
284         expected_x_vec[i],
285         __FILE__,
286         __LINE__
287     );
288 }
289
290 for (int i = 0; i < test_interpolator.interp_map_2D[data_key].n_rows; i++) {
291     testFloatEquals(
292         test_interpolator.interp_map_2D[data_key].y_vec[i],
293         expected_y_vec[i],
294         __FILE__,
295         __LINE__
296     );
297 }
298
299 testFloatEquals(
300     test_interpolator.interp_map_2D[data_key].min_x,
301     expected_x_vec[0],
302     __FILE__,
303     __LINE__
304 );
305
306 testFloatEquals(
307     test_interpolator.interp_map_2D[data_key].max_x,
308     expected_x_vec[expected_x_vec.size() - 1],
309     __FILE__,
310     __LINE__
311 );
312
313 testFloatEquals(
314     test_interpolator.interp_map_2D[data_key].min_y,
315     expected_y_vec[0],
316     __FILE__,
317     __LINE__

```



```

318 );
319
320 testFloatEquals(
321     test_interpolator.interp_map_2D[data_key].max_y,
322     expected_y_vec[expected_y_vec.size() - 1],
323     __FILE__,
324     __LINE__
325 );
326
327 std::vector<std::vector<double>> expected_z_matrix = {
328     {0, 0.129128125, 0.268078125, 0.404253125, 0.537653125, 0.668278125, 0.796128125, 0.921203125, 1, 1,
329     1, 0, 0, 0, 0, 0},
330     {0, 0.11160375, 0.24944375, 0.38395375, 0.51513375, 0.64298375, 0.76750375, 0.88869375, 1, 1, 1, 1,
331     1, 1, 1, 1},
332     {0, 0.094079375, 0.230809375, 0.363654375, 0.492614375, 0.617689375, 0.738879375, 0.856184375,
333     0.969604375, 1, 1, 1, 1, 1, 1, 1},
334     {0, 0.076555, 0.212175, 0.343355, 0.470095, 0.592395, 0.710255, 0.823675, 0.932655, 1, 1, 1, 1, 1,
335     1, 1},
336     {0, 0.059030625, 0.193540625, 0.323055625, 0.447575625, 0.567100625, 0.681630625, 0.791165625,
337     0.895705625, 0.995250625, 1, 1, 1, 1, 1, 1},
338     {0, 0.04150625, 0.17490625, 0.30275625, 0.42505625, 0.54180625, 0.65300625, 0.75865625, 0.85875625,
339     0.95330625, 1, 1, 1, 1, 1, 1},
340     {0, 0.023981875, 0.156271875, 0.282456875, 0.402536875, 0.516511875, 0.624381875, 0.726146875,
341     0.821806875, 0.911361875, 0.994811875, 1, 1, 1, 1, 1},
342     {0, 0.0064575, 0.1376375, 0.2621575, 0.3800175, 0.4912175, 0.5957575, 0.6936375, 0.7848575,
343     0.8694175, 0.9473175, 1, 1, 1, 1, 1},
344     {0, 0, 0.119003125, 0.241858125, 0.357498125, 0.465923125, 0.567133125, 0.661128125, 0.747908125,
345     0.827473125, 0.899823125, 0.964958125, 1, 1, 1, 1},
346     {0, 0, 0.10036875, 0.22155875, 0.33497875, 0.44062875, 0.53850875, 0.62861875, 0.71095875,
347     0.78552875, 0.85232875, 0.91135875, 0.96261875, 1, 1, 1},
348     {0, 0, 0.081734375, 0.201259375, 0.312459375, 0.415334375, 0.509884375, 0.596109375, 0.674009375,
349     0.743584375, 0.804834375, 0.857759375, 0.902359375, 0.938634375, 0.966584375, 0.986209375},
350     {0, 0, 0.0631, 0.18096, 0.28994, 0.39004, 0.48126, 0.5636, 0.63706, 0.70164, 0.75734, 0.80416,
351     0.8421, 0.87116, 0.89134, 0.90264},
352     {0, 0, 0.044465625, 0.160660625, 0.267420625, 0.364745625, 0.452635625, 0.531090625, 0.600110625,
353     0.659695625, 0.709845625, 0.750560625, 0.781840625, 0.803685624999999, 0.816095625, 0.819070625},
354     {0, 0, 0.02583125, 0.14036125, 0.24490125, 0.33945125, 0.42401125, 0.49858125, 0.56316125,
355     0.61775125, 0.66235125, 0.69696125, 0.72158125, 0.73621125, 0.74085125, 0.73550125},
356     {0, 0, 0.007196875, 0.120061875, 0.222381875, 0.314156875, 0.395386875, 0.466071875, 0.526211875,
357     0.575806875, 0.614856875, 0.643361875, 0.661321875, 0.668736875, 0.665606875, 0.651931875},
358     {0, 0, 0, 0.0997625, 0.1998625, 0.2888625, 0.3667625, 0.4335625, 0.4892625, 0.5338625, 0.5673625,
359     0.5897625, 0.6010625, 0.6012625, 0.5903625, 0.5683625}
360 };
361
362 for (int i = 0; i < test_interpolator.interp_map_2D[data_key].n_rows; i++) {
363     for (int j = 0; j < test_interpolator.interp_map_2D[data_key].n_cols; j++) {
364         testFloatEquals(
365             test_interpolator.interp_map_2D[data_key].z_matrix[i][j],
366             expected_z_matrix[i][j],
367             __FILE__,
368             __LINE__
369         );
370     }
371 }
372
373 interp_x_vec = {
374     0.389211848822208,
375     0.836477431896843,
376     1.52738334015579,
377     1.92640601114508,
378     2.27297317532019,
379     2.87416589636605,
380     3.72275770908175,
381     3.95063175885536,
382     4.68097139867404,
383     4.97775020449812,
384     5.55184219980547,
385     6.06566629451658,
386     6.27927876785062,
387     6.96218133671013,
388     7.51754442460228
389 };
390
391 std::vector<double> interp_y_vec = {
392     5.45741899698926,
393     6.00101329139007,
394     7.50567689404182,
395     8.77681262912881,
396     9.45143678206774,
397     10.7767876462885,
398     11.4795760857165,
399     12.9430684577599,
400     13.303544885703,
401     14.5069863517863,
402     15.1487890438045,
403     16.086524049077,
404     17.176609978648,
405

```

```

389     18.4155153740256,
390     19.1704554940162
391 };
392
393 std::vector<std::vector<double>> expected_interp_z_matrix = {
394     {0.0337204906738533,0.145056406036013,0.334677248806653,0.441674658936075,0.533295755691263,0.68807895676592,0.8996148
395     {0.0310681846933292,0.135425896595439,0.324045598153363,0.430214268249038,0.520985043044784,0.673879556322479,0.882058
396     {0.0237266281076604,0.108768742207538,0.294617294841705,0.398492020763049,0.486909112828702,0.63457575706117,0.8334608
397     {0.0175245009938255,0.0862488504001753,0.269756343931147,0.371693152028768,0.458121859300634,0.601372013927032,0.79240
398     {0.0142328739589644,0.0742969694833995,0.256562003243255,0.357470308928265,0.442843729679424,0.583749940636223,0.77061
399     {0.0077662203173173,0.0508165832074184,0.230640709501637,0.329528443353471,0.41282867283787,0.549130026772199,0.727811
400     {0.00433717405958826,0.0383657337957315,0.21689552996585,0.314711823368423,0.396912710109449,0.530772265145106,0.70511
401     {0.000102358416923608,0.0210697053701168,0.188272456115393,0.283857573197153,0.363769179652786,0.492543912767949,0.657
402     {0,0.0196038727057393,0.181222235960193,0.276257786480759,0.355605514643888,0.483127792688125,0.646203044346932,0.6855
403     {0,0.0157252942367668,0.157685253727545,0.250886090139653,0.328351324840186,0.451692313207986,0.607334650020078,0.6442
404     {0,0.0136568246246201,0.145132837191606,0.23735520935175,0.313816498778623,0.43492757979648,0.586605897674033,0.622265
405     {0,0.0106345930466366,0.12679255826648,0.217585300741544,0.292579730277991,0.410432703770651,0.556319211544087,0.59010
406     {0,0.00712134879261874,0.10547259059088,0.194603435839713,0.267892689267542,0.381958220518761,0.52111194060085,0.55272
407     {0,0.00312847342058727,0.0812420026472571,0.168484067035528,0.239835352250276,0.349596376397684,0.481098142839729,0.51
408     {0,0.00103256269522045,0.0673448574082101,0.152567953107312,0.222738316872545,0.329876344040866,0.456715311514779,0.48
409 };
410
411 for (size_t i = 0; i < interp_y_vec.size(); i++) {
412     for (size_t j = 0; j < interp_x_vec.size(); j++) {
413         testFloatEquals(
414             test_interpolator.interp2D(data_key, interp_x_vec[j], interp_y_vec[i]),
415             expected_interp_z_matrix[i][j],
416             __FILE__,
417             __LINE__
418         );
419     }
420 }
421
422 // ===== END METHODS ===== //
423
424 } /* try */
425
426 catch (...) {
427     //...
428
429     printGold(" ..... ");
430     printRed("FAIL");
431     std::cout << std::endl;
432     throw;
433 }
434
435
436
437 printGold(" ..... ");
438 printGreen("PASS");
439 std::cout << std::endl;
440 return 0;
441 } /* main() */

```

5.62 test/source/test_Model.cpp File Reference

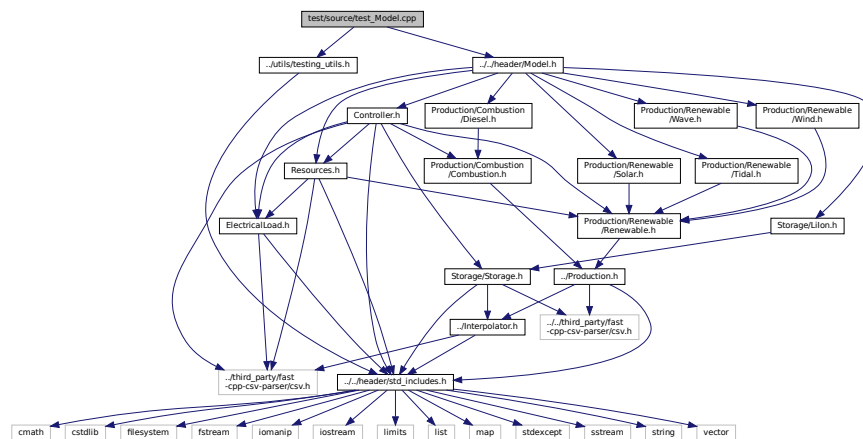
Testing suite for [Model](#) class.

```

#include "../utils/testing_utils.h"
#include "../../header/Model.h"

```

Include dependency graph for test_Model.cpp:



Functions

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

5.62.1 Detailed Description

Testing suite for [Model](#) class.

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

5.62.2 Function Documentation

5.62.2.1 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;    // path_2_electrical_load_time_series left empty
    45         }
```

```

46     Model bad_model(bad_model_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
57 try {
58     ModelInputs bad_model_inputs;
59     bad_model_inputs.path_2_electrical_load_time_series =
60         "data/test/electrical_load/bad_path_240984069830.csv";
61
62     Model bad_model(bad_model_inputs);
63
64     error_flag = false;
65 } catch (...) {
66     // Task failed successfully! =P
67 }
68 if (not error_flag) {
69     expectedErrorNotDetected(__FILE__, __LINE__);
70 }
71
72
73 std::string path_2_electrical_load_time_series =
74     "data/test/electrical_load/electrical_load_generic_peak-500kW_1yr_dt-1hr.csv";
75
76 ModelInputs test_model_inputs;
77 test_model_inputs.path_2_electrical_load_time_series =
78     path_2_electrical_load_time_series;
79
80 Model test_model(test_model_inputs);
81
82 // ===== END CONSTRUCTION ===== //
83
84
85 // ===== ATTRIBUTES ===== //
86
87 testTruth(
88     test_model.electrical_load.path_2_electrical_load_time_series ==
89     path_2_electrical_load_time_series,
90     __FILE__,
91     __LINE__
92 );
93
94 testFloatEquals(
95     test_model.electrical_load.n_points,
96     8760,
97     __FILE__,
98     __LINE__
99 );
100
101 testFloatEquals(
102     test_model.electrical_load.n_years,
103     0.999886,
104     __FILE__,
105     __LINE__
106 );
107
108 testFloatEquals(
109     test_model.electrical_load.min_load_kW,
110     82.1211213927802,
111     __FILE__,
112     __LINE__
113 );
114
115 testFloatEquals(
116     test_model.electrical_load.mean_load_kW,
117     258.373472633202,
118     __FILE__,
119     __LINE__
120 );
121
122
123 testFloatEquals(
124     test_model.electrical_load.max_load_kW,
125     500,
126     __FILE__,
127     __LINE__
128 );
129
130
131 std::vector<double> expected_dt_vec_hrs (48, 1);
132

```

```

133 std::vector<double> expected_time_vec_hrs = {
134     0,  1,  2,  3,  4,  5,  6,  7,  8,  9, 10, 11,
135     12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23,
136     24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35,
137     36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47
138 };
139
140 std::vector<double> expected_load_vec_kW = {
141     360.253836463674,
142     355.171277826775,
143     353.776453532298,
144     353.75405737934,
145     346.592867404975,
146     340.132411175118,
147     337.354867340578,
148     340.644115618736,
149     363.639028500678,
150     378.787797779238,
151     372.215798201712,
152     395.093925731298,
153     402.325427142659,
154     386.907725462306,
155     380.709170928091,
156     372.062070914977,
157     372.328646856954,
158     391.841444284136,
159     394.029351759596,
160     383.369407765254,
161     381.093099675206,
162     382.604158946193,
163     390.744843709034,
164     383.13949492437,
165     368.150393976985,
166     364.629744480226,
167     363.572736804082,
168     359.854924202248,
169     355.207590170267,
170     349.094656012401,
171     354.365935871597,
172     343.380608328546,
173     404.673065729266,
174     486.296896820126,
175     480.225974100847,
176     457.318764401085,
177     418.177339948609,
178     414.399018364126,
179     409.678420185754,
180     404.768766016563,
181     401.699589920585,
182     402.44339040654,
183     398.138372541906,
184     396.010498627646,
185     390.165117432277,
186     375.850429417013,
187     365.567100746484,
188     365.429624610923
189 };
190
191 for (int i = 0; i < 48; i++) {
192     testFloatEquals(
193         test_model.electrical_load.dt_vec_hrs[i],
194         expected_dt_vec_hrs[i],
195         __FILE__,
196         __LINE__
197     );
198
199     testFloatEquals(
200         test_model.electrical_load.time_vec_hrs[i],
201         expected_time_vec_hrs[i],
202         __FILE__,
203         __LINE__
204     );
205
206     testFloatEquals(
207         test_model.electrical_load.load_vec_kW[i],
208         expected_load_vec_kW[i],
209         __FILE__,
210         __LINE__
211     );
212 }
213
214 // ===== END ATTRIBUTES ===== //
215
216
217
218 // ===== METHODS ===== //
219

```

```

220 // add Solar resource
221 int solar_resource_key = 0;
222 std::string path_2_solar_resource_data =
223     "data/test/resources/solar_GHI_peak-1kWm2_1yr-dt-1hr.csv";
224
225 test_model.addResource(
226     RenewableType :: SOLAR,
227     path_2_solar_resource_data,
228     solar_resource_key
229 );
230
231 std::vector<double> expected_solar_resource_vec_kWm2 = {
232     0,
233     0,
234     0,
235     0,
236     0,
237     0,
238     8.51702662684015E-05,
239     0.000348341567045,
240     0.00213793728593,
241     0.004099863613322,
242     0.000997135230553,
243     0.009534527624657,
244     0.022927996790616,
245     0.0136071715294,
246     0.002535134127751,
247     0.005206897515821,
248     0.005627658648597,
249     0.000701186722215,
250     0.00017119827089,
251     0,
252     0,
253     0,
254     0,
255     0,
256     0,
257     0,
258     0,
259     0,
260     0,
261     0,
262     0,
263     0.000141055102242,
264     0.00084525014743,
265     0.024893647822702,
266     0.091245556190749,
267     0.158722176731637,
268     0.152859680515876,
269     0.149922903895116,
270     0.13049996570866,
271     0.03081254222795,
272     0.001218928911125,
273     0.000206092647423,
274     0,
275     0,
276     0,
277     0,
278     0,
279     0
280 };
281
282 for (size_t i = 0; i < expected_solar_resource_vec_kWm2.size(); i++) {
283     testFloatEquals(
284         test_model.resources.resource_map_1D[solar_resource_key][i],
285         expected_solar_resource_vec_kWm2[i],
286         __FILE__,
287         __LINE__
288     );
289 }
290
291
292 // add Tidal resource
293 int tidal_resource_key = 1;
294 std::string path_2_tidal_resource_data =
295     "data/test/resources/tidal_speed_peak-3ms_1yr-dt-1hr.csv";
296
297 test_model.addResource(
298     RenewableType :: TIDAL,
299     path_2_tidal_resource_data,
300     tidal_resource_key
301 );
302
303
304 // add Wave resource
305 int wave_resource_key = 2;
306 std::string path_2_wave_resource_data =

```

```

307     "data/test/resources/waves_H_s_peak-8m_T_e_peak-15s_1yr_dt-1hr.csv";
308
309 test_model.addResource(
310     RenewableType :: WAVE,
311     path_2_wave_resource_data,
312     wave_resource_key
313 );
314
315
316 // add Wind resource
317 int wind_resource_key = 3;
318 std::string path_2_wind_resource_data =
319     "data/test/resources/wind_speed_peak-25ms_1yr_dt-1hr.csv";
320
321 test_model.addResource(
322     RenewableType :: WIND,
323     path_2_wind_resource_data,
324     wind_resource_key
325 );
326
327
328 // add Diesel assets
329 DieselInputs diesel_inputs;
330 diesel_inputs.combustion_inputs.production_inputs.capacity_kW = 100;
331 diesel_inputs.combustion_inputs.production_inputs.is_sunk = true;
332
333 test_model.addDiesel(diesel_inputs);
334
335 testFloatEquals(
336     test_model.combustion_ptr_vec.size(),
337     1,
338     __FILE__,
339     __LINE__
340 );
341
342 testFloatEquals(
343     test_model.combustion_ptr_vec[0]->type,
344     CombustionType :: DIESEL,
345     __FILE__,
346     __LINE__
347 );
348
349 diesel_inputs.combustion_inputs.production_inputs.capacity_kW = 150;
350
351 test_model.addDiesel(diesel_inputs);
352
353 diesel_inputs.combustion_inputs.production_inputs.capacity_kW = 250;
354
355 test_model.addDiesel(diesel_inputs);
356
357 testFloatEquals(
358     test_model.combustion_ptr_vec.size(),
359     3,
360     __FILE__,
361     __LINE__
362 );
363
364 std::vector<int> expected_diesel_capacity_vec_kW = {100, 150, 250};
365
366 for (int i = 0; i < 3; i++) {
367     testFloatEquals(
368         test_model.combustion_ptr_vec[i]->capacity_kW,
369         expected_diesel_capacity_vec_kW[i],
370         __FILE__,
371         __LINE__
372     );
373 }
374
375 diesel_inputs.combustion_inputs.production_inputs.capacity_kW = 100;
376
377 for (int i = 0; i < 2 * ((double)rand() / RAND_MAX); i++) {
378     test_model.addDiesel(diesel_inputs);
379 }
380
381
382 // add Solar asset
383 SolarInputs solar_inputs;
384 solar_inputs.resource_key = solar_resource_key;
385
386 test_model.addSolar(solar_inputs);
387
388 testFloatEquals(
389     test_model.renewable_ptr_vec.size(),
390     1,
391     __FILE__,
392     __LINE__
393 );

```

```

394
395 testFloatEquals(
396     test_model.renewable_ptr_vec[0]->type,
397     RenewableType :: SOLAR,
398     __FILE__,
399     __LINE__
400 );
401
402
403 // add Tidal asset
404 TidalInputs tidal_inputs;
405 tidal_inputs.resource_key = tidal_resource_key;
406
407 test_model.addTidal(tidal_inputs);
408
409 testFloatEquals(
410     test_model.renewable_ptr_vec.size(),
411     2,
412     __FILE__,
413     __LINE__
414 );
415
416 testFloatEquals(
417     test_model.renewable_ptr_vec[1]->type,
418     RenewableType :: TIDAL,
419     __FILE__,
420     __LINE__
421 );
422
423
424 // add Wave asset
425 WaveInputs wave_inputs;
426 wave_inputs.resource_key = wave_resource_key;
427
428 test_model.addWave(wave_inputs);
429
430 testFloatEquals(
431     test_model.renewable_ptr_vec.size(),
432     3,
433     __FILE__,
434     __LINE__
435 );
436
437 testFloatEquals(
438     test_model.renewable_ptr_vec[2]->type,
439     RenewableType :: WAVE,
440     __FILE__,
441     __LINE__
442 );
443
444
445 // add Wind asset
446 WindInputs wind_inputs;
447 wind_inputs.resource_key = wind_resource_key;
448
449 test_model.addWind(wind_inputs);
450
451 testFloatEquals(
452     test_model.renewable_ptr_vec.size(),
453     4,
454     __FILE__,
455     __LINE__
456 );
457
458 testFloatEquals(
459     test_model.renewable_ptr_vec[3]->type,
460     RenewableType :: WIND,
461     __FILE__,
462     __LINE__
463 );
464
465
466 // add LiIon asset
467 LiIonInputs liion_inputs;
468
469 test_model.addLiIon(liion_inputs);
470
471 testFloatEquals(
472     test_model.storage_ptr_vec.size(),
473     1,
474     __FILE__,
475     __LINE__
476 );
477
478 testFloatEquals(
479     test_model.storage_ptr_vec[0]->type,
480     StorageType :: LIION,

```



```

481     __FILE__,
482     __LINE__
483 );
484
485
486 // run
487 test_model.run();
488
489
490 // write results
491 test_model.writeResults("test/test_results/");
492
493
494 // test post-run attributes
495 double net_load_kW;
496
497 Combustion* combustion_ptr;
498 Renewable* renewable_ptr;
499 Storage* storage_ptr;
500
501 for (int i = 0; i < test_model.electrical_load.n_points; i++) {
502     net_load_kW = test_model.controller.net_load_vec_kW[i];
503
504     testLessThanOrEqualTo(
505         test_model.controller.net_load_vec_kW[i],
506         test_model.electrical_load.max_load_kW,
507         __FILE__,
508         __LINE__
509     );
510
511     for (size_t j = 0; j < test_model.combustion_ptr_vec.size(); j++) {
512         combustion_ptr = test_model.combustion_ptr_vec[j];
513
514         testFloatEquals(
515             combustion_ptr->production_vec_kW[i] -
516             combustion_ptr->dispatch_vec_kW[i] -
517             combustion_ptr->curtailment_vec_kW[i] -
518             combustion_ptr->storage_vec_kW[i],
519             0,
520             __FILE__,
521             __LINE__
522         );
523
524         net_load_kW -= combustion_ptr->production_vec_kW[i];
525     }
526
527     for (size_t j = 0; j < test_model.renewable_ptr_vec.size(); j++) {
528         renewable_ptr = test_model.renewable_ptr_vec[j];
529
530         testFloatEquals(
531             renewable_ptr->production_vec_kW[i] -
532             renewable_ptr->dispatch_vec_kW[i] -
533             renewable_ptr->curtailment_vec_kW[i] -
534             renewable_ptr->storage_vec_kW[i],
535             0,
536             __FILE__,
537             __LINE__
538         );
539
540         net_load_kW -= renewable_ptr->production_vec_kW[i];
541     }
542
543     for (size_t j = 0; j < test_model.storage_ptr_vec.size(); j++) {
544         storage_ptr = test_model.storage_ptr_vec[j];
545
546         testTruth(
547             not (
548                 storage_ptr->charging_power_vec_kW[i] > 0 and
549                 storage_ptr->discharging_power_vec_kW[i] > 0
550             ),
551             __FILE__,
552             __LINE__
553         );
554
555         net_load_kW -= storage_ptr->discharging_power_vec_kW[i];
556     }
557
558     testLessThanOrEqualTo(
559         net_load_kW,
560         0,
561         __FILE__,
562         __LINE__
563     );
564 }
565
566 testGreaterThan(
567     test_model.net_present_cost,

```

```

568     0,
569     __FILE__,
570     __LINE__
571 );
572
573 testFloatEquals(
574     test_model.total_dispatch_discharge_kWh,
575     2263351.62026685,
576     __FILE__,
577     __LINE__
578 );
579
580 testGreaterThan(
581     test_model.levelized_cost_of_energy_kWh,
582     0,
583     __FILE__,
584     __LINE__
585 );
586
587 testGreaterThan(
588     test_model.total_fuel_consumed_L,
589     0,
590     __FILE__,
591     __LINE__
592 );
593
594 testGreaterThan(
595     test_model.total_emissions.CO2_kg,
596     0,
597     __FILE__,
598     __LINE__
599 );
600
601 testGreaterThan(
602     test_model.total_emissions.CO_kg,
603     0,
604     __FILE__,
605     __LINE__
606 );
607
608 testGreaterThan(
609     test_model.total_emissions.NOx_kg,
610     0,
611     __FILE__,
612     __LINE__
613 );
614
615 testGreaterThan(
616     test_model.total_emissions.SOx_kg,
617     0,
618     __FILE__,
619     __LINE__
620 );
621
622 testGreaterThan(
623     test_model.total_emissions.CH4_kg,
624     0,
625     __FILE__,
626     __LINE__
627 );
628
629 testGreaterThan(
630     test_model.total_emissions.PM_kg,
631     0,
632     __FILE__,
633     __LINE__
634 );
635
636 // ===== END METHODS ===== //
637
638 } /* try */
639
640
641 catch (...) {
642     //...
643
644     printGold(" ..... ");
645     printRed("FAIL");
646     std::cout << std::endl;
647     throw;
648 }
649
650
651 printGold(" ..... ");
652 printGreen("PASS");
653 std::cout << std::endl;
654 return 0;

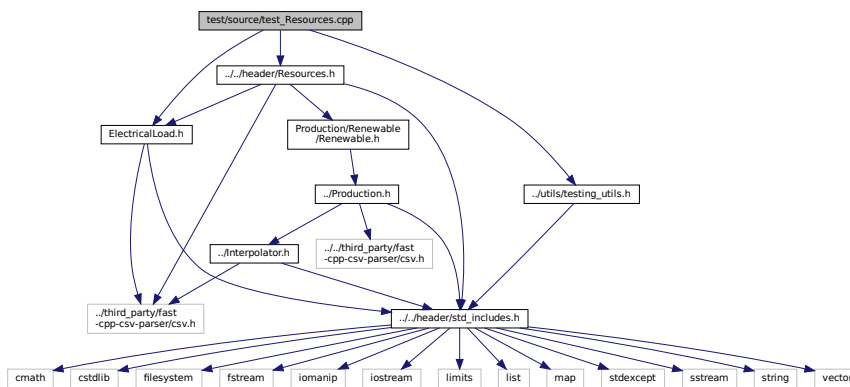
```

```
655 }    /* main() */
```

5.63 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)

5.63.1 Detailed Description

Testing suite for [Resources](#) class.

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

5.63.2 Function Documentation

5.63.2.1 main()

```

int main (
    int argc,
    char ** argv )
28 {
29     #ifdef _WIN32
30         activateVirtualTerminal();
31     #endif /* _WIN32 */
32
33     printGold("\tTesting Resources");
34
35     srand(time(NULL));
36
37
38     try {
39
40         // ===== CONSTRUCTION ===== //
41
42         std::string path_2_electrical_load_time_series =
43             "data/test/electrical_load/electrical_load_generic_peak-500kW_1yr_dt-1hr.csv";
44
45         ElectricalLoad test_electrical_load(path_2_electrical_load_time_series);
46
47         Resources test_resources;
48
49         // ===== END CONSTRUCTION ===== //
50
51
52
53         // ===== ATTRIBUTES ===== //
54
55         testFloatEquals(
56             test_resources.resource_map_1D.size(),
57             0,
58             __FILE__,
59             __LINE__
60         );
61
62         testFloatEquals(
63             test_resources.path_map_1D.size(),
64             0,
65             __FILE__,
66             __LINE__
67         );
68
69         testFloatEquals(
70             test_resources.resource_map_2D.size(),
71             0,
72             __FILE__,
73             __LINE__
74         );
75
76         testFloatEquals(
77             test_resources.path_map_2D.size(),
78             0,
79             __FILE__,
80             __LINE__
81         );
82
83         // ===== END ATTRIBUTES ===== //
84
85
86         // ===== METHODS ===== //
87
88         int solar_resource_key = 0;
89         std::string path_2_solar_resource_data =
90             "data/test/resources/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/resources/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/resources/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/resources/tidal_speed_peak-3ms_1yr_dt-1hr.csv";
220
221 test_resources.addResource(
222     RenewableType::TIDAL,
223     path_2_tidal_resource_data,
224     tidal_resource_key,
225     &test_electrical_load
226 );
227
228 std::vector<double> expected_tidal_resource_vec_ms = {
229     0.347439913040533,
230     0.770545522195602,
231     0.731352084836198,
232     0.293389814389542,
233     0.209959110813115,
234     0.610609623896497,
235     1.78067162013604,
236     2.53522775118089,
237     2.75966627832024,
238     2.52101111143895,
239     2.05389330201031,
240     1.3461515862445,
241     0.28909254878384,
242     0.897754086048563,
243     1.71406453837407,
244     1.85047408742869,
245     1.71507908595979,
246     1.33540349705416,
247     0.434586143463003,
248     0.500623815700637,
249     1.37172172646733,
250     1.68294125491228,
251     1.56101300975417,
252     1.04925834219412,
253     0.211395463930223,
254     1.03720048903385,
255     1.85059536356448,
256     1.85203242794517,
257     1.4091471616277,
258     0.767776539039899,
259     0.251464906990961,
260     1.47018469375652,
261     2.36260493698197,
262     2.46653750048625,
263     2.12851908739291,
264     1.62783753197988,
265     0.734594890957439,
266     0.441886297300355,
267     1.6574418350918,
268     2.0684558286637,
269     1.87717416992136,
270     1.58871262337931,
271     1.03451227609235,
272     0.193371305159817,
273     0.976400122458815,
274     1.6583227369707,
275     1.76690616570953,
276     1.54801328553115
277 };
278
279 for (size_t i = 0; i < expected_tidal_resource_vec_ms.size(); i++) {
280     testFloatEquals(
281         test_resources.resource_map_1D[tidal_resource_key][i],

```

```

282         expected_tidal_resource_vec_ms[i],
283         __FILE__,
284         __LINE__
285     );
286 }
287
288
289 int wave_resource_key = 2;
290 std::string path_2_wave_resource_data =
291     "data/test/resources/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/resources/wind_speed_peak-25ms_1yr_dt-1hr.csv";
422
423 test_resources.addResource(
424     RenewableType::WIND,
425     path_2_wind_resource_data,
426     wind_resource_key,
427     &test_electrical_load
428 );
429
430 std::vector<double> expected_wind_resource_vec_ms = {
431     6.88566688469997,
432     5.02177105466549,
433     3.74211715899568,
434     5.67169579985362,
435     4.90670669971858,
436     4.29586955031368,
437     7.41155377205065,
438     10.2243290476943,
439     13.1258696725555,
440     13.7016198628274,
441     16.2481482330233,
442     16.5096744355418,
443     13.4354482206162,
444     14.0129230731609,
445     14.5554549260515,
446     13.4454539065912,
447     13.3447169512094,
448     11.7372615098554,
449     12.7200070078013,
450     10.6421127908149,
451     6.09869498990661,
452     5.66355596602321,
453     4.97316966910831,
454     3.48937138360567,
455     2.15917470979169,

```



```

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

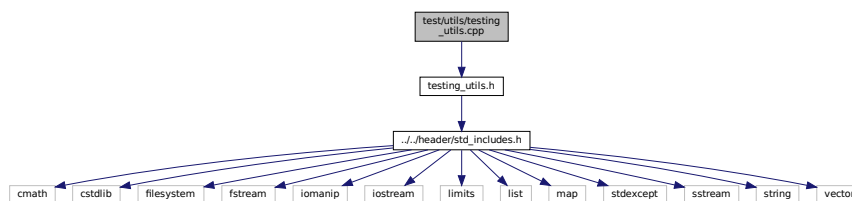
```

5.64 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.

5.64.1 Detailed Description

Header file for various PGMcpp testing utilities.

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

5.64.2 Function Documentation

5.64.2.1 `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() */
```

5.64.2.2 printGold()

```
void printGold (
    std::string input_str )
```

A function that sends gold text to std::cout.

Parameters

<i>input_str</i>	The text of the string to be sent to std::cout.
------------------	---

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

5.64.2.3 printGreen()

```
void printGreen (
    std::string input_str )
```

A function that sends green text to std::cout.

Parameters

<i>input_str</i>	The text of the string to be sent to std::cout.
------------------	---

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

5.64.2.4 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() */

```

5.64.2.5 testFloatEquals()

```

void testFloatEquals (
    double x,
    double y,
    std::string file,
    int line )

```

Tests for the equality of two floating point numbers x and y (to within `FLOAT_TOLERANCE`).

Parameters

<i>x</i>	The first of two numbers to test.
<i>y</i>	The second of two numbers to test.
<i>file</i>	The file in which the test is applied (you should be able to just pass in " <code>__FILE__</code> ").
<i>line</i>	The line of the file in which the test is applied (you should be able to just pass in " <code>__LINE__</code> ").

```

138 {
139     if (fabs(x - y) <= FLOAT_TOLERANCE) {
140         return;
141     }
142
143     std::string error_str = "ERROR: testFloatEquals():\t in ";
144     error_str += file;
145     error_str += "\tline ";
146     error_str += std::to_string(line);
147     error_str += ":\t\n";
148     error_str += std::to_string(x);
149     error_str += " and ";
150     error_str += std::to_string(y);
151     error_str += " are not equal to within +/- ";
152     error_str += std::to_string(FLOAT_TOLERANCE);
153     error_str += "\n";
154
155     #ifdef WIN32
156         std::cout << error_str << std::endl;
157     #endif
158
159     throw std::runtime_error(error_str);
160     return;
161 } /* testFloatEquals() */

```

5.64.2.6 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() */

```

5.64.2.7 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() */

```

5.64.2.8 testLessThan()

```

void testLessThan (
    double x,
    double y,
    std::string file,
    int line )

```

Tests if $x < y$.

Parameters

<i>x</i>	The first of two numbers to test.
<i>y</i>	The second of two numbers to test.
<i>file</i>	The file in which the test is applied (you should be able to just pass in "__FILE__").
<i>line</i>	The line of the file in which the test is applied (you should be able to just pass in "__LINE__").

```

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

```

5.64.2.9 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() */

```

5.64.2.10 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() */

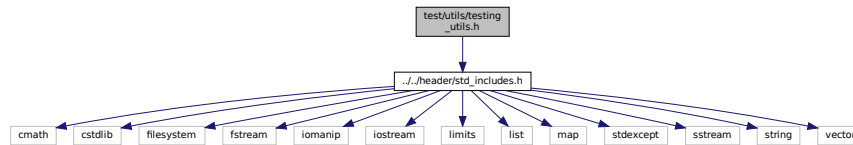
```

5.65 test/utills/testing_utils.h File Reference

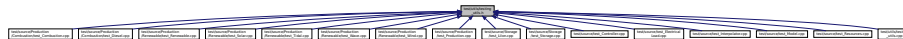
Header file for various PGMcpp testing utilities.

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

Include dependency graph for testing_utils.h:



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



Macros

- `#define FLOAT_TOLERANCE 1e-6`
A tolerance for application to floating point equality tests.

Functions

- void **printGreen** (std::string)
A function that sends green text to std::cout.
- void **printGold** (std::string)
A function that sends gold text to std::cout.
- void **printRed** (std::string)
A function that sends red text to std::cout.
- void **testFloatEquals** (double, double, std::string, int)
*Tests for the equality of two floating point numbers x and y (to within **FLOAT_TOLERANCE**).*
- void **testGreaterThan** (double, double, std::string, int)
Tests if $x > y$.
- void **testGreaterThanOrEqualTo** (double, double, std::string, int)
Tests if $x \geq y$.
- void **testLessThan** (double, double, std::string, int)
Tests if $x < y$.
- void **testLessThanOrEqualTo** (double, double, std::string, int)
Tests if $x \leq y$.
- void **testTruth** (bool, std::string, int)
Tests if the given statement is true.
- void **expectedErrorNotDetected** (std::string, int)
A utility function to print out a meaningful error message whenever an expected error fails to be thrown/caught/detected.

5.65.1 Detailed Description

Header file for various PGMcpp testing utilities.

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

5.65.2 Macro Definition Documentation

5.65.2.1 FLOAT_TOLERANCE

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

A tolerance for application to floating point equality tests.

5.65.3 Function Documentation

5.65.3.1 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() */
```

5.65.3.2 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() */

```

5.65.3.3 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() */

```

5.65.3.4 printRed()

```

void printRed (
    std::string input_str )

```

A function that sends red text to std::cout.

Parameters

<i>input_str</i>	The text of the string to be sent to std::cout.
------------------	---

```

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

```

5.65.3.5 testFloatEquals()

```

void testFloatEquals (
    double x,
    double y,
    std::string file,
    int line )

```

Tests for the equality of two floating point numbers *x* and *y* (to within FLOAT_TOLERANCE).

Parameters

<i>x</i>	The first of two numbers to test.
----------	-----------------------------------

Parameters

<i>y</i>	The second of two numbers to test.
<i>file</i>	The file in which the test is applied (you should be able to just pass in "__FILE__").
<i>line</i>	The line of the file in which the test is applied (you should be able to just pass in "__LINE__").

```

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

```

5.65.3.6 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() */

```

5.65.3.7 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() */

```

5.65.3.8 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() */

```

5.65.3.9 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() */

```

5.65.3.10 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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Index

- __applyCycleChargingControl_CHARGING
Controller, [27](#)
- __applyCycleChargingControl_DISCHARGING
Controller, [28](#)
- __applyLoadFollowingControl_CHARGING
Controller, [29](#)
- __applyLoadFollowingControl_DISCHARGING
Controller, [30](#)
- __checkBounds1D
Interpolator, [68](#)
- __checkBounds2D
Interpolator, [69](#)
- __checkDataKey1D
Interpolator, [70](#)
- __checkDataKey2D
Interpolator, [70](#)
- __checkInputs
Combustion, [14](#)
Diesel, [46](#)
Lilon, [88](#)
Model, [111](#)
Production, [130](#)
Renewable, [143](#)
Solar, [163](#)
Storage, [174](#)
Tidal, [189](#)
Wave, [203](#)
Wind, [219](#)
- __checkResourceKey1D
Resources, [151](#)
- __checkResourceKey2D
Resources, [151](#)
- __checkTimePoint
Resources, [152](#)
- __computeCubicProductionkW
Tidal, [190](#)
- __computeEconomics
Model, [112](#)
- __computeExponentialProductionkW
Tidal, [190](#)
Wind, [220](#)
- __computeFuelAndEmissions
Model, [112](#)
- __computeGaussianProductionkW
Wave, [204](#)
- __computeLevellizedCostOfEnergy
Model, [112](#)
- __computeLookupProductionkW
Tidal, [191](#)
Wave, [205](#)
Wind, [220](#)
- __computeNetLoad
Controller, [31](#)
- __computeNetPresentCost
Model, [113](#)
- __computeParaboloidProductionkW
Wave, [206](#)
- __computeRealDiscountAnnual
Storage, [175](#)
- __constructCombustionMap
Controller, [32](#)
- __getBcal
Lilon, [90](#)
- __getDataStringMatrix
Interpolator, [71](#)
- __getEacal
Lilon, [91](#)
- __getGenericCapitalCost
Diesel, [47](#)
Lilon, [91](#)
Solar, [163](#)
Tidal, [192](#)
Wave, [206](#)
Wind, [221](#)
- __getGenericFuelIntercept
Diesel, [48](#)
- __getGenericFuelSlope
Diesel, [48](#)
- __getGenericOpMaintCost
Diesel, [48](#)
Lilon, [91](#)
Solar, [163](#)
Tidal, [192](#)
Wave, [207](#)
Wind, [221](#)
- __getInterpolationIndex
Interpolator, [71](#)
- __getRenewableProduction
Controller, [33](#)
- __handleCombustionDispatch
Controller, [34](#)
- __handleDegradation
Lilon, [92](#)
- __handleStartStop
Diesel, [49](#)
Renewable, [143](#)
- __handleStorageCharging
Controller, [35](#), [37](#)

- __handleStorageDischarging
 - Controller, [38](#)
- __isNonNumeric
 - Interpolator, [72](#)
- __modelDegradation
 - Lilon, [92](#)
- __readData1D
 - Interpolator, [72](#)
- __readData2D
 - Interpolator, [73](#)
- __readSolarResource
 - Resources, [153](#)
- __readTidalResource
 - Resources, [154](#)
- __readWaveResource
 - Resources, [154](#)
- __readWindResource
 - Resources, [155](#)
- __splitCommaSeparatedString
 - Interpolator, [75](#)
- __throwLengthError
 - Resources, [156](#)
- __throwReadError
 - Interpolator, [76](#)
- __toggleDepleted
 - Lilon, [94](#)
- __writeSummary
 - Combustion, [14](#)
 - Diesel, [50](#)
 - Lilon, [94](#)
 - Model, [114](#)
 - Renewable, [144](#)
 - Solar, [164](#)
 - Storage, [176](#)
 - Tidal, [192](#)
 - Wave, [207](#)
 - Wind, [221](#)
- __writeTimeSeries
 - Combustion, [14](#)
 - Diesel, [52](#)
 - Lilon, [96](#)
 - Model, [116](#)
 - Renewable, [144](#)
 - Solar, [165](#)
 - Storage, [176](#)
 - Tidal, [193](#)
 - Wave, [209](#)
 - Wind, [223](#)
- ~Combustion
 - Combustion, [13](#)
- ~Controller
 - Controller, [27](#)
- ~Diesel
 - Diesel, [45](#)
- ~ElectricalLoad
 - ElectricalLoad, [61](#)
- ~Interpolator
 - Interpolator, [68](#)
- ~Lilon
 - Lilon, [87](#)
- ~Model
 - Model, [111](#)
- ~Production
 - Production, [129](#)
- ~Renewable
 - Renewable, [143](#)
- ~Resources
 - Resources, [150](#)
- ~Solar
 - Solar, [162](#)
- ~Storage
 - Storage, [174](#)
- ~Tidal
 - Tidal, [189](#)
- ~Wave
 - Wave, [203](#)
- ~Wind
 - Wind, [219](#)
- addData1D
 - Interpolator, [76](#)
- addData2D
 - Interpolator, [77](#)
- addDiesel
 - Model, [117](#)
- addLilon
 - Model, [117](#)
- addResource
 - Model, [118](#)
 - Resources, [157](#)
- addSolar
 - Model, [118](#)
- addTidal
 - Model, [119](#)
- addWave
 - Model, [119](#)
- addWind
 - Model, [119](#)
- applyDispatchControl
 - Controller, [38](#)
- capacity_kW
 - Production, [133](#)
 - ProductionInputs, [139](#)
- capital_cost
 - DieselInputs, [57](#)
 - LilonInputs, [105](#)
 - Production, [134](#)
 - SolarInputs, [169](#)
 - Storage, [179](#)
 - TidalInputs, [198](#)
 - WaveInputs, [214](#)
 - WindInputs, [229](#)
- capital_cost_vec
 - Production, [134](#)
 - Storage, [179](#)
- CH4_emissions_intensity_kgL

- Combustion, [19](#)
- DieselInputs, [57](#)
- CH4_emissions_vec_kg
 - Combustion, [19](#)
- CH4_kg
 - Emissions, [65](#)
- charge_kWh
 - Storage, [179](#)
- charge_vec_kWh
 - Storage, [180](#)
- charging_efficiency
 - Lilon, [100](#)
 - LilonInputs, [105](#)
- charging_power_vec_kW
 - Storage, [180](#)
- clear
 - Controller, [40](#)
 - ElectricalLoad, [61](#)
 - Model, [120](#)
 - Resources, [158](#)
- CO2_emissions_intensity_kgL
 - Combustion, [20](#)
 - DieselInputs, [57](#)
- CO2_emissions_vec_kg
 - Combustion, [20](#)
- CO2_kg
 - Emissions, [65](#)
- CO_emissions_intensity_kgL
 - Combustion, [20](#)
 - DieselInputs, [58](#)
- CO_emissions_vec_kg
 - Combustion, [20](#)
- CO_kg
 - Emissions, [65](#)
- Combustion, [9](#)
 - __checkInputs, [14](#)
 - __writeSummary, [14](#)
 - __writeTimeSeries, [14](#)
 - ~Combustion, [13](#)
 - CH4_emissions_intensity_kgL, [19](#)
 - CH4_emissions_vec_kg, [19](#)
 - CO2_emissions_intensity_kgL, [20](#)
 - CO2_emissions_vec_kg, [20](#)
 - CO_emissions_intensity_kgL, [20](#)
 - CO_emissions_vec_kg, [20](#)
 - Combustion, [12](#)
 - commit, [15](#)
 - computeEconomics, [16](#)
 - computeFuelAndEmissions, [16](#)
 - fuel_consumption_vec_L, [20](#)
 - fuel_cost_L, [20](#)
 - fuel_cost_vec, [21](#)
 - fuel_mode, [21](#)
 - fuel_mode_str, [21](#)
 - getEmissionskg, [16](#)
 - getFuelConsumptionL, [17](#)
 - handleReplacement, [18](#)
 - linear_fuel_intercept_LkWh, [21](#)
 - linear_fuel_slope_LkWh, [21](#)
 - nominal_fuel_escalation_annual, [21](#)
 - NOx_emissions_intensity_kgL, [22](#)
 - NOx_emissions_vec_kg, [22](#)
 - PM_emissions_intensity_kgL, [22](#)
 - PM_emissions_vec_kg, [22](#)
 - real_fuel_escalation_annual, [22](#)
 - requestProductionkW, [18](#)
 - SOx_emissions_intensity_kgL, [22](#)
 - SOx_emissions_vec_kg, [23](#)
 - total_emissions, [23](#)
 - total_fuel_consumed_L, [23](#)
 - type, [23](#)
 - writeResults, [18](#)
- Combustion.h
 - CombustionType, [237](#)
 - DIESEL, [237](#)
 - FUEL_MODE_LINEAR, [237](#)
 - FUEL_MODE_LOOKUP, [237](#)
 - FuelMode, [237](#)
 - N_COMBUSTION_TYPES, [237](#)
 - N_FUEL_MODES, [237](#)
- combustion_inputs
 - DieselInputs, [58](#)
- combustion_map
 - Controller, [41](#)
- combustion_ptr_vec
 - Model, [122](#)
- CombustionInputs, [24](#)
 - fuel_mode, [24](#)
 - nominal_fuel_escalation_annual, [24](#)
 - path_2_fuel_interp_data, [25](#)
 - production_inputs, [25](#)
- CombustionType
 - Combustion.h, [237](#)
- commit
 - Combustion, [15](#)
 - Diesel, [53](#)
 - Production, [131](#)
 - Renewable, [144](#)
 - Solar, [166](#)
 - Tidal, [194](#)
 - Wave, [209](#)
 - Wind, [224](#)
- commitCharge
 - Lilon, [96](#)
 - Storage, [176](#)
- commitDischarge
 - Lilon, [97](#)
 - Storage, [176](#)
- computeEconomics
 - Combustion, [16](#)
 - Production, [132](#)
 - Renewable, [145](#)
 - Storage, [176](#)
- computeFuelAndEmissions
 - Combustion, [16](#)
- computeProductionkW

- Renewable, 145, 146
- Solar, 166
- Tidal, 195
- Wave, 210
- Wind, 224
- computeRealDiscountAnnual
 - Production, 132
- control_mode
 - Controller, 41
 - ModelInputs, 125
- control_string
 - Controller, 41
- Controller, 25
 - __applyCycleChargingControl_CHARGING, 27
 - __applyCycleChargingControl_DISCHARGING, 28
 - __applyLoadFollowingControl_CHARGING, 29
 - __applyLoadFollowingControl_DISCHARGING, 30
 - __computeNetLoad, 31
 - __constructCombustionMap, 32
 - __getRenewableProduction, 33
 - __handleCombustionDispatch, 34
 - __handleStorageCharging, 35, 37
 - __handleStorageDischarging, 38
 - ~Controller, 27
 - applyDispatchControl, 38
 - clear, 40
 - combustion_map, 41
 - control_mode, 41
 - control_string, 41
 - Controller, 27
 - init, 40
 - missed_load_vec_kW, 41
 - net_load_vec_kW, 42
 - setControlMode, 40
- controller
 - Model, 123
- Controller.h
 - ControlMode, 232
 - CYCLE_CHARGING, 232
 - LOAD_FOLLOWING, 232
 - N_CONTROL_MODES, 232
- ControlMode
 - Controller.h, 232
- curtailment_vec_kW
 - Production, 134
- CYCLE_CHARGING
 - Controller.h, 232
- degradation_a_cal
 - Lilon, 100
 - LilonInputs, 105
- degradation_alpha
 - Lilon, 100
 - LilonInputs, 105
- degradation_B_hat_cal_0
 - Lilon, 100
 - LilonInputs, 105
- degradation_beta
 - Lilon, 100
- LilonInputs, 105
- degradation_Ea_cal_0
 - Lilon, 101
 - LilonInputs, 106
- degradation_r_cal
 - Lilon, 101
 - LilonInputs, 106
- degradation_s_cal
 - Lilon, 101
 - LilonInputs, 106
- derating
 - Solar, 168
 - SolarInputs, 169
- design_energy_period_s
 - Wave, 212
 - WaveInputs, 214
- design_significant_wave_height_m
 - Wave, 212
 - WaveInputs, 214
- design_speed_ms
 - Tidal, 197
 - TidalInputs, 198
 - Wind, 227
 - WindInputs, 229
- DIESEL
 - Combustion.h, 237
- Diesel, 42
 - __checkInputs, 46
 - __getGenericCapitalCost, 47
 - __getGenericFuelIntercept, 48
 - __getGenericFuelSlope, 48
 - __getGenericOpMaintCost, 48
 - __handleStartStop, 49
 - __writeSummary, 50
 - __writeTimeSeries, 52
 - ~Diesel, 45
 - commit, 53
 - Diesel, 44
 - handleReplacement, 53
 - minimum_load_ratio, 55
 - minimum_runtime_hrs, 55
 - requestProductionkW, 54
 - time_since_last_start_hrs, 55
- DieselInputs, 56
 - capital_cost, 57
 - CH4_emissions_intensity_kgL, 57
 - CO2_emissions_intensity_kgL, 57
 - CO_emissions_intensity_kgL, 58
 - combustion_inputs, 58
 - fuel_cost_L, 58
 - linear_fuel_intercept_LkWh, 58
 - linear_fuel_slope_LkWh, 58
 - minimum_load_ratio, 58
 - minimum_runtime_hrs, 59
 - NOx_emissions_intensity_kgL, 59
 - operation_maintenance_cost_kWh, 59
 - PM_emissions_intensity_kgL, 59
 - replace_running_hrs, 59

- SOx_emissions_intensity_kgL, [59](#)
- discharging_efficiency
 - Lilon, [101](#)
 - LilonInputs, [106](#)
- discharging_power_vec_kW
 - Storage, [180](#)
- dispatch_vec_kW
 - Production, [134](#)
- dt_vec_hrs
 - ElectricalLoad, [63](#)
- dynamic_energy_capacity_kWh
 - Lilon, [101](#)
- electrical_load
 - Model, [123](#)
- ElectricalLoad, [60](#)
 - ~ElectricalLoad, [61](#)
 - clear, [61](#)
 - dt_vec_hrs, [63](#)
 - ElectricalLoad, [61](#)
 - load_vec_kW, [63](#)
 - max_load_kW, [63](#)
 - mean_load_kW, [63](#)
 - min_load_kW, [64](#)
 - n_points, [64](#)
 - n_years, [64](#)
 - path_2_electrical_load_time_series, [64](#)
 - readLoadData, [62](#)
 - time_vec_hrs, [64](#)
- Emissions, [65](#)
 - CH4_kg, [65](#)
 - CO2_kg, [65](#)
 - CO_kg, [65](#)
 - NOx_kg, [66](#)
 - PM_kg, [66](#)
 - SOx_kg, [66](#)
- energy_capacity_kWh
 - Storage, [180](#)
 - StorageInputs, [184](#)
- expectedErrorNotDetected
 - testing_utils.cpp, [324](#)
 - testing_utils.h, [331](#)
- FLOAT_TOLERANCE
 - testing_utils.h, [331](#)
- fuel_consumption_vec_L
 - Combustion, [20](#)
- fuel_cost_L
 - Combustion, [20](#)
 - DieselInputs, [58](#)
- fuel_cost_vec
 - Combustion, [21](#)
- fuel_mode
 - Combustion, [21](#)
 - CombustionInputs, [24](#)
- FUEL_MODE_LINEAR
 - Combustion.h, [237](#)
- FUEL_MODE_LOOKUP
 - Combustion.h, [237](#)
- fuel_mode_str
 - Combustion, [21](#)
- FuelMode
 - Combustion.h, [237](#)
- gas_constant_JmolK
 - Lilon, [101](#)
 - LilonInputs, [106](#)
- getAcceptablekW
 - Lilon, [98](#)
 - Storage, [177](#)
- getAvailablekW
 - Lilon, [99](#)
 - Storage, [177](#)
- getEmissionskg
 - Combustion, [16](#)
- getFuelConsumptionL
 - Combustion, [17](#)
- handleReplacement
 - Combustion, [18](#)
 - Diesel, [53](#)
 - Lilon, [99](#)
 - Production, [133](#)
 - Renewable, [146](#)
 - Solar, [167](#)
 - Storage, [178](#)
 - Tidal, [196](#)
 - Wave, [211](#)
 - Wind, [226](#)
- header/Controller.h, [231](#)
- header/doxygen_cite.h, [233](#)
- header/ElectricalLoad.h, [233](#)
- header/Interpolator.h, [234](#)
- header/Model.h, [235](#)
- header/Production/Combustion/Combustion.h, [236](#)
- header/Production/Combustion/Diesel.h, [237](#)
- header/Production/Production.h, [238](#)
- header/Production/Renewable/Renewable.h, [239](#)
- header/Production/Renewable/Solar.h, [241](#)
- header/Production/Renewable/Tidal.h, [242](#)
- header/Production/Renewable/Wave.h, [243](#)
- header/Production/Renewable/Wind.h, [245](#)
- header/Resources.h, [246](#)
- header/std_includes.h, [247](#)
- header/Storage/Lilon.h, [248](#)
- header/Storage/Storage.h, [249](#)
- hysteresis_SOC
 - Lilon, [102](#)
 - LilonInputs, [106](#)
- init
 - Controller, [40](#)
- init_SOC
 - Lilon, [102](#)
 - LilonInputs, [107](#)
- interp1D
 - Interpolator, [77](#)
- interp2D

- Interpolator, 78
- interp_map_1D
 - Interpolator, 79
- interp_map_2D
 - Interpolator, 79
- Interpolator, 66
 - __checkBounds1D, 68
 - __checkBounds2D, 69
 - __checkDataKey1D, 70
 - __checkDataKey2D, 70
 - __getDataStringMatrix, 71
 - __getInterpolationIndex, 71
 - __isNonNumeric, 72
 - __readData1D, 72
 - __readData2D, 73
 - __splitCommaSeparatedString, 75
 - __throwReadError, 76
 - ~Interpolator, 68
 - addData1D, 76
 - addData2D, 77
 - interp1D, 77
 - interp2D, 78
 - interp_map_1D, 79
 - interp_map_2D, 79
 - Interpolator, 68
 - path_map_1D, 79
 - path_map_2D, 79
- interpolator
 - Production, 134
 - Storage, 180
- InterpolatorStruct1D, 80
 - max_x, 80
 - min_x, 80
 - n_points, 80
 - x_vec, 81
 - y_vec, 81
- InterpolatorStruct2D, 81
 - max_x, 82
 - max_y, 82
 - min_x, 82
 - min_y, 82
 - n_cols, 82
 - n_rows, 82
 - x_vec, 83
 - y_vec, 83
 - z_matrix, 83
- is_depleted
 - Storage, 180
- is_running
 - Production, 134
- is_running_vec
 - Production, 135
- is_sunk
 - Production, 135
 - ProductionInputs, 139
 - Storage, 181
 - StorageInputs, 184
- levellized_cost_of_energy_kWh
 - Model, 123
 - Production, 135
 - Storage, 181
- LIION
 - Storage.h, 250
- Lilon, 84
 - __checkInputs, 88
 - __getBcal, 90
 - __getEacal, 91
 - __getGenericCapitalCost, 91
 - __getGenericOpMaintCost, 91
 - __handleDegradation, 92
 - __modelDegradation, 92
 - __toggleDepleted, 94
 - __writeSummary, 94
 - __writeTimeSeries, 96
 - ~Lilon, 87
 - charging_efficiency, 100
 - commitCharge, 96
 - commitDischarge, 97
 - degradation_a_cal, 100
 - degradation_alpha, 100
 - degradation_B_hat_cal_0, 100
 - degradation_beta, 100
 - degradation_Ea_cal_0, 101
 - degradation_r_cal, 101
 - degradation_s_cal, 101
 - discharging_efficiency, 101
 - dynamic_energy_capacity_kWh, 101
 - gas_constant_JmolK, 101
 - getAcceptablekW, 98
 - getAvailablekW, 99
 - handleReplacement, 99
 - hysteresis_SOC, 102
 - init_SOC, 102
 - Lilon, 86
 - max_SOC, 102
 - min_SOC, 102
 - replace_SOH, 102
 - SOH, 102
 - SOH_vec, 103
 - temperature_K, 103
- LilonInputs, 103
 - capital_cost, 105
 - charging_efficiency, 105
 - degradation_a_cal, 105
 - degradation_alpha, 105
 - degradation_B_hat_cal_0, 105
 - degradation_beta, 105
 - degradation_Ea_cal_0, 106
 - degradation_r_cal, 106
 - degradation_s_cal, 106
 - discharging_efficiency, 106
 - gas_constant_JmolK, 106
 - hysteresis_SOC, 106
 - init_SOC, 107
 - max_SOC, 107
 - min_SOC, 107

- operation_maintenance_cost_kWh, 107
- replace_SOH, 107
- storage_inputs, 107
- temperature_K, 108
- linear_fuel_intercept_LkWh
 - Combustion, 21
 - DieselInputs, 58
- linear_fuel_slope_LkWh
 - Combustion, 21
 - DieselInputs, 58
- LOAD_FOLLOWING
 - Controller.h, 232
- load_vec_kW
 - ElectricalLoad, 63
- main
 - test_Combustion.cpp, 264
 - test_Controller.cpp, 299
 - test_Diesel.cpp, 266
 - test_ElectricalLoad.cpp, 300
 - test_Interpolator.cpp, 303
 - test_Lilon.cpp, 293
 - test_Model.cpp, 309
 - test_Production.cpp, 291
 - test_Renewable.cpp, 273
 - test_Resources.cpp, 317
 - test_Solar.cpp, 274
 - test_Storage.cpp, 296
 - test_Tidal.cpp, 278
 - test_Wave.cpp, 282
 - test_Wind.cpp, 287
- max_load_kW
 - ElectricalLoad, 63
- max_SOC
 - Lilon, 102
 - LilonInputs, 107
- max_x
 - InterpolatorStruct1D, 80
 - InterpolatorStruct2D, 82
- max_y
 - InterpolatorStruct2D, 82
- mean_load_kW
 - ElectricalLoad, 63
- min_load_kW
 - ElectricalLoad, 64
- min_SOC
 - Lilon, 102
 - LilonInputs, 107
- min_x
 - InterpolatorStruct1D, 80
 - InterpolatorStruct2D, 82
- min_y
 - InterpolatorStruct2D, 82
- minimum_load_ratio
 - Diesel, 55
 - DieselInputs, 58
- minimum_runtime_hrs
 - Diesel, 55
 - DieselInputs, 59
- missed_load_vec_kW
 - Controller, 41
- Model, 108
 - __checkInputs, 111
 - __computeEconomics, 112
 - __computeFuelAndEmissions, 112
 - __computeLevellizedCostOfEnergy, 112
 - __computeNetPresentCost, 113
 - __writeSummary, 114
 - __writeTimeSeries, 116
 - ~Model, 111
 - addDiesel, 117
 - addLilon, 117
 - addResource, 118
 - addSolar, 118
 - addTidal, 119
 - addWave, 119
 - addWind, 119
 - clear, 120
 - combustion_ptr_vec, 122
 - controller, 123
 - electrical_load, 123
 - levellized_cost_of_energy_kWh, 123
 - Model, 110
 - net_present_cost, 123
 - renewable_ptr_vec, 123
 - reset, 120
 - resources, 123
 - run, 121
 - storage_ptr_vec, 124
 - total_dispatch_discharge_kWh, 124
 - total_emissions, 124
 - total_fuel_consumed_L, 124
 - writeResults, 121
- ModelInputs, 124
 - control_mode, 125
 - path_2_electrical_load_time_series, 125
- n_cols
 - InterpolatorStruct2D, 82
- N_COMBUSTION_TYPES
 - Combustion.h, 237
- N_CONTROL_MODES
 - Controller.h, 232
- N_FUEL_MODES
 - Combustion.h, 237
- n_points
 - ElectricalLoad, 64
 - InterpolatorStruct1D, 80
 - Production, 135
 - Storage, 181
- N_RENEWABLE_TYPES
 - Renewable.h, 240
- n_replacements
 - Production, 135
 - Storage, 181
- n_rows
 - InterpolatorStruct2D, 82
- n_starts

- Production, [135](#)
- N_STORAGE_TYPES
 - Storage.h, [250](#)
- N_TIDAL_POWER_PRODUCTION_MODELS
 - Tidal.h, [243](#)
- N_WAVE_POWER_PRODUCTION_MODELS
 - Wave.h, [244](#)
- N_WIND_POWER_PRODUCTION_MODELS
 - Wind.h, [246](#)
- n_years
 - ElectricalLoad, [64](#)
 - Production, [136](#)
 - Storage, [181](#)
- net_load_vec_kW
 - Controller, [42](#)
- net_present_cost
 - Model, [123](#)
 - Production, [136](#)
 - Storage, [181](#)
- nominal_discount_annual
 - Production, [136](#)
 - ProductionInputs, [139](#)
 - Storage, [182](#)
 - StorageInputs, [184](#)
- nominal_fuel_escalation_annual
 - Combustion, [21](#)
 - CombustionInputs, [24](#)
- nominal_inflation_annual
 - Production, [136](#)
 - ProductionInputs, [139](#)
 - Storage, [182](#)
 - StorageInputs, [185](#)
- NOx_emissions_intensity_kgL
 - Combustion, [22](#)
 - DieselInputs, [59](#)
- NOx_emissions_vec_kg
 - Combustion, [22](#)
- NOx_kg
 - Emissions, [66](#)
- operation_maintenance_cost_kWh
 - DieselInputs, [59](#)
 - LilonInputs, [107](#)
 - Production, [136](#)
 - SolarInputs, [169](#)
 - Storage, [182](#)
 - TidalInputs, [198](#)
 - WaveInputs, [214](#)
 - WindInputs, [229](#)
- operation_maintenance_cost_vec
 - Production, [136](#)
 - Storage, [182](#)
- path_2_electrical_load_time_series
 - ElectricalLoad, [64](#)
 - ModelInputs, [125](#)
- path_2_fuel_interp_data
 - CombustionInputs, [25](#)
- path_2_normalized_performance_matrix
 - WaveInputs, [214](#)
- path_map_1D
 - Interpolator, [79](#)
 - Resources, [158](#)
- path_map_2D
 - Interpolator, [79](#)
 - Resources, [159](#)
- PM_emissions_intensity_kgL
 - Combustion, [22](#)
 - DieselInputs, [59](#)
- PM_emissions_vec_kg
 - Combustion, [22](#)
- PM_kg
 - Emissions, [66](#)
- power_capacity_kW
 - Storage, [182](#)
 - StorageInputs, [185](#)
- power_kW
 - Storage, [182](#)
- power_model
 - Tidal, [197](#)
 - TidalInputs, [199](#)
 - Wave, [212](#)
 - WaveInputs, [215](#)
 - Wind, [227](#)
 - WindInputs, [229](#)
- power_model_string
 - Tidal, [197](#)
 - Wave, [212](#)
 - Wind, [227](#)
- print_flag
 - Production, [137](#)
 - ProductionInputs, [139](#)
 - Storage, [183](#)
 - StorageInputs, [185](#)
- printGold
 - testing_utils.cpp, [325](#)
 - testing_utils.h, [331](#)
- printGreen
 - testing_utils.cpp, [325](#)
 - testing_utils.h, [332](#)
- printRed
 - testing_utils.cpp, [325](#)
 - testing_utils.h, [332](#)
- Production, [126](#)
 - __checkInputs, [130](#)
 - ~Production, [129](#)
 - capacity_kW, [133](#)
 - capital_cost, [134](#)
 - capital_cost_vec, [134](#)
 - commit, [131](#)
 - computeEconomics, [132](#)
 - computeRealDiscountAnnual, [132](#)
 - curtailment_vec_kW, [134](#)
 - dispatch_vec_kW, [134](#)
 - handleReplacement, [133](#)
 - interpolator, [134](#)
 - is_running, [134](#)

- is_running_vec, 135
- is_sunk, 135
- levellized_cost_of_energy_kWh, 135
- n_points, 135
- n_replacements, 135
- n_starts, 135
- n_years, 136
- net_present_cost, 136
- nominal_discount_annual, 136
- nominal_inflation_annual, 136
- operation_maintenance_cost_kWh, 136
- operation_maintenance_cost_vec, 136
- print_flag, 137
- Production, 128
- production_vec_kW, 137
- real_discount_annual, 137
- replace_running_hrs, 137
- running_hours, 137
- storage_vec_kW, 137
- total_dispatch_kWh, 138
- type_str, 138
- production_inputs
 - CombustionInputs, 25
 - RenewableInputs, 148
- production_vec_kW
 - Production, 137
- ProductionInputs, 138
 - capacity_kW, 139
 - is_sunk, 139
 - nominal_discount_annual, 139
 - nominal_inflation_annual, 139
 - print_flag, 139
 - replace_running_hrs, 139
- PYBIND11_MODULE
 - PYBIND11_PGM.cpp, 251
- PYBIND11_PGM.cpp
 - PYBIND11_MODULE, 251
- pybindings/PYBIND11_PGM.cpp, 250
- pybindings/snippets/Production/Combustion/PYBIND11_Combustion.cpp, 251
- pybindings/snippets/Production/Combustion/PYBIND11_Diesel.cpp, 251
- pybindings/snippets/Production/PYBIND11_Production.cpp, 252
- pybindings/snippets/Production/Renewable/PYBIND11_Renewable.cpp, 252
- pybindings/snippets/Production/Renewable/PYBIND11_Solar.cpp, 252
- pybindings/snippets/Production/Renewable/PYBIND11_Tidal.cpp, 252
- pybindings/snippets/Production/Renewable/PYBIND11_Wave.cpp, 253
- pybindings/snippets/Production/Renewable/PYBIND11_Wind.cpp, 253
- pybindings/snippets/PYBIND11_Controller.cpp, 253
- pybindings/snippets/PYBIND11_ElectricalLoad.cpp, 254
- pybindings/snippets/PYBIND11_Interpolator.cpp, 254
- pybindings/snippets/PYBIND11_Model.cpp, 254
- pybindings/snippets/PYBIND11_Resources.cpp, 254
- pybindings/snippets/Storage/PYBIND11_Lilon.cpp, 255
- pybindings/snippets/Storage/PYBIND11_Storage.cpp, 255
- readLoadData
 - ElectricalLoad, 62
- real_discount_annual
 - Production, 137
 - Storage, 183
- real_fuel_escalation_annual
 - Combustion, 22
- Renewable, 140
 - __checkInputs, 143
 - __handleStartStop, 143
 - __writeSummary, 144
 - __writeTimeSeries, 144
 - ~Renewable, 143
 - commit, 144
 - computeEconomics, 145
 - computeProductionkW, 145, 146
 - handleReplacement, 146
 - Renewable, 142
 - resource_key, 147
 - type, 147
 - writeResults, 146
- Renewable.h
 - N_RENEWABLE_TYPES, 240
 - RenewableType, 240
 - SOLAR, 240
 - TIDAL, 240
 - WAVE, 240
 - WIND, 240
- renewable_inputs
 - SolarInputs, 170
 - TidalInputs, 199
 - WaveInputs, 215
 - WindInputs, 229
- renewable_ptr_vec
 - Model, 123
 - RenewableInputs, 148
 - production_inputs, 148
 - RenewableType
 - Renewable.h, 240
 - replace_running_hrs
 - DieselInputs, 59
 - Production, 137
 - ProductionInputs, 139
 - replace_SOH
 - Lilon, 102
 - LilonInputs, 107
 - requestProductionkW
 - Combustion, 18
 - Diesel, 54
- reset
 - Model, 120
- resource_key
 - Renewable, 147

- SolarInputs, 170
- TidalInputs, 199
- WaveInputs, 215
- WindInputs, 229
- resource_map_1D
 - Resources, 159
- resource_map_2D
 - Resources, 159
- Resources, 149
 - __checkResourceKey1D, 151
 - __checkResourceKey2D, 151
 - __checkTimePoint, 152
 - __readSolarResource, 153
 - __readTidalResource, 154
 - __readWaveResource, 154
 - __readWindResource, 155
 - __throwLengthError, 156
 - ~Resources, 150
 - addResource, 157
 - clear, 158
 - path_map_1D, 158
 - path_map_2D, 159
 - resource_map_1D, 159
 - resource_map_2D, 159
 - Resources, 150
 - string_map_1D, 159
 - string_map_2D, 159
- resources
 - Model, 123
- run
 - Model, 121
- running_hours
 - Production, 137
- setControlMode
 - Controller, 40
- SOH
 - Lilon, 102
- SOH_vec
 - Lilon, 103
- SOLAR
 - Renewable.h, 240
- Solar, 160
 - __checkInputs, 163
 - __getGenericCapitalCost, 163
 - __getGenericOpMaintCost, 163
 - __writeSummary, 164
 - __writeTimeSeries, 165
 - ~Solar, 162
 - commit, 166
 - computeProductionkW, 166
 - derating, 168
 - handleReplacement, 167
 - Solar, 161, 162
- SolarInputs, 168
 - capital_cost, 169
 - derating, 169
 - operation_maintenance_cost_kWh, 169
 - renewable_inputs, 170
 - resource_key, 170
- source/Controller.cpp, 255
- source/ElectricalLoad.cpp, 256
- source/Interpolator.cpp, 256
- source/Model.cpp, 257
- source/Production/Combustion/Combustion.cpp, 257
- source/Production/Combustion/Diesel.cpp, 258
- source/Production/Production.cpp, 259
- source/Production/Renewable/Renewable.cpp, 259
- source/Production/Renewable/Solar.cpp, 260
- source/Production/Renewable/Tidal.cpp, 260
- source/Production/Renewable/Wave.cpp, 261
- source/Production/Renewable/Wind.cpp, 261
- source/Resources.cpp, 262
- source/Storage/Lilon.cpp, 263
- source/Storage/Storage.cpp, 263
- SOx_emissions_intensity_kgL
 - Combustion, 22
 - DieselInputs, 59
- SOx_emissions_vec_kg
 - Combustion, 23
- SOx_kg
 - Emissions, 66
- Storage, 170
 - __checkInputs, 174
 - __computeRealDiscountAnnual, 175
 - __writeSummary, 176
 - __writeTimeSeries, 176
 - ~Storage, 174
 - capital_cost, 179
 - capital_cost_vec, 179
 - charge_kWh, 179
 - charge_vec_kWh, 180
 - charging_power_vec_kW, 180
 - commitCharge, 176
 - commitDischarge, 176
 - computeEconomics, 176
 - discharging_power_vec_kW, 180
 - energy_capacity_kWh, 180
 - getAcceptablekW, 177
 - getAvailablekW, 177
 - handleReplacement, 178
 - interpolator, 180
 - is_depleted, 180
 - is_sunk, 181
 - levellized_cost_of_energy_kWh, 181
 - n_points, 181
 - n_replacements, 181
 - n_years, 181
 - net_present_cost, 181
 - nominal_discount_annual, 182
 - nominal_inflation_annual, 182
 - operation_maintenance_cost_kWh, 182
 - operation_maintenance_cost_vec, 182
 - power_capacity_kW, 182
 - power_kW, 182
 - print_flag, 183
 - real_discount_annual, 183

- Storage, 173
- total_discharge_kWh, 183
- type, 183
- type_str, 183
- writeResults, 178
- Storage.h
 - LIION, 250
 - N_STORAGE_TYPES, 250
 - StorageType, 250
- storage_inputs
 - LilonInputs, 107
- storage_ptr_vec
 - Model, 124
- storage_vec_kW
 - Production, 137
- StorageInputs, 184
 - energy_capacity_kWh, 184
 - is_sunk, 184
 - nominal_discount_annual, 184
 - nominal_inflation_annual, 185
 - power_capacity_kW, 185
 - print_flag, 185
- StorageType
 - Storage.h, 250
- string_map_1D
 - Resources, 159
- string_map_2D
 - Resources, 159
- temperature_K
 - Lilon, 103
 - LilonInputs, 108
- test/source/Production/Combustion/test_Combustion.cpp, 264
- test/source/Production/Combustion/test_Diesel.cpp, 266
- test/source/Production/Renewable/test_Renewable.cpp, 272
- test/source/Production/Renewable/test_Solar.cpp, 273
- test/source/Production/Renewable/test_Tidal.cpp, 277
- test/source/Production/Renewable/test_Wave.cpp, 281
- test/source/Production/Renewable/test_Wind.cpp, 286
- test/source/Production/test_Production.cpp, 290
- test/source/Storage/test_Lilon.cpp, 293
- test/source/Storage/test_Storage.cpp, 296
- test/source/test_Controller.cpp, 298
- test/source/test_ElectricalLoad.cpp, 300
- test/source/test_Interpolator.cpp, 302
- test/source/test_Model.cpp, 308
- test/source/test_Resources.cpp, 317
- test/utis/testing_utils.cpp, 323
- test/utis/testing_utils.h, 329
- test_Combustion.cpp
 - main, 264
- test_Controller.cpp
 - main, 299
- test_Diesel.cpp
 - main, 266
- test_ElectricalLoad.cpp
 - main, 300
- test_Interpolator.cpp
 - main, 303
- test_Lilon.cpp
 - main, 293
- test_Model.cpp
 - main, 309
- test_Production.cpp
 - main, 291
- test_Renewable.cpp
 - main, 273
- test_Resources.cpp
 - main, 317
- test_Solar.cpp
 - main, 274
- test_Storage.cpp
 - main, 296
- test_Tidal.cpp
 - main, 278
- test_Wave.cpp
 - main, 282
- test_Wind.cpp
 - main, 287
- testFloatEquals
 - testing_utils.cpp, 326
 - testing_utils.h, 332
- testGreaterThan
 - testing_utils.cpp, 326
 - testing_utils.h, 333
- testGreaterThanOrEqualTo
 - testing_utils.cpp, 327
 - testing_utils.h, 334
- testing_utils.cpp
 - expectedErrorNotDetected, 324
 - printGold, 325
 - printGreen, 325
 - printRed, 325
 - testFloatEquals, 326
 - testGreaterThan, 326
 - testGreaterThanOrEqualTo, 327
 - testLessThan, 328
 - testLessThanOrEqualTo, 328
 - testTruth, 329
- testing_utils.h
 - expectedErrorNotDetected, 331
 - FLOAT_TOLERANCE, 331
 - printGold, 331
 - printGreen, 332
 - printRed, 332
 - testFloatEquals, 332
 - testGreaterThan, 333
 - testGreaterThanOrEqualTo, 334
 - testLessThan, 334
 - testLessThanOrEqualTo, 335
 - testTruth, 335
- testLessThan
 - testing_utils.cpp, 328
 - testing_utils.h, 334

- testLessThanOrEqualTo
 - testing_utils.cpp, 328
 - testing_utils.h, 335
- testTruth
 - testing_utils.cpp, 329
 - testing_utils.h, 335
- TIDAL
 - Renewable.h, 240
- Tidal, 186
 - __checkInputs, 189
 - __computeCubicProductionkW, 190
 - __computeExponentialProductionkW, 190
 - __computeLookupProductionkW, 191
 - __getGenericCapitalCost, 192
 - __getGenericOpMaintCost, 192
 - __writeSummary, 192
 - __writeTimeSeries, 193
 - ~Tidal, 189
 - commit, 194
 - computeProductionkW, 195
 - design_speed_ms, 197
 - handleReplacement, 196
 - power_model, 197
 - power_model_string, 197
 - Tidal, 188
- Tidal.h
 - N_TIDAL_POWER_PRODUCTION_MODELS, 243
 - TIDAL_POWER_CUBIC, 243
 - TIDAL_POWER_EXPONENTIAL, 243
 - TIDAL_POWER_LOOKUP, 243
 - TidalPowerProductionModel, 243
- TIDAL_POWER_CUBIC
 - Tidal.h, 243
- TIDAL_POWER_EXPONENTIAL
 - Tidal.h, 243
- TIDAL_POWER_LOOKUP
 - Tidal.h, 243
- TidalInputs, 197
 - capital_cost, 198
 - design_speed_ms, 198
 - operation_maintenance_cost_kWh, 198
 - power_model, 199
 - renewable_inputs, 199
 - resource_key, 199
- TidalPowerProductionModel
 - Tidal.h, 243
- time_since_last_start_hrs
 - Diesel, 55
- time_vec_hrs
 - ElectricalLoad, 64
- total_discharge_kWh
 - Storage, 183
- total_dispatch_discharge_kWh
 - Model, 124
- total_dispatch_kWh
 - Production, 138
- total_emissions
 - Combustion, 23
 - Model, 124
- total_fuel_consumed_L
 - Combustion, 23
 - Model, 124
- type
 - Combustion, 23
 - Renewable, 147
 - Storage, 183
- type_str
 - Production, 138
 - Storage, 183
- WAVE
 - Renewable.h, 240
- Wave, 200
 - __checkInputs, 203
 - __computeGaussianProductionkW, 204
 - __computeLookupProductionkW, 205
 - __computeParaboloidProductionkW, 206
 - __getGenericCapitalCost, 206
 - __getGenericOpMaintCost, 207
 - __writeSummary, 207
 - __writeTimeSeries, 209
 - ~Wave, 203
 - commit, 209
 - computeProductionkW, 210
 - design_energy_period_s, 212
 - design_significant_wave_height_m, 212
 - handleReplacement, 211
 - power_model, 212
 - power_model_string, 212
 - Wave, 202
- Wave.h
 - N_WAVE_POWER_PRODUCTION_MODELS, 244
 - WAVE_POWER_GAUSSIAN, 244
 - WAVE_POWER_LOOKUP, 244
 - WAVE_POWER_PARABOLOID, 244
 - WavePowerProductionModel, 244
- WAVE_POWER_GAUSSIAN
 - Wave.h, 244
- WAVE_POWER_LOOKUP
 - Wave.h, 244
- WAVE_POWER_PARABOLOID
 - Wave.h, 244
- WaveInputs, 213
 - capital_cost, 214
 - design_energy_period_s, 214
 - design_significant_wave_height_m, 214
 - operation_maintenance_cost_kWh, 214
 - path_2_normalized_performance_matrix, 214
 - power_model, 215
 - renewable_inputs, 215
 - resource_key, 215
- WavePowerProductionModel
 - Wave.h, 244
- WIND
 - Renewable.h, 240

Wind, [216](#)

- [__checkInputs](#), [219](#)
- [__computeExponentialProductionkW](#), [220](#)
- [__computeLookupProductionkW](#), [220](#)
- [__getGenericCapitalCost](#), [221](#)
- [__getGenericOpMaintCost](#), [221](#)
- [__writeSummary](#), [221](#)
- [__writeTimeSeries](#), [223](#)
- [~Wind](#), [219](#)
- [commit](#), [224](#)
- [computeProductionkW](#), [224](#)
- [design_speed_ms](#), [227](#)
- [handleReplacement](#), [226](#)
- [power_model](#), [227](#)
- [power_model_string](#), [227](#)
- [Wind](#), [218](#)

Wind.h

- [N_WIND_POWER_PRODUCTION_MODELS](#), [246](#)
- [WIND_POWER_EXPONENTIAL](#), [246](#)
- [WIND_POWER_LOOKUP](#), [246](#)
- [WindPowerProductionModel](#), [246](#)

WIND_POWER_EXPONENTIAL

- [Wind.h](#), [246](#)

WIND_POWER_LOOKUP

- [Wind.h](#), [246](#)

WindInputs, [228](#)

- [capital_cost](#), [229](#)
- [design_speed_ms](#), [229](#)
- [operation_maintenance_cost_kWh](#), [229](#)
- [power_model](#), [229](#)
- [renewable_inputs](#), [229](#)
- [resource_key](#), [229](#)

WindPowerProductionModel

- [Wind.h](#), [246](#)

writeResults

- [Combustion](#), [18](#)
- [Model](#), [121](#)
- [Renewable](#), [146](#)
- [Storage](#), [178](#)

x_vec

- [InterpolatorStruct1D](#), [81](#)
- [InterpolatorStruct2D](#), [83](#)

y_vec

- [InterpolatorStruct1D](#), [81](#)
- [InterpolatorStruct2D](#), [83](#)

z_matrix

- [InterpolatorStruct2D](#), [83](#)