
CERC hub reference manual

Release 0.2.0.10

CERC Next-Generation Cities

Oct 17, 2024

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CERC HUB' REFERENCE MANUAL

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1.3 About the HUB

This document contains the essential documentation for the CERC HUB, a set of classes, factories, and helpers that simplifies the research at urban scale in multiples domains; these components are designed around three central axes, **extensibility**, **code clarity** and **consistency** as we intend to allow domain experts to perform urban scale simulations with multiple programs and enrich the city from several data sources. HUB is composed of four main components: **city model structure**, **factories**, **catalogs** and, **helpers**.

- **City model structure** is the set of classes designed to be familiar to the domain experts; this familiarity will be possible thanks to using a *standard-based* approach in order to flatten the learning curve. These classes compose the CERC *data model* that provides a simple way to study cities at an urban scale after the enriching process.
- **Factories** are pieces of code in charge of import and export information in and out of the **data model** they will perform the needed conversions to read or write different formats such as epw weather files, insel files or citygml. these factories are mean to be extended, allowing the HUB ecosystem to expand with new formats.
- **Catalogs** are datasets used in the enrichment of the city that can also be used by third party consumers like researchers or simulations software.
- **Helpers** are sets of general tools used by any of the other parts and does not fit in any of the previous categories.

CITY MODEL STRUCTURE

The **city model structure** contains the common data model intended to represent a city digital twin, CERC team and contributors, will further extend these classes to include other domains, in the following sections, researchers and developers could find information about the methods and properties exposed by the city model structure classes.

Important: Please take a look to HUB tutorial to see how to use HUB for your own research

[\[how to use the hub\]](#)

2.2 Folder structure

2.2.1 city_model_structure

Main city objects.

```
../hub/hub/city_model_structure/  
├── building.py  
├── buildings_cluster.py  
├── city_object.py  
├── city_objects_cluster.py  
├── city.py  
├── greenery  
│   ├── __init__.py  
│   ├── plant.py  
│   ├── soil.py  
│   └── vegetation.py  
├── __init__.py  
├── level_of_detail.py  
├── network.py  
└── parts_consisting_building.py
```

2 directories, 13 files

2.2.2 attributes

Geometrical and non physical components of the city.

```
../hub/hub/city_model_structure/attributes/  
├── edge.py  
├── __init__.py  
├── node.py  
├── plane.py  
├── point.py  
├── polygon.py  
├── polyhedron.py  
├── record.py  
├── schedule.py  
└── time_series.py
```

1 directory, 10 files

2.2.3 building_demand

Main classes to model building energy demand.

```
../hub/hub/city_model_structure/building_demand/
├── appliances.py
├── construction.py
├── domestic_hot_water.py
├── household.py
├── __init__.py
├── internal_gain.py
├── internal_zone.py
├── layer.py
├── lighting.py
├── occupancy.py
├── storey.py
├── surface.py
├── thermal_archetype.py
├── thermal_boundary.py
├── thermal_control.py
├── thermal_opening.py
├── thermal_zone.py
└── usage.py
```

1 directory, 18 files

2.2.4 energy_systems

Main classes to model energy systems.

```
../hub/hub/city_model_structure/energy_systems/
├── control_system.py
├── distribution_system.py
├── electrical_storage_system.py
├── emission_system.py
├── energy_storage_system.py
├── energy_system.py
├── generation_system.py
├── __init__.py
├── non_pv_generation_system.py
├── performance_curve.py
├── pv_generation_system.py
└── thermal_storage_system.py
```

1 directory, 12 files

2.2.5 iot

Classes to model IoT devices.

```
../hub/hub/city_model_structure/iot/
├── __init__.py
├── sensor_measure.py
├── sensor.py
├── sensor_type.py
└── station.py
```

1 directory, 5 files

2.2.6 full schema

```

../hub/hub/city_model_structure/
├── attributes
│   ├── edge.py
│   ├── __init__.py
│   ├── node.py
│   ├── plane.py
│   ├── point.py
│   ├── polygon.py
│   ├── polyhedron.py
│   ├── record.py
│   ├── schedule.py
│   └── time_series.py
├── building_demand
│   ├── appliances.py
│   ├── construction.py
│   ├── domestic_hot_water.py
│   ├── household.py
│   ├── __init__.py
│   ├── internal_gain.py
│   ├── internal_zone.py
│   ├── layer.py
│   ├── lighting.py
│   ├── occupancy.py
│   ├── storey.py
│   ├── surface.py
│   ├── thermal_archetype.py
│   ├── thermal_boundary.py
│   ├── thermal_control.py
│   ├── thermal_opening.py
│   ├── thermal_zone.py
│   └── usage.py
├── energy_systems
│   ├── control_system.py
│   ├── distribution_system.py
│   ├── electrical_storage_system.py
│   ├── emission_system.py
│   ├── energy_storage_system.py
│   ├── energy_system.py
│   ├── generation_system.py
│   ├── __init__.py
│   ├── non_pv_generation_system.py
│   ├── performance_curve.py
│   ├── pv_generation_system.py
│   └── thermal_storage_system.py
├── greenery
│   ├── __init__.py
│   ├── plant.py
│   ├── soil.py
│   └── vegetation.py
├── iot
│   ├── __init__.py
│   ├── sensor_measure.py
│   ├── sensor.py
│   ├── sensor_type.py
│   └── station.py
├── building.py
├── buildings_cluster.py
├── city_object.py
├── city_objects_cluster.py
├── city.py
├── __init__.py
├── level_of_detail.py
├── network.py
└── parts_consisting_building.py

```

6 directories, 58 files

2.3 Classes

2.3.1 City

class `City`(*lower_corner*, *upper_corner*, *srs_name*)

Inherit: `:py:class:object`

City class

add_building_alias(*building*, *alias*)

Add an alias to the building

add_city_object(*new_city_object*)

Add a CityObject to the city

Parameter *new_city_object* CityObject

Returns None or not implemented error

add_city_objects_cluster(*new_city_objects_cluster*)


Add a CityObject to the city

Parameter *new_city_objects_cluster* CityObjectsCluster

Returns None or NotImplementedError

building_alias(*alias*) → Building[] | None

Retrieve the city CityObject with the given alias *alias*

 Building alias is not guaranteed to be unique

Parameter *alias* str

Returns None or [CityObject]

property buildings → Optional[[*Building*]]

Get the buildings belonging to the city

Returns None or [Building]

property buildings_clusters → Optional[[*BuildingsCluster*]]

Get buildings clusters belonging to the city

Returns None or [BuildingsCluster]

city_object(*name*) → OptionalCityObject]

Retrieve the city CityObject with the given name

Parameter *name* str

Returns None or CityObject

property city_objects → Optional[[*CityObject*]]

Get the city objects belonging to the city

Returns None or [CityObject]

property city_objects_clusters → Optional[[*CityObjectsCluster*]]

Get city objects clusters belonging to the city

Returns None or [CityObjectsCluster]

- property climate_file** → Optional[Path]
Get the climate file full path
Returns None or Path
- property climate_reference_city** → Optional[str]
Get the name for the climatic information reference city
Returns None or str
- property copy** → *City*
Get a copy of the current city
- property country_code**
Get city country code
Returns str
- property generic_energy_systems** → dict
Get dictionary with generic energy systems installed in the city
Returns dict
- property latitude** → Optional[float]
Get city latitude in degrees
Returns None or float
- property level_of_detail** → *LevelOfDetail*
Get level of detail of different aspects of the city: geometry, construction and usage
Returns LevelOfDetail
- static load**(*city_filename*) → *City*
Load a city saved with city.save(*city_filename*)
Parameter *city_filename* city filename
Returns *City*
- static load_compressed**(*compressed_city_filename*, *destination_filename*) → *City*
Load a city from *compressed_city_filename*
Parameter *compressed_city_filename* Compressed pickle as source
Parameter *destination_filename* Pickle file as destination
Returns *City*
- property location** → *Location*
Get city location
Returns *Location*
- property longitude** → Optional[float]
Get city longitude in degrees
Returns None or float
- property lower_corner** → [float]
Get city lower corner
Returns [x,y,z]

merge(*city*) → *City*

Return a merged city combining the current city and the given one

Returns City

property name

Get city name

Returns str

property parts_consisting_buildings → Optional[[*PartsConsistingBuilding*]]

Get parts consisting buildings belonging to the city

Returns None or [PartsConsistingBuilding]

region(*center, radius*) → *City*

Get a region from the city

Parameter center specific point in space [x, y, z]

Parameter radius distance to center of the sphere selected in meters

Returns selected_region_city

property region_code

Get city region name

Returns str

remove_city_object(*city_object*)

Remove a CityObject from the city

Parameter city_object CityObject

Returns None

save(*city_filename*)

Save a city into the given filename

Parameter city_filename destination city filename

Returns None

save_compressed(*city_filename*)

Save a city into the given filename

Parameter city_filename destination city filename

Returns None

property srs_name → Optional[str]

Get city srs name

Returns None or str

property stations → [*Station*]

Get the sensors stations belonging to the city

Returns [Station]

property time_zone → Optional[float]

Get city time_zone

Returns None or float

property upper_corner → [float]

Get city upper corner

Returns [x,y,z]

2.3.2 CityObject

class CityObject(*name, surfaces*)

Inherit: :py:class:object

class CityObject

property beam → dict

Get beam radiation surrounding the city object in J/m2

Returns dict{dict{[float]}}

property centroid → [float]

Get city object centroid

Returns [x,y,z]

property detailed_polyhedron → *Polyhedron*

Get city object polyhedron including details such as holes

Returns Polyhedron

property diffuse → dict

Get diffuse radiation surrounding the city object in J/m2

Returns dict{dict{[float]}}

property direct_normal → dict

Get beam radiation surrounding the city object in J/m2

Returns dict{dict{[float]}}

property external_temperature → {float}

Get external temperature surrounding the city object in Celsius

Returns dict{dict{[float]}}

property global_horizontal → dict

Get global horizontal radiation surrounding the city object in J/m2

Returns dict{dict{[float]}}

property ground_temperature → dict

Get ground temperature under the city object in Celsius at different depths in meters for different time steps

example of use: {month: {0.5: [10, 10, 10, 10, 10, 10, 10, 10, 10, 10, 10]}}

Returns dict{dict{[float]}}

property level_of_detail → *LevelOfDetail*

Get level of detail of different aspects of the city: geometry, construction and usage

Returns LevelOfDetail

property lower_corner

Get city object lower corner coordinates [x, y, z]

Returns [x,y,z]

property max_height → float

Get city object maximal height in meters

Returns float

property name

Get city object name

Returns str

property neighbours → Optional[[*CityObject*]]

Get the list of neighbour_objects and their properties associated to the current city_object

property sensors → [*Sensor*]

Get sensors belonging to the city object

Returns [Sensor]

property simplified_polyhedron → *Polyhedron*

Get city object polyhedron, just the simple lod2 representation

Returns Polyhedron

surface(*name*) → OptionalSurface]

Get the city object surface with a given name

Parameter name str

Returns None or Surface

surface_by_id(*identification_number*) → OptionalSurface]

Get the city object surface with a given name

Parameter identification_number str

Returns None or Surface

property surfaces → [*Surface*]

Get city object surfaces

Returns [Surface]

property type → str

Get city object type

Returns str

property upper_corner

Get city object upper corner coordinates [x, y, z]

Returns [x,y,z]

property volume → float

Get city object volume in cubic meters

Returns float

2.3.3 City Objects Cluster

class CityObjectsCluster(*name, cluster_type, city_objects*)

Inherit: ABC, CityObject

CityObjectsCluster(ABC) class

add_city_object(*city_object*) → CityObject]

add new object to the cluster

Returns [CityObjects]

property city_objects

raises not implemented error

property name

Get cluster name

Returns str

property sensors → [*Sensor*]

Get sensors belonging to the city objects cluster

Returns [Sensor]

property type

raises not implemented error

2.3.4 Building

class Building(*name, surfaces, year_of_construction, function, terrains=None, city=None*)

Inherit: CityObject

Building(CityObject) class

add_alias(*value*)

Add a new alias for the building

property aliases

Get the alias name for the building

Returns str

property appliances_electrical_demand → dict

Get appliances electrical demand in J

Returns dict{[float]}

property appliances_peak_load → Optional[dict]

Get appliances peak load in W

Returns dict{[float]}

property attic_heated → Optional[int]

Get if the city object attic is heated

0: no attic in the building

1: attic exists but is not heated

2: attic exists and is heated

Returns None or int

property average_storey_height → Optional[float]

Get building average storey height in meters

Returns None or float

property basement_heated → Optional[int]

Get if the city object basement is heated

0: no basement in the building

1: basement exists but is not heated

2: basement exists and is heated

Returns None or int

property city → *City*

Get the city containing the building

Returns City

property cold_water_temperature → {float}

Get cold water temperature in degrees Celsius

Returns dict[{float}]

property cooling_consumption

Get energy consumption for cooling according to the cooling system installed in J

return: dict

property cooling_demand → dict

Get cooling demand in J

Returns dict[{float}]

property cooling_peak_load → Optional[dict]

Get cooling peak load in W

Returns dict[{float}]

property distribution_systems_electrical_consumption

Get total electricity consumption for distribution and emission systems in J

return: dict

property domestic_hot_water_consumption

Get energy consumption for domestic according to the domestic hot water system installed in J

return: dict

property domestic_hot_water_heat_demand → dict

Get domestic hot water heat demand in J

Returns dict[{float}]

property domestic_hot_water_peak_load → Optional[dict]

Get cooling peak load in W

Returns dict[{float}]

property eave_height

Get building eave height in meters

Returns float

property energy_consumption_breakdown → dict

Get energy consumption of different sectors

return: dict

property energy_systems → Optional[[EnergySystem]]

Get list of energy systems installed to cover the building demands

Returns [EnergySystem]

property energy_systems_archetype_name

Get energy systems archetype name

Returns str

property floor_area

Get building floor area in square meters

Returns float

property function → Optional[str]

Get building function

Returns None or str

property grounds → [*Surface*]

Get building ground surfaces

Returns [Surface]

property heating_consumption

Get energy consumption for heating according to the heating system installed in J

return: dict

property heating_demand → dict

Get heating demand in J

Returns dict{[float]}

property heating_peak_load → Optional[dict]

Get heating peak load in W

Returns dict{[float]}

property households → [*Household*]

Get the list of households inside the building

Returns List[Household]

property internal_walls → [*Surface*]

Get building internal wall surfaces

Returns [Surface]

property internal_zones → [*InternalZone*]

Get building internal zones

For Lod up to 3, there is only one internal zone which corresponds to the building shell.

In LoD 4 there can be more than one. In this case the definition of surfaces and floor area must be redefined.

Returns [*InternalZone*]

property is_conditioned

Get building heated flag

Returns Boolean

property lighting_electrical_demand → dict

Get lighting electrical demand in J

Returns dict{[float]}

property lighting_peak_load → Optional[dict]

Get lighting peak load in W

Returns dict{[float]}

property lower_corner

Get building lower corner.

property onsite_electrical_production

Get total electricity produced onsite in J

return: dict

property roof_type

Get roof type for the building flat or pitch

Returns str

property roofs → [*Surface*]

Get building roof surfaces

Returns [*Surface*]

property shell → *Polyhedron*

Get building's external polyhedron

Returns [*Polyhedron*]

property storeys_above_ground → Optional[int]

Get building storeys number above ground

Returns None or int

property terrains → Optional[[*Surface*]]

Get city object terrain surfaces

Returns [*Surface*]

property thermal_zones_from_internal_zones → Optional[[*ThermalZone*]]

Get building thermal zones

Returns [*ThermalZone*]

property upper_corner

Get building upper corner.

property usages_percentage

Get the usages and percentages for the building

property walls → [*Surface*]

Get building wall surfaces

Returns [*Surface*]**property year_of_construction**

Get building year of construction

Returns int

2.3.5 Parts Consisting Building

class **PartsConsistingBuilding**(*name, city_objects*)**Inherit:** **CityObjectsCluster**

PartsConsistingBuilding(CityObjectsCluster) class

property city_objects → [*CityObject*]

Get city objects that compose the cluster

Returns [*CityObject*]**property type**

Get type of cluster

Returns str

2.3.6 Buildings Cluster

class **BuildingsCluster**(*name, city_objects*)**Inherit:** **CityObjectsCluster**

BuildingsCluster(CityObjectsCluster) class

property city_objects → [*CityObject*]

Get the list of city objects conforming the cluster

Returns [*CityObject*]**property type**

Get cluster type

Returns str

2.3.7 Network

class Network(*name, edges=None, nodes=None*)

Inherit: CityObject

Generic network class to be used as base for the network models

property edges → [*Edge*]

Get network edges

Returns [Edge]

property id

Get network id, a universally unique identifier randomly generated

Returns str

property nodes → [*Node*]

Get network nodes

Returns [Node]

2.3.8 Level of detail

class LevelOfDetail

Inherit: :py:class:object

Level of detail for the city class

property construction

Get the city minimal construction level of detail, 1 or 2

Returns int

property energy_systems

Get the city minimal energy systems level of detail, 1 or 2

Returns int

property geometry

Get the city minimal geometry level of detail from 0 to 4

Returns int

property surface_radiation

Get the city minimal surface radiation level of detail, 0 (yearly), 1 (monthly), 2 (hourly)

Returns int

property usage

Get the city minimal usage level of detail, 1 or 2

Returns int

property weather

Get the city minimal weather level of detail, 0 (yearly), 1 (monthly), 2 (hourly)

Returns int

2.3.9 Edge

class `Edge(name, nodes=None)`

Inherit: `:py:class:object`

Generic edge class to be used as base for the network edges

property `id`

Get edge id, a universally unique identifier randomly generated

Returns str

property `name`

Get edge name

Returns str

property `nodes` → `[Node]`

Get delimiting nodes for the edge

Returns `[Node]`

2.3.10 Node

class `Node(name, edges=None)`

Inherit: `:py:class:object`

Generic node class to be used as base for the network nodes

property `edges` → `[Edge]`

Get edges delimited by the node

Returns `[Edge]`

property `id`

Get node id, a universally unique identifier randomly generated

Returns str

property `name`

Get node name

Returns str

property `time_series` → `TimeSeries`

Add explanation here

Returns add type of variable here

2.3.11 Plane

class `Plane(origin, normal)`

Inherit: `:py:class:object`

Plane class

distance_to_point(`point`)

Distance between the given point and the plane

Returns float

property equation()

Get the plane equation components $Ax + By + Cz + D = 0$

Returns (A, B, C, D)

property normal

Get plane normal [x, y, z]

Returns np.ndarray

property opposite_normal

get plane normal in the opposite direction [x, y, z]

Returns np.ndarray

property origin → *Point*

Get plane origin point

Returns Point

2.3.12 Point

class Point(*coordinates*)

Inherit: :py:class:object

Point class

property coordinates

Get point coordinates

Returns [ndarray]

distance_to_point(*other_point*)

Calculates distance between points in an n-D Euclidean space

Parameter other_point point or vertex

Returns float

2.3.13 Polygon

class Polygon(*coordinates*)

Inherit: :py:class:object

Polygon class

property area

Get surface area in square meters

Returns float

property coordinates → [ndarray]

Get the points in the shape of its coordinates belonging to the polygon [[x, y, z],...]

Returns [np.ndarray]

divide(*plane*)

Divides the polygon in two by a plane

Parameter *plane* plane that intersects with self to divide it in two parts (Plane)

Returns Polygon, Polygon, [Point]

property edges → [[*Point*]]

Get polygon edges list

Returns [[Point]]

property faces → [[int]]

Get polygon triangular faces

Returns [face]

property inverse

Get the polygon coordinates in reversed order

Returns [np.ndarray]

property normal → ndarray

Get surface normal vector

Returns np.ndarray

property plane → *Plane*

Get the polygon plane

Returns Plane

property points → [*Point*]

Get the points belonging to the polygon [[x, y, z],...]

Returns [Point]

property points_list → ndarray

Get the solid surface point coordinates list [x, y, z, x, y, z,...]

Returns np.ndarray

static triangle_mesh(*vertices, normal*) → Trimesh

Get the triangulated mesh for the polygon

Returns Trimesh

property triangles → [*Polygon*]

Triangulate the polygon and return a list of triangular polygons

Returns [Polygon]

property vertices → ndarray

Get polygon vertices

Returns np.ndarray(int)

2.3.14 Polyhedron

class Polyhedron(*polygons*)

Inherit: :py:class:object

Polyhedron class

property centroid → Optional[[float]]

Get polyhedron centroid

Returns [x,y,z]

property faces → [[int]]

Get polyhedron triangular faces

Returns [face]

property max_x

Get polyhedron maximal x value in meters

Returns float

property max_y

Get polyhedron maximal y value in meters

Returns float

property max_z

Get polyhedron maximal z value in meters

Returns float

property min_x

Get polyhedron minimal x value in meters

Returns float

property min_y

Get polyhedron minimal y value in meters

Returns float

property min_z

Get polyhedron minimal z value in meters

Returns float

obj_export(*full_path*)

Export the polyhedron to obj given file

Parameter full_path str

Returns None

show()

Auxiliary function to render the polyhedron

Returns None

stl_export(*full_path*)
 Export the polyhedron to stl given file
Parameter *full_path* str
Returns None

property trimesh → Optional[Trimesh]
 Get polyhedron trimesh
Returns Trimesh

property vertices → ndarray
 Get polyhedron vertices
Returns np.ndarray(int)

property volume
 Get polyhedron volume in cubic meters
Returns float

2.3.15 Record

class Record(*time=None, value=None, flag=None*)

Inherit: :py:class:object

Record class

property flag
 Add explanation here
Returns add type of variable here

property time
 Add explanation here
Returns add type of variable here

property value
 Add explanation here
Returns add type of variable here

2.3.16 Schedule

class Schedule

Inherit: :py:class:object

Schedule class

property data_type → Optional[str]
 Get schedule data type from:
 ['any_number', 'fraction', 'on_off', 'temperature', 'humidity', 'control_type']
Returns None or str

property day_types → Optional[[str]]

Get schedule day types, as many as needed from:

['monday', 'tuesday', 'wednesday', 'thursday', 'friday', 'saturday', 'sunday', 'holiday', 'winter_design_day',
 'summer_design_day']

Returns None or [str]

property id

Get schedule id, a universally unique identifier randomly generated

Returns str

property time_range → Optional[str]

Get schedule time range from:

['minute', 'hour', 'day', 'week', 'month', 'year']

Returns None or str

property time_step → Optional[str]

Get schedule time step from:

['second', 'minute', 'hour', 'day', 'week', 'month']

Returns None or str

property type → Optional[str]

Get schedule type

Returns None or str

property values

Get schedule values

Returns [Any]

2.3.17 Time Series

class TimeSeries(*time_series_type=None, records=None*)

Inherit: :py:class:object

TimeSeries class

property records → [Record]

Add explanation here

Returns List[Record]

property time_series_type

Add explanation here

Returns add type of variable here

2.3.18 Appliances

class Appliances

Inherit: `:py:class:object`

Appliances class

property convective_fraction → Optional[float]

Get convective fraction

Returns None or float

property density → Optional[float]

Get appliances density in Watts per m2

Returns None or float

property latent_fraction → Optional[float]

Get latent fraction

Returns None or float

property radiative_fraction → Optional[float]

Get radiant fraction

Returns None or float

property schedules → Optional[[*Schedule*]]

Get schedules

dataType = fraction

Returns None or [*Schedule*]

2.3.19 Household

class Household

Inherit: `:py:class:object`

Household class

property number_of_cars

Get number of cars owned by the householders

Returns int

property number_of_people

Get number of people living in the household

Returns int

2.3.20 Internal Gain

class InternalGain

Inherit: `:py:class:object`

InternalGain class

property average_internal_gain → Optional[float]

Get internal gains average internal gain in W/m2

Returns None or float

property convective_fraction → Optional[float]

Get internal gains convective fraction

Returns None or float

property latent_fraction → Optional[float]

Get internal gains latent fraction

Returns None or float

property radiative_fraction → Optional[float]

Get internal gains radiative fraction

Returns None or float

property schedules → Optional[[*Schedule*]]

Get internal gain schedules

data type = any number

time step = 1 hour

time range = 1 day

Returns [Schedule]

property type → Optional[str]

Get internal gains type

Returns None or string

2.3.21 Internal Zone

Note: The internal zone class represents each of the internal zones described in the geometry when imported.

This imported geometry can be later on divided in different thermal zones in a workflow (e.g. if the building with no interiors defined (LoD up to 3), it will produce one interior zone. Later on, this can be divided by storey and create one thermal zone per each).

Also, several usages can be associated with that internal zone. This usages are described in the Usage class, which has not only the parameters that describe each usage, but also the percentage of the internal zone volume that is affected by that specific use.

class InternalZone(*surfaces, area, volume*)

Inherit: `:py:class:object`

InternalZone class

property area

Get internal zone area in square meters

Returns float**property geometry** → *Polyhedron*

Get internal zone geometry

Returns Polyhedron**property id**

Get internal zone id, a universally unique identifier randomly generated

Returns str**property mean_height**

Get internal zone mean height in meters

Returns float**property surfaces**

Get internal zone surfaces

Returns [Surface]**property thermal_archetype** → ThermalArchetype

Get thermal archetype parameters

Returns ThermalArchetype**property thermal_zones_from_internal_zones** → Optional[[*ThermalZone*]]

Get building thermal zones as one per internal zone

Returns [ThermalZone]**property usages** → [*Usage*]

Get usage archetypes

Returns [Usage]**property volume**

Get internal zone volume in cubic meters

Returns float

2.3.22 Layer

class Layer**Inherit:** :py:class:object

Layer class

property conductivity → Optional[float]

Get material conductivity in W/mK

Returns None or float**property density** → Optional[float]Get material density in kg/m³**Returns** None or float

property id

Get layer id, a universally unique identifier randomly generated

Returns str

property material_name

Get material name

Returns str

property no_mass → Optional[bool]

Get material no mass flag

Returns None or Boolean

property solar_absorptance → Optional[float]

Get material solar absorptance

Returns None or float

property specific_heat → Optional[float]

Get material conductivity in J/kgK

Returns None or float

property thermal_absorptance → Optional[float]

Get material thermal absorptance

Returns None or float

property thermal_resistance → Optional[float]

Get material thermal resistance in m2K/W

Returns None or float

property thickness → Optional[float]

Get layer thickness in meters

Returns None or float

property visible_absorptance → Optional[float]

Get material visible absorptance

Returns None or float

2.3.23 Lighting

class Lighting

Inherit: :py:class:object

Lighting class

property convective_fraction → Optional[float]

Get convective fraction

Returns None or float

property density → Optional[float]

Get lighting density in Watts per m2

Returns None or float

property latent_fraction → Optional[float]

Get latent fraction

Returns None or float

property radiative_fraction → Optional[float]

Get radiant fraction

Returns None or float

property schedules → Optional[[*Schedule*]]

Get schedules

dataType = fraction

Returns None or [Schedule]

2.3.24 Occupancy

class Occupancy

Inherit: :py:class:object

Occupancy class

property latent_internal_gain → Optional[float]

Get latent internal gain in Watts per m2

Returns None or float

property occupancy_density → Optional[float]

Get density in persons per m2

Returns None or float

property occupancy_schedules → Optional[[*Schedule*]]

Get occupancy schedules

dataType = fraction

Returns None or [Schedule]

property sensible_convective_internal_gain → Optional[float]

Get sensible convective internal gain in Watts per m2

Returns None or float

property sensible_radiative_internal_gain → Optional[float]

Get sensible radiant internal gain in Watts per m2

Returns None or float

2.3.25 Storey

class Storey(*name, storey_surfaces, neighbours, volume, internal_zone, floor_area*)

Inherit: :py:class:object

Storey class

property floor_area

Get storey's floor area in square meters

Returns float

property name

Get storey's name

Returns str

property neighbours

Get the neighbour storeys' names

Returns [str]

property surfaces → [*Surface*]

Get external surfaces enclosing the storey

Returns [Surface]

property thermal_boundaries → [*ThermalBoundary*]

Get the thermal boundaries bounding the thermal zone

Returns [ThermalBoundary]

property thermal_zone → *ThermalZone*

Get the thermal zone inside the storey

Returns ThermalZone

property virtual_surfaces → [*Surface*]

Get the internal surfaces enclosing the thermal zone

Returns [Surface]

property volume

Get storey's volume in cubic meters

Returns float

2.3.26 Surface

class Surface(*solid_polygon, perimeter_polygon, holes_polygons=None, name=None, surface_type=None*)

Inherit: :py:class:object

Surface class

property associated_thermal_boundaries → Optional[[*ThermalBoundary*]]

Get the list of thermal boundaries that has this surface as external face

Returns None or [ThermalBoundary]

property azimuth

Get surface azimuth in radians (north = 0)

Returns float

divide(*z*)

Divides a surface at Z plane

Returns Surface, Surface, Any

property global_irradiance → dict

Get global irradiance on surface in W/m²

Returns dict

property global_irradiance_tilted → dict

Get global irradiance on a tilted surface in W/m²

Returns dict

property holes_polygons → Optional[[*Polygon*]]

Get hole surfaces, a list of hole polygons found in the surface

Returns None, [] or [*Polygon*]

None -> not known whether holes exist in reality or not due to low level of detail of input data

[] -> no holes in the surface

[*Polygon*] -> one or more holes in the surface

property id

Get the surface id

Returns str

property inclination

Get surface inclination in radians (zenith = 0, horizon = pi/2)

Returns float

property installed_solar_collector_area

Get installed solar collector area in m²

Returns dict

property inverse → *Surface*

Get the inverse surface (the same surface pointing backwards)

Returns *Surface*

property long_wave_emittance

Get the long wave emittance of the surface

The thermal absorptance can be calculated as 1-long_wave_emittance

Returns float

property lower_corner

Get surface's lower corner [x, y, z]

Returns [float]

property name

Get the surface name

Returns str

property percentage_shared

Get percentage of the wall shared with other walls

Returns float

property perimeter_area

Get perimeter surface area in square meters (opaque + transparent)

Returns float

property perimeter_polygon → *Polygon*

Get a polygon surface defined by the perimeter, merging solid and holes

Returns Polygon

property short_wave_reflectance

Get the short wave reflectance, this includes all solar spectrum, visible and not visible

The absorptance as an opaque surface, can be calculated as 1-short_wave_reflectance

Returns float

property solar_collectors_area_reduction_factor

Get factor area collector per surface area if set or calculate using Romero Rodriguez, L. et al (2017) model if not

Returns float

property solid_polygon → *Polygon*

Get the solid surface

Returns Polygon

property type

Get surface type Ground, Ground wall, Wall, Attic floor, Interior slab, Interior wall, Roof or Virtual internal

If the geometrical LoD is lower than 4,

the surfaces' types are not defined in the importer and can only be Ground, Wall or Roof

Returns str

property upper_corner

Get surface's upper corner [x, y, z]

Returns [float]

property vegetation → Optional[*Vegetation*]

Get the vegetation construction at the external surface of the thermal boundary

Returns None or Vegetation

2.3.27 Thermal Boundary

class ThermalBoundary(*parent_surface, opaque_area, windows_areas*)

Inherit: :py:class:object

ThermalBoundary class

property construction_name

Get construction name

Returns str

property he → Optional[float]

Get external convective heat transfer coefficient (W/m²K)

Returns None or float

property hi → Optional[float]

Get internal convective heat transfer coefficient (W/m²K)

Returns None or float

property id

Get thermal zone id, a universally unique identifier randomly generated

Returns str

property internal_surface → *Surface*

Get the internal surface of the thermal boundary

Returns Surface

property layers → [*Layer*]

Get thermal boundary layers

Returns [Layers]

property opaque_area

Get the thermal boundary area in square meters

Returns float

property parent_surface → *Surface*

Get the surface that belongs to the thermal boundary, considered the external surface of that boundary

Returns Surface

property thermal_openings → Optional[*ThermalOpening*]

Get thermal boundary thermal openings

Returns None or [ThermalOpening]

property thermal_zones → [*ThermalZone*]

Get the thermal zones delimited by the thermal boundary

Returns [ThermalZone]

property thickness

Get the thermal boundary thickness in meters

Returns float

property type

Get thermal boundary surface type

Returns str

property u_value → Optional[float]

Get thermal boundary U-value in W/m²K

internal and external convective coefficient in W/m²K values, can be configured at configuration.ini

Returns None or float

property window_ratio → Optional[float]

Get thermal boundary window ratio

It returns the window ratio calculated as the total windows' areas in a wall divided by

the total (opaque + transparent) area of that wall if windows are defined in the geometry imported.

If not, it returns the window ratio imported from an external source (e.g. construction library, manually assigned).

If none of those sources are available, it returns None.

Returns float

property windows_areas → [float]

Get windows areas

Returns [float]

2.3.28 Thermal Control

class ThermalControl

Inherit: :py:class:object

ThermalControl class

property cooling_set_point_schedules → Optional[[Schedule]]

Get cooling set point schedule defined for a thermal zone in Celsius

dataType = temperature

Returns None or [Schedule]

property heating_set_back → Optional[float]

Get heating set back defined for a thermal zone in Celsius

Returns None or float

property heating_set_point_schedules → Optional[[Schedule]]

Get heating set point schedule defined for a thermal zone in Celsius

dataType = temperature

Returns None or [Schedule]

property hvac_availability_schedules → Optional[[Schedule]]

Get the availability of the conditioning system defined for a thermal zone

dataType = on/off

Returns None or [Schedule]

property mean_cooling_set_point → Optional[float]
 Get cooling set point defined for a thermal zone in Celsius
Returns None or float

property mean_heating_set_point → Optional[float]
 Get heating set point defined for a thermal zone in Celsius
Returns None or float

2.3.29 Thermal Opening

class ThermalOpening

Inherit: :py:class:object

ThermalOpening class

property area → Optional[float]
 Get thermal opening area in square meters
Returns None or float

property conductivity → Optional[float]
 Get thermal opening conductivity in W/mK
Returns None or float

property construction_name
 Get thermal opening construction name

property frame_ratio → Optional[float]
 Get thermal opening frame ratio
Returns None or float

property g_value → Optional[float]
 Get thermal opening transmittance at normal incidence
Returns None or float

property he → Optional[float]
 Get external convective heat transfer coefficient (W/m²K)
Returns None or float

property hi → Optional[float]
 Get internal convective heat transfer coefficient (W/m²K)
Returns None or float

property id
 Get thermal zone id, a universally unique identifier randomly generated
Returns str

property overall_u_value → Optional[float]
 Get thermal opening overall U-value in W/m²K
Returns None or float

property thickness → Optional[float]
 Get thermal opening thickness in meters
Returns None or float

2.3.30 Thermal Zone

class ThermalZone(*thermal_boundaries, parent_internal_zone, volume, footprint_area, number_of_storeys, usage_name=None*)

Inherit: :py:class:object

ThermalZone class

property additional_thermal_bridge_u_value → Optional[float]
 Get thermal zone additional thermal bridge u value per footprint area W/m2K
Returns None or float

property appliances → Optional[Appliances]
 Get appliances information
Returns None or Appliances

property days_year → Optional[float]
 Get thermal zone usage days per year
Returns None or float

property domestic_hot_water → Optional[DomesticHotWater]
 Get domestic hot water information of this thermal zone
Returns None or DomesticHotWater

property effective_thermal_capacity → Optional[float]
 Get thermal zone effective thermal capacity in J/m3K
Returns None or float

property footprint_area → float
 Get thermal zone footprint area in m2
Returns float

property hours_day → Optional[float]
 Get thermal zone usage hours per day
Returns None or float

property id
 Get thermal zone id, a universally unique identifier randomly generated
Returns str

property indirectly_heated_area_ratio → Optional[float]
 Get thermal zone indirectly heated area ratio
Returns None or float

- property infiltration_rate_area_system_off**
Get thermal zone infiltration rate system off in air changes per second (1/s)
Returns None or float
- property infiltration_rate_area_system_on**
Get thermal zone infiltration rate system on in air changes per second (1/s)
Returns None or float
- property infiltration_rate_system_off**
Get thermal zone infiltration rate system off in air changes per second (1/s)
Returns None or float
- property infiltration_rate_system_on**
Get thermal zone infiltration rate system on in air changes per second (1/s)
Returns None or float
- property internal_gains** → Optional[[*InternalGain*]]
Calculates and returns the list of all internal gains defined
Returns [*InternalGain*]
- property lighting** → Optional[*Lighting*]
Get lighting information
Returns None or *Lighting*
- property mechanical_air_change** → Optional[float]
Get thermal zone mechanical air change in air change per second (1/s)
Returns None or float
- property occupancy** → Optional[*Occupancy*]
Get occupancy in the thermal zone
Returns None or *Occupancy*
- property ordinate_number** → Optional[int]
Get the order in which the thermal_zones need to be enumerated
Returns None or int
- property parent_internal_zone** → *InternalZone*
Get the internal zone to which this thermal zone belongs
Returns *InternalZone*
- property thermal_boundaries** → [*ThermalBoundary*]
Get thermal boundaries bounding with the thermal zone
Returns [*ThermalBoundary*]
- property thermal_control** → Optional[*ThermalControl*]
Get thermal control of this thermal zone
Returns None or *ThermalControl*

property total_floor_area

Get the total floor area of this thermal zone in m2

Returns float

property usage_name → Optional[str]

Get thermal zone usage name

Returns None or str

property usages

Get the thermal zone usages including percentage with the format [percentage]-usage_[percentage]-usage...

Eg: 70-office_30-residential

Returns str

property view_factors_matrix

Get thermal zone view factors matrix

Returns [[float]]

property volume

Get thermal zone volume

Returns float

2.3.31 Usage

class Usage

Inherit: :py:class:object

Usage class

property appliances → Optional[Appliances]

Get appliances information

Returns None or Appliances

property days_year → Optional[float]

Get usage zone usage days per year

Returns None or float

property domestic_hot_water → Optional[DomesticHotWater]

Get domestic hot water information

Returns None or ThermalControl

property hours_day → Optional[float]

Get usage zone usage hours per day

Returns None or float

property id

Get usage zone id, a universally unique identifier randomly generated

Returns str

- property internal_gains** → [*InternalGain*]
 Calculates and returns the list of all internal gains defined
Returns InternalGains
- property lighting** → Optional[*Lighting*]
 Get lighting information
Returns None or Lighting
- property mechanical_air_change** → Optional[float]
 Get usage zone mechanical air change in air change per second (1/s)
Returns None or float
- property name** → Optional[str]
 Get usage zone usage
Returns None or str
- property occupancy** → Optional[*Occupancy*]
 Get occupancy in the usage zone
Returns None or Occupancy
- property percentage**
 Get usage zone percentage in range[0,1]
Returns float
- property thermal_control** → Optional[*ThermalControl*]
 Get thermal control information
Returns None or ThermalControl

2.3.32 Plant

class Plant(*name, height, leaf_area_index, leaf_reflectivity, leaf_emissivity, minimal_stomatal_resistance, co2_sequestration, grows_on_soils*)

Inherit: :py:class:object

- Plant class
- property co2_sequestration**
 Get plant co2 sequestration capacity in kg CO2 equivalent
Returns float
- property grows_on** → [*Soil*]
 Get plant compatible soils
Returns [Soil]
- property height**
 Get plant height in m
Returns float

property leaf_area_index

Get plant leaf area index

Returns float**property leaf_emissivity**

Get plant leaf emissivity

Returns float**property leaf_reflectivity**

Get plant leaf area index

Returns float**property minimal_stomatal_resistance**

Get plant minimal stomatal resistance in s/m

Returns float**property name**

Get plant name

Returns string**property percentage**

Get percentage of plant in vegetation

Returns float

2.3.33 Soil

class Soil(*name, roughness, dry_conductivity, dry_density, dry_specific_heat, thermal_absorptance, solar_absorptance, visible_absorptance, saturation_volumetric_moisture_content, residual_volumetric_moisture_content*)

Inherit: :py:class:object

Soil class

property dry_conductivity

Get soil dry conductivity in W/mK

Returns float**property dry_density**Get soil dry density in kg/m³**Returns** float**property dry_specific_heat**

Get soil dry specific heat in J/kgK

Returns float**property initial_volumetric_moisture_content**

Get soil initial volumetric moisture content

Returns None or float

property name

Get soil name

Returns string**property residual_volumetric_moisture_content**

Get soil residual volumetric moisture content

Returns None or float**property roughness**

Get soil roughness

Returns string**property saturation_volumetric_moisture_content**

Get soil saturation volumetric moisture content

Returns float**property solar_absorptance**

Get soil solar absorptance

Returns float**property thermal_absorptance**

Get soil thermal absorptance

Returns float**property visible_absorptance**

Get soil visible absorptance

Returns float

2.3.34 Vegetation

class `Vegetation`(*name, soil, soil_thickness, plants*)**Inherit:** `:py:class:object`

Vegetation class

property air_gap

Get air gap in m

Returns float**property management**

Get management

Returns string**property name**

Get vegetation name

Returns string**property plants** → [*Plant*]

Get list plants in the vegetation

Returns List[Plant]

property soil → *Soil*

Get soil

Returns Soil

property soil_thickness

Get soil thickness in m

Returns float

2.3.35 Sensor

class Sensor

Inherit: :py:class:object

Sensor abstract class

property location → *Location*

Get sensor location

Returns Location

property measures → [*SensorMeasure*]

Raises not implemented error

property name

Get sensor name

Returns str

property type → <enum 'Sensor'>

Get sensor type

Returns str

property units

Get sensor units

Returns str

2.3.36 Sensor Measure

class SensorMeasure(*latitude, longitude, utc_timestamp, value*)

Inherit: :py:class:object

Sensor measure class

property latitude

Get measure latitude

property longitude

Get measure longitude

property utc_timestamp

Get measure timestamp in utc

property value

Get sensor measure value

2.3.37 Sensor Type

class `SensorType`(*value*, *names=None*, *, *module=None*, *qualname=None*, *type=None*, *start=1*, *boundary=None*)

Inherit: `Enum`

Sensor type enumeration

2.3.38 Station

class `Station`(*station_id=None*, *_mobile=False*)

Inherit: `:py:class:object`

Station class

property `id`

Get the station id a random uuid will be assigned if no ID was provided to the constructor

Returns ID

property `mobile`

Get if the station is mobile or not

Returns bool


property `sensors` → [*Sensor*]

Get the sensors belonging to the station

Returns [Sensor]

FACTORIES

Factories are divided into Imports and Exports, depending on if they are used to enrich (Import) the *city model structure* or to deliver third party defined formats (Export) such as **INSEL** or **IDF** file, the factories could be extended to include new imports and outputs providing an additional level of abstraction to researchers.

 Please, note that the private methods, the ones starting with an underscore character (`_`), documented in the factories are mean to be called by using the **handler** parameter; this parameter must contain the method name without the `_` character.

Note: For instance, to use `_citygml` handler in the Geometry factory, the handler parameter value needs to be `'citygml'`

 **This documentation includes only the base factories classes as these are the intended entry points for the Import/Export functionality.**

Important: Please refer to the development manual if you want to create your own factories.

[\[development manual\]](#)

3.1 Folder structure

3.1.1 Imports

```

./hub/hub/imports/
├── energy_systems
│   ├── __init__.py
│   ├── montreal_custom_energy_system_parameters.py
│   ├── montreal_future_energy_systems_parameters.py
│   └── north_america_custom_energy_system_parameters.py
├── results
│   ├── energy_plus.py
│   ├── energy_plus_single_building.py
│   ├── ep_multiple_buildings.py
│   ├── __init__.py
│   ├── insel_monthly_energy_balance.py
│   └── simplified_radiosity_algorithm.py
├── construction_factory.py
├── energy_systems_factory.py
├── geometry_factory.py
├── __init__.py
├── results_factory.py
├── usage_factory.py
└── weather_factory.py

```

3 directories, 17 files

3.1.2 Exports

```

./hub/hub/exports/
├── building_energy
│   ├── idf_files
│   │   ├── Energy+.idd
│   │   └── Minimal.idf
│   ├── insel
│   │   ├── __init__.py
│   │   └── insel_monthly_energy_balance.py
│   ├── energy_ade.py
│   ├── idf.py
│   └── __init__.py
├── energy_systems
│   ├── air_source_hp_export.py
│   ├── heat_pump_export.py
│   └── water_to_water_hp_export.py
├── energy_building_exports_factory.py
├── energy_systems_factory.py
├── exports_factory.py
└── __init__.py

```

5 directories, 14 files

3.2 Imports Classes

3.2.1 Construction Factory

class **ConstructionFactory**(*handler, city*)

Inherit: `:py:class:object`

ConstructionFactory class

_eilat()

Enrich the city by using Eilat information

_nrcan()

Enrich the city by using NRCAN information

_nrel()

Enrich the city by using NREL information

enrich()

Enrich the city given to the class using the class given handler

Returns None

3.2.2 Geometry Factory

class **GeometryFactory**(*file_type, path=None, aliases_field=None, height_field=None, year_of_construction_field=None, function_field=None, function_to_hub=None, hub_crs=None*)

Inherit: `:py:class:object`

GeometryFactory class

property **_citygml** → *City*

Enrich the city by using CityGML information as data source

Returns City

property **_geojson** → *City*

Enrich the city by using Geojson information as data source

Returns City

property **_obj** → *City*

Enrich the city by using OBJ information as data source

Returns City

property **city** → *City*

Enrich the city given to the class using the class given handler

Returns City

3.2.3 Usage Factory

class UsageFactory(*handler, city*)

Inherit: :py:class:object

UsageFactory class

_comnet()

Enrich the city with COMNET usage library

_eilat()

Enrich the city with Eilat usage library

_nrcan()

Enrich the city with NRCAN usage library

enrich()

Enrich the city given to the class using the usage factory given handler

Returns None

3.2.4 Weather Factory

class WeatherFactory(*handler, city: City*)

Inherit: :py:class:object

WeatherFactory class

_epw()

Enrich the city with energy plus weather file

enrich()

Enrich the city given to the class using the given weather handler

Returns None

3.3 Exports

3.3.1 Export Factory

class ExportsFactory(*handler, city, path, target_buildings=None, adjacent_buildings=None, base_uri=None*)

Inherit: :py:class:object

Exports factory class

property _cesiumjs_tileset

Export the city to a cesiumJs tileset format

Returns None

property _obj

Export the city geometry to obj

Returns None

property _sra

Export the city to Simplified Radiosity Algorithm xml format

Returns None

property _stl

Export the city geometry to stl

Returns None

export()

Export the city given to the class using the given export type handler

Returns None

CATALOGS

In its simplest form, a catalogue is a file or group of files that provide technical and/or commercial information regarding components that form a system within any domain. The components are listed with relevant details and associated data is tabulated. Also listed are the dominant/standard configurations in which the components may be used to satisfy use-cases/output requirements (as supplied by component manufacturer/standard organisations).

Note: Examples, Heat Pump catalogue should consist of the heat pump models produced, heat pump type, manufacturer name, output temperatures, nominal capacities, typical configurations for the heat pumps (e.g., configurations when used for space heating only, Domestic Hot Water/DHW purposes only, both space heating and DHW, combinations with solar thermal/PV), storage tank data, circulation pump data, compressor type and associated technical data, valve types etc.

Important: Please refer to the catalogs manual if you want to create or extend your own catalogs.

[[catalogs manual](#)]

4.1 Folder structure

4.1.1 Catalogs

```

./hub/hub/catalog_factories/
├── construction
│   ├── construction_helper.py
│   ├── eliat_catalog.py
│   ├── __init__.py
│   ├── nrcan_catalog.py
│   └── nrel_catalog.py
├── cost
│   ├── __init__.py
│   └── montreal_custom_catalog.py
├── data_models
│   ├── construction
│   │   ├── archetype.py
│   │   ├── construction.py
│   │   ├── content.py
│   │   ├── __init__.py
│   │   ├── layer.py
│   │   ├── material.py
│   │   └── window.py
│   ├── cost
│   │   ├── archetype.py
│   │   ├── capital_cost.py
│   │   ├── chapter.py
│   │   ├── content.py
│   │   ├── fuel.py
│   │   ├── income.py
│   │   ├── __init__.py
│   │   ├── item_description.py
│   │   └── operational_cost.py
│   ├── energy_systems
│   │   ├── archetype.py
│   │   ├── content.py
│   │   ├── distribution_system.py
│   │   ├── electrical_storage_system.py
│   │   ├── emission_system.py
│   │   ├── energy_storage_system.py
│   │   ├── generation_system.py
│   │   ├── __init__.py
│   │   ├── non_pv_generation_system.py
│   │   ├── performance_curves.py
│   │   ├── pv_generation_system.py
│   │   ├── system.py
│   │   └── thermal_storage_system.py
│   ├── greenery
│   │   ├── content.py
│   │   ├── __init__.py
│   │   ├── plant_percentage.py
│   │   ├── plant.py
│   │   ├── soil.py
│   │   └── vegetation.py
│   └── usages
│       ├── appliances.py
│       ├── content.py
│       ├── domestic_hot_water.py
│       ├── __init__.py
│       ├── lighting.py
│       ├── occupancy.py
│       ├── schedule.py
│       ├── thermal_control.py
│       └── usage.py
├── __init__.py
├── energy_systems
│   ├── __init__.py
│   ├── montreal_custom_catalog.py
│   └── montreal_future_system_catalogue.py
├── greenery
│   ├── ecore_greenery
│   │   ├── greenerycatalog.ecore
│   │   ├── greenerycatalog_no_quantiles.ecore
│   │   └── greenerycatalog.py
│   ├── greenery_catalog.py
│   └── __init__.py
├── usage
│   ├── comnet_catalog.py
│   ├── eliat_catalog.py
│   ├── __init__.py
│   ├── nrcan_catalog.py
│   └── usage_helper.py
├── catalog.py
├── construction_catalog_factory.py
├── costs_catalog_factory.py
├── energy_systems_catalog_factory.py
├── greenery_catalog_factory.py
├── __init__.py
└── usage_catalog_factory.py

```

13 directories, 72 files

4.2 Catalog Base Class

4.2.1 Catalog

class Catalog

Inherit: :py:class:object

Catalogs base class catalog_factories will inherit from this class.

entries(*category=None*)

Base property to return the catalog entries

Returns Catalog content filter by category if provided

get_entry(*name*)

Base property to return the catalog entry matching the given name

Returns Catalog entry with the matching name

names(*category=None*)

Base property to return the catalog entries names.

Returns Catalog names filter by category if provided

4.3 Greenery

4.3.1 Greenery Catalog Factory

class `GreeneryCatalogFactory`(*handler, base_path=None*)

Inherit: `:py:class:object`

GreeneryCatalogFactory class

property `_nrel`

Return a greenery catalog based in NREL using ecore as datasource

Returns GreeneryCatalog

property `catalog` → *Catalog*

Enrich the city given to the class using the class given handler

Returns Catalog

4.3.2 Greenery Content Data Model

class `Content`(*vegetations, plants, soils*)

Inherit: `:py:class:object`

Content class

property `plants`

All plants in the catalog

property `soils`

All soils in the catalog

to_dictionary()

Class content to dictionary

property `vegetations`

All vegetation in the catalog

4.3.3 Greenery Plant Data Model

class `Plant`(*category, plant*)

Inherit: `:py:class:object`

Plant class

property `category`

Get plant category name

Returns string

property `co2_sequestration`

Get plant co2 sequestration capacity in kg CO2 equivalent

Returns float

property grows_on → [*Soil*]
 Get plant compatible soils
Returns [*Soil*]

property height
 Get plant height in m
Returns float

property leaf_area_index
 Get plant leaf area index
Returns float

property leaf_emissivity
 Get plant leaf emissivity
Returns float

property leaf_reflectivity
 Get plant leaf area index
Returns float

property minimal_stomatal_resistance
 Get plant minimal stomatal resistance in s/m
Returns float

property name
 Get plant name
Returns string

to_dictionary()
 Class content to dictionary

4.3.4 Greenery Plant Percentage Data Model

class PlantPercentage(*percentage, plant_category, plant*)

Inherit: Plant

Plant percentage class

property percentage
 Get plant percentage
Returns float

to_dictionary()
 Class content to dictionary

4.3.5 Greenery Plant Soil Data Model

class Soil(*soil*)

Inherit: :py:class:object

Soil class

property dry_conductivity

Get soil dry conductivity in W/mK

Returns float

property dry_density

Get soil dry density in kg/m³

Returns float

property dry_specific_heat

Get soil dry specific heat in J/kgK

Returns float

property initial_volumetric_moisture_content

Get soil initial volumetric moisture content

Returns float

property name

Get soil name

Returns string

property residual_volumetric_moisture_content

Get soil residual volumetric moisture content

Returns float

property roughness

Get soil roughness

Returns string

property saturation_volumetric_moisture_content

Get soil saturation volumetric moisture content

Returns float

property solar_absorptance

Get soil solar absorptance

Returns float

property thermal_absorptance

Get soil thermal absorptance

Returns float

to_dictionary()

Class content to dictionary

property visible_absorptance

Get soil visible absorptance

Returns float

4.3.6 Greenery Vegetation Data Model

class `Vegetation`(*category, vegetation, plant_percentages*)

Inherit: `:py:class:object`

Vegetation class

property `air_gap`

Get air gap in m

Returns float

property `category`

Get vegetation category

Returns string

property `dry_soil_conductivity`

Get soil dry conductivity in W/mK

Returns float

property `dry_soil_density`

Get soil dry density in kg/m³

Returns float

property `dry_soil_specific_heat`

Get soil dry specific heat in J/kgK

Returns float

property `management`

Get management

Returns string

property `name`

Get vegetation name

Returns string

property `plant_percentages` → [*PlantPercentage*]

Get plant percentages

Returns [*PlantPercentage*]

property `soil_initial_volumetric_moisture_content`

Get soil initial volumetric moisture content

Returns float

property `soil_name`

Get soil name

Returns string

property `soil_residual_volumetric_moisture_content`

Get soil residual volumetric moisture content

Returns float

property soil_roughness

Get soil roughness

Returns float

property soil_saturation_volumetric_moisture_content

Get soil saturation volumetric moisture content

Returns float

property soil_solar_absorptance

Get soil solar absorptance

Returns float

property soil_thermal_absorptance

Get soil thermal absorptance

Returns float

property soil_thickness

Get soil thickness in m

Returns float

property soil_visible_absorptance

Get soil visible absorptance

Returns float

to_dictionary()

Class content to dictionary

4.4 Construction

4.4.1 Construction Catalog Factory

class `ConstructionCatalogFactory`(*handler, base_path=None*)

Inherit: `:py:class:object`

Construction catalog factory class

property `_eilat`

Retrieve Eilat catalog

property `_nrcan`

Retrieve NRCAN catalog

property `_nrel`

Retrieve NREL catalog

property `catalog` → *Catalog*

Enrich the city given to the class using the class given handler

Returns *Catalog*

4.4.2 Construction Content Data Model

class `Content`(*archetypes, constructions, materials, windows*)

Inherit: `:py:class:object`

Content class

property `archetypes`

All archetypes in the catalog

property `constructions`

All constructions in the catalog

property `materials`

All materials in the catalog

to_dictionary()

Class content to dictionary

property `windows`

All windows in the catalog

4.4.3 Construction Archetype Data Model

class `Archetype`(*archetype_id, name, function, climate_zone, construction_period, constructions, average_storey_height, thermal_capacity, extra_loses_due_to_thermal_bridges, indirect_heated_ratio, infiltration_rate_for_ventilation_system_off, infiltration_rate_for_ventilation_system_on, infiltration_rate_area_for_ventilation_system_off, infiltration_rate_area_for_ventilation_system_on*)

Inherit: `:py:class:object`

Archetype class

property average_storey_height

Get archetype average storey height in m

Returns float

property climate_zone

Get archetype climate zone

Returns str

property construction_period

Get archetype construction period

Returns str

property constructions → [*Construction*]

Get archetype constructions

Returns [Construction]

property extra_loses_due_to_thermal_bridges

Get archetype extra loses due to thermal bridges in W/m²K

Returns float

property function

Get archetype function

Returns str

property id

Get archetype id

Returns str

property indirect_heated_ratio

Get archetype indirect heated area ratio

Returns float

property infiltration_rate_area_for_ventilation_system_off

Get archetype infiltration rate for ventilation system off in m³/sm²

Returns float

property infiltration_rate_area_for_ventilation_system_on

Get archetype infiltration rate for ventilation system on in m³/sm²

Returns float

property infiltration_rate_for_ventilation_system_off

Get archetype infiltration rate for ventilation system off in 1/s

Returns float

property infiltration_rate_for_ventilation_system_on

Get archetype infiltration rate for ventilation system on in 1/s

Returns float

property name

Get archetype name

Returns str**property thermal_capacity**Get archetype thermal capacity in J/m³K**Returns** float**to_dictionary()**

Class content to dictionary

4.4.4 Construction Construction Data Model

class Construction(*construction_id, construction_type, name, layers, window_ratio=None, window=None*)**Inherit:** :py:class:object

Construction class

property id

Get construction id

Returns str**property layers** → [*Layer*]

Get construction layers

Returns [layer]**property name**

Get construction name

Returns str**to_dictionary()**

Class content to dictionary

property type

Get construction type

Returns str**property window** → *Window*

Get construction window

Returns Window**property window_ratio**

Get construction window ratio

Returns dict

4.4.5 Construction Layer Data Model

class Layer(*layer_id, name, material, thickness*)

Inherit: :py:class:object

Layer class

property id

Get layer id

Returns str

property material → *Material*

Get layer material

Returns Material

property name

Get layer name

Returns str

property thickness

Get layer thickness in meters

Returns None or float

to_dictionary()

Class content to dictionary

4.4.6 Construction Material Data Model

class Material(*material_id, name, solar_absorptance, thermal_absorptance, visible_absorptance, no_mass=False, thermal_resistance=None, conductivity=None, density=None, specific_heat=None*)

Inherit: :py:class:object

Material class

property conductivity

Get material conductivity in W/mK

Returns None or float

property density

Get material density in kg/m³

Returns None or float

property id

Get material id

Returns str

property name

Get material name

Returns str

property no_mass

Get material no mass flag

Returns None or Boolean**property solar_absorptance**

Get material solar absorptance

Returns None or float**property specific_heat**

Get material conductivity in J/kgK

Returns None or float**property thermal_absorptance**

Get material thermal absorptance

Returns None or float**property thermal_resistance**

Get material thermal resistance in m2K/W

Returns None or float**to_dictionary()**

Class content to dictionary

property visible_absorptance

Get material visible absorptance

Returns None or float

4.4.7 Construction Window Data Model

class Window(*window_id, frame_ratio, g_value, overall_u_value, name, window_type=None*)**Inherit:** :py:class:object

Window class

property frame_ratio

Get window frame ratio

Returns float**property g_value**

Get thermal opening g-value

Returns float**property id**

Get window id

Returns str**property name**

Get window name

Returns str

property overall_u_value

Get thermal opening overall U-value in W/m²K

Returns float

to_dictionary()

Class content to dictionary

property type

Get transparent surface type, 'window' or 'skylight'

Returns str

4.5 Costs

4.5.1 Costs Catalog Factory

class `CostsCatalogFactory`(*file_type*, *base_path=None*)

Inherit: `:py:class:object`

CostsCatalogFactory class

property `_montreal_custom`

Retrieve Montreal Custom catalog

property `catalog` → *Catalog*

Return a cost catalog

Returns CostCatalog

4.5.2 Costs Content Data Model

class `Content`(*archetypes*)

Inherit: `:py:class:object`

Content class

property `archetypes`

All archetypes in the catalog

to_dictionary()

Class content to dictionary

4.5.3 Costs Archetype Data Model

class `Archetype`(*lod*, *function*, *municipality*, *country*, *currency*, *capital_cost*, *operational_cost*, *end_of_life_cost*, *income*)

Inherit: `:py:class:object`

Archetype class

property `capital_cost` → *CapitalCost*

Get capital cost

Returns CapitalCost

property `country`

Get country

Returns string

property `currency`

Get currency

Returns string

property `end_of_life_cost`

Get end of life cost in given currency per m2

Returns float

property function

Get function

Returns string**property income** → *Income*

Get income

Returns Income**property lod**

Get level of detail of the catalog

Returns string**property municipality**

Get municipality

Returns string**property name**

Get name

Returns string**property operational_cost** → *OperationalCost*

Get operational cost

Returns OperationalCost**to_dictionary()**

Class content to dictionary

4.5.4 Costs Capital Cost Data Model

class CapitalCost(*general_chapters, design_allowance, overhead_and_profit*)**Inherit:** :py:class:object

Capital cost class

chapter(*name*) → *Chapter*

Get specific chapter by name

Returns Chapter**property design_allowance**

Get design allowance in percentage (-)

Returns float**property general_chapters** → [*Chapter*]

Get general chapters in capital costs

Returns [Chapter]**property overhead_and_profit**

Get overhead profit in percentage (-)

Returns float**to_dictionary()**

Class content to dictionary

4.5.5 Costs Chapter Data Model

class Chapter(*chapter_type*, *items*)

Inherit: :py:class:object

Chapter class

property chapter_type

Get chapter type

Returns str

item(*name*) → *ItemDescription*

Get specific item by name

Returns ItemDescription

property items → [*ItemDescription*]

Get list of items contained in the chapter

Returns [str]

to_dictionary()

Class content to dictionary

4.5.6 Costs Fuel Data Model

class Fuel(*fuel_type*, *fixed_monthly*=None, *fixed_power*=None, *variable*=None, *variable_units*=None)

Inherit: :py:class:object

Fuel class

property fixed_monthly → Optional[float]

Get fixed operational costs in currency per month

Returns None or float

property fixed_power → Optional[float]

Get fixed operational costs depending on the peak power consumed in currency per month per W

Returns None or float

to_dictionary()

Class content to dictionary

property type

Get fuel type

Returns str

property variable → Optional[tuple[None], tuple[float, str]]

Get variable costs in given units

Returns None, None or float, str

4.5.7 Costs Income Data Model

```
class Income(construction_subsidy=None, hvac_subsidy=None, photovoltaic_subsidy=None,  
electricity_export=None, reductions_tax=None)
```

Inherit: `:py:class:object`

Income class

property construction_subsidy → Optional[float]

Get subsidy for construction in percentage %

Returns None or float

property electricity_export → Optional[float]

Get electricity export incomes in currency per J

Returns None or float

property hvac_subsidy → Optional[float]

Get subsidy for HVAC system in percentage %

Returns None or float

property photovoltaic_subsidy → Optional[float]

Get subsidy PV systems in percentage

Returns None or float

property reductions_tax → Optional[float]

Get reduction in taxes in percentage (-)

Returns None or float

to_dictionary()

Class content to dictionary

4.5.8 Costs Item Description Data Model

```
class ItemDescription(item_type, initial_investment=None, initial_investment_unit=None,  
refurbishment=None, refurbishment_unit=None, reposition=None,  
reposition_unit=None, lifetime=None)
```

Inherit: `:py:class:object`

Item description class

property initial_investment → Optional[tuple[None], tuple[float, str]]

Get initial investment of the specific item in given units

Returns None, None or float, str

property lifetime → Optional[float]

Get lifetime in years

Returns None or float

property refurbishment → Optional[tuple[None], tuple[float, str]]

Get refurbishment costs of the specific item in given units

Returns None, None or float, str

property reposition → Optional[tuple[None], tuple[float, str]]

Get reposition costs of the specific item in given units

Returns None, None or float, str

to_dictionary()

Class content to dictionary

property type

Get item type

Returns str

4.5.9 Costs Operational Cost Data Model

class OperationalCost(*fuels, maintenance_heating, maintenance_cooling, maintenance_pv, co2*)

Inherit: :py:class:object

Operational cost class

property co2

Get cost of CO2 emissions in currency/kgCO2

Returns float

property fuels → [*Fuel*]

Get fuels listed in capital costs

Returns [*Fuel*]

property maintenance_cooling

Get cost of maintaining the cooling system in currency/W

Returns float

property maintenance_heating

Get cost of maintaining the heating system in currency/W

Returns float

property maintenance_pv

Get cost of maintaining the PV system in currency/m2

Returns float

to_dictionary()

Class content to dictionary

4.6 Energy Systems

4.6.1 Energy Systems Catalog Factory

class `EnergySystemsCatalogFactory`(*handler*, *base_path=None*)

Inherit: `:py:class:object`

Energy system catalog factory class

property `_montreal_custom`

Retrieve NRCAN catalog

property `_montreal_future`

Retrieve North American catalog

property `catalog` → *Catalog*

Enrich the city given to the class using the class given handler

Returns `Catalog`

4.6.2 Energy Systems Content Data Model

class `Content`(*archetypes*, *systems*, *generations=None*, *distributions=None*)

Inherit: `:py:class:object`

Content class

property `archetypes`

All archetype system clusters in the catalog

property `distribution equipments`

All distribution equipments in the catalog

property `generation equipments`

All generation equipments in the catalog

property `systems`

All systems in the catalog

to_dictionary()

Class content to dictionary

4.6.3 Energy Systems Archetype Data Model

class `Archetype`(*name*, *systems*)

Inherit: `:py:class:object`

Archetype class

property `name`

Get name

Returns `string`

property systems → [*System*]

Get list of equipments that compose the total energy system

Returns [Equipment]

to_dictionary()

Class content to dictionary

4.6.4 Energy Systems Distribution System Data Model

```
class DistributionSystem(system_id, model_name=None, system_type=None, supply_temperature=None,
                        distribution_consumption_fix_flow=None,
                        distribution_consumption_variable_flow=None, heat_losses=None,
                        generation_systems=None, energy_storage_systems=None,
                        emission_systems=None)
```

Inherit: :py:class:object

Distribution system class

property distribution_consumption_fix_flow

Get distribution_consumption if the pump or fan work at fix mass or volume flow in ratio over peak power (W/W)

Returns float

property distribution_consumption_variable_flow

Get distribution_consumption if the pump or fan work at variable mass or volume flow in ratio over energy produced (J/J)

Returns float

property emission_systems → Optional[[*EmissionSystem*]]

Get energy emission systems connected to this distribution system

Returns [EmissionSystem]

property energy_storage_systems → Optional[[*EnergyStorageSystem*]]

Get energy storage systems connected to this distribution system

Returns [EnergyStorageSystem]

property generation_systems → Optional[[*GenerationSystem*]]

Get generation systems connected to the distribution system

Returns [GenerationSystem]

property heat_losses

Get heat_losses in ratio over energy produced in J/J

Returns float

property id

Get system id

Returns float

property model_name

Get model name

Returns string**property supply_temperature**

Get supply_temperature in degree Celsius

Returns float**to_dictionary()**

Class content to dictionary

property type

Get type from [air, water, refrigerant]

Returns string

4.6.5 Energy Systems Emission System Data Model

class EmissionSystem(*system_id, model_name=None, system_type=None, parasitic_energy_consumption=0*)**Inherit:** `::py:class:object`

Emission system class

property id

Get system id

Returns float**property model_name**

Get model name

Returns string**property parasitic_energy_consumption**

Get parasitic_energy_consumption in ratio (J/J)

Returns float**to_dictionary()**

Class content to dictionary

property type

Get type

Returns string

4.6.6 Energy Systems Generation System Data Model

class GenerationSystem(*system_id, name, model_name=None, manufacturer=None, fuel_type=None, distribution_systems=None, energy_storage_systems=None*)**Inherit:** `ABC`

Heat Generation system class

property distribution_systems → Optional[[*DistributionSystem*]]
 Get distributions systems connected to this generation system
Returns [DistributionSystem]

property energy_storage_systems → Optional[[EnergyStorageSystem]]
 Get energy storage systems connected to this generation system
Returns [EnergyStorageSystem]

property fuel_type
 Get fuel_type from [renewable, gas, diesel, electricity, wood, coal, biogas]
Returns string

property id
 Get system id
Returns float

property manufacturer
 Get name
Returns string

property model_name
 Get system id
Returns float

property name
 Get system name
Returns string

property system_type
 Get type
Returns string

to_dictionary()
 Class content to dictionary

4.6.7 Energy Systems Energy Systems Data Model

class System(*system_id*, *demand_types*, *name=None*, *generation_systems=None*, *distribution_systems=None*,
configuration_schema=None)

Inherit: :py:class:object

System class

property configuration_schema → Path

Get system configuration schema

Returns Path

property demand_types

Get demand able to cover from ['heating', 'cooling', 'domestic_hot_water', 'electricity']

Returns [string]

property distribution_systems → Optional[[*DistributionSystem*]]

Get distribution systems

Returns [DistributionSystem]

property generation_systems → Optional[[*GenerationSystem*]]

Get generation systems

Returns [GenerationSystem]

property id

Get equipment id

Returns string

property name

Get the system name

Returns string

to_dictionary()

Class content to dictionary

4.7 Usage

4.7.1 Usage Catalog Factory

class UsageCatalogFactory(*handler, base_path=None*)

Inherit: :py:class:object

Usage catalog factory class

property _comnet

Retrieve Comnet catalog

property _eilat

Retrieve Eilat catalog

property _nrcan

Retrieve NRCAN catalog

property catalog → *Catalog*

Enrich the city given to the class using the class given handler

Returns Catalog

4.7.2 Usage Content Data Model

class Content(*usages*)

Inherit: :py:class:object

Content class

to_dictionary()

Class content to dictionary

property usages → [*Usage*]

Get catalog usages

4.7.3 Usage Appliances Data Model

class Appliances(*density, convective_fraction, radiative_fraction, latent_fraction, schedules*)

Inherit: :py:class:object

Appliances class

property convective_fraction → Optional[float]

Get convective fraction

Returns None or float

property density → Optional[float]

Get appliances density in W/m2

Returns None or float

property latent_fraction → Optional[float]

Get latent fraction

Returns None or float

property radiative_fraction → Optional[float]

Get radiant fraction

Returns None or float

property schedules → Optional[[*Schedule*]]

Get schedules

dataType = fraction

Returns None or [*Schedule*]

to_dictionary()

Class content to dictionary

4.7.4 Usage Content Data Model

class Content(*usages*)

Inherit: :py:class:object

Content class

to_dictionary()

Class content to dictionary

property usages → [*Usage*]

Get catalog usages

4.7.5 Usage Domestic Hot Water Data Model

class DomesticHotWater(*density, peak_flow, service_temperature, schedules*)

Inherit: :py:class:object

DomesticHotWater class

property density → Optional[float]

Get domestic hot water load density in Watts per m2

Returns None or float

property peak_flow → Optional[float]

Get domestic hot water peak_flow density in m3 per second and m2

Returns None or float

property schedules → Optional[[*Schedule*]]

Get schedules

dataType = fraction of loads

Returns None or [*Schedule*]

property service_temperature → Optional[float]

Get service temperature in degrees Celsius

Returns None or float

to_dictionary()

Class content to dictionary

4.7.6 Usage Internal Gain Data Model

4.7.7 Usage Lighting Data Model

class `Lighting`(*density, convective_fraction, radiative_fraction, latent_fraction, schedules*)

Inherit: `:py:class:object`

Lighting class

property `convective_fraction` → Optional[float]

Get convective fraction

Returns None or float

property `density` → Optional[float]

Get lighting density in Watts per m2

Returns None or float

property `latent_fraction` → Optional[float]

Get latent fraction

Returns None or float

property `radiative_fraction` → Optional[float]

Get radiant fraction

Returns None or float

property `schedules` → Optional[[*Schedule*]]

Get schedules

dataType = fraction

Returns None or [*Schedule*]

to_dictionary()

Class content to dictionary

4.7.8 Usage Occupancy Data Model

class `Occupancy`(*occupancy_density, sensible_convective_internal_gain, sensible_radiative_internal_gain, latent_internal_gain, schedules*)

Inherit: `:py:class:object`

Occupancy class

property `latent_internal_gain` → Optional[float]

Get latent internal gain in Watts per m2

Returns None or float

property `occupancy_density` → Optional[float]

Get density in persons per m2

Returns None or float

property schedules → Optional[[*Schedule*]]

Get occupancy schedules

dataType = fraction

Returns None or [*Schedule*]

property sensible_convective_internal_gain → Optional[float]

Get sensible convective internal gain in Watts per m2

Returns None or float

property sensible_radiative_internal_gain → Optional[float]

Get sensible radiant internal gain in Watts per m2

Returns None or float

to_dictionary()

Class content to dictionary

4.7.9 Usage Schedule Data Model

class Schedule(*schedule_type, values, data_type, time_step, time_range, day_types*)

Inherit: :py:class:object

Schedule class

property data_type → Optional[str]

Get schedule data type from:

['any_number', 'fraction', 'on_off', 'temperature', 'humidity', 'control_type']

Returns None or str

property day_types → Optional[[str]]

Get schedule day types, as many as needed from:

['monday', 'tuesday', 'wednesday', 'thursday', 'friday', 'saturday', 'sunday', 'holiday', 'winter_design_day',
'summer_design_day']

Returns None or [str]

property time_range → Optional[str]

Get schedule time range from:

['minute', 'hour', 'day', 'week', 'month', 'year']

Returns None or str

property time_step → Optional[str]

Get schedule time step from:

['second', 'minute', 'hour', 'day', 'week', 'month']

Returns None or str

to_dictionary()

Class content to dictionary

property type → Optional[str]

Get schedule type

Returns None or str

property values

Get schedule values

Returns [Any]

4.7.10 Usage Thermal Control Data Model

class ThermalControl(*mean_heating_set_point, heating_set_back, mean_cooling_set_point, hvac_availability_schedules, heating_set_point_schedules, cooling_set_point_schedules*)

Inherit: :py:class:object

ThermalControl class

property cooling_set_point_schedules → Optional[[Schedule]]

Get cooling set point schedule defined for a thermal zone in Celsius

dataType = temperature

Returns None or [Schedule]

property heating_set_back → Optional[float]

Get heating set back defined for a thermal zone in Celsius

Returns None or float

property heating_set_point_schedules → Optional[[Schedule]]

Get heating set point schedule defined for a thermal zone in Celsius

dataType = temperature

Returns None or [Schedule]

property hvac_availability_schedules → Optional[[Schedule]]

Get the availability of the conditioning system defined for a thermal zone

dataType = on/off

Returns None or [Schedule]

property mean_cooling_set_point → Optional[float]

Get cooling set point defined for a thermal zone in Celsius

Returns None or float

property mean_heating_set_point → Optional[float]

Get heating set point defined for a thermal zone in Celsius

Returns None or float

to_dictionary()

Class content to dictionary

4.7.11 Usage Usage Data Model

class Usage(*name, hours_day, days_year, mechanical_air_change, ventilation_rate, occupancy, lighting, appliances, thermal_control, domestic_hot_water*)

Inherit: :py:class:object

Usage class

property appliances → Optional[*Appliances*]

Get appliances information

Returns None or Appliances

property days_year → Optional[float]

Get usage zone usage days per year

Returns None or float

property domestic_hot_water → Optional[*DomesticHotWater*]

Get domestic hot water information

Returns None or DomesticHotWater

property hours_day → Optional[float]

Get usage zone usage hours per day

Returns None or float

property lighting → Optional[*Lighting*]

Get lighting information

Returns None or Lighting

property mechanical_air_change → Optional[float]

Get usage zone mechanical air change in air change per second (1/s)

Returns None or float

property name → Optional[str]

Get usage zone usage name

Returns None or str

property occupancy → Optional[*Occupancy*]

Get occupancy in the usage zone

Returns None or Occupancy

property thermal_control → Optional[*ThermalControl*]

Get thermal control information

Returns None or ThermalControl

to_dictionary()

Class content to dictionary

property ventilation_rate → Optional[float]

Get usage zone ventilation rate in m³/m²s

Returns None or float

HELPERS

CERC hub provides a set of *helpers* that will simplify certain operations; these helpers are mean to be freely used at any point and therefore could be consumed from several places.

5.1 Folder structure

```
./hub/hub/helpers/
├── data
│   ├── alkis_function_to_hub_function.py
│   ├── ellat_function_to_hub_function.py
│   ├── hft_function_to_hub_function.py
│   ├── hub_function_to_ellat_construction_function.py
│   ├── hub_function_to_montreal_custom_costs_function.py
│   ├── hub_function_to_nrcan_construction_function.py
│   ├── hub_function_to_nrel_construction_function.py
│   ├── hub_usage_to_comnet_usage.py
│   ├── hub_usage_to_ellat_usage.py
│   ├── hub_usage_to_hft_usage.py
│   ├── hub_usage_to_nrcan_usage.py
│   └── __init__.py
├── montreal_custom_fuel_to_hub_fuel.py
├── montreal_demand_type_to_hub_energy_demand_type.py
├── montreal_function_to_hub_function.py
├── montreal_generation_system_to_hub_energy_generation_system.py
├── montreal_system_to_hub_energy_generation_system.py
├── north_america_custom_fuel_to_hub_fuel.py
├── north_america_demand_type_to_hub_energy_demand_type.py
├── north_america_storage_system_to_hub_storage.py
├── north_america_system_to_hub_energy_generation_system.py
├── pluto_function_to_hub_function.py
├── peak_calculation
│   ├── __init__.py
│   └── loads_calculation.py
├── auth.py
├── configuration_helper.py
├── constants.py
├── dictionaries.py
├── geometry_helper.py
├── __init__.py
├── location.py
├── monthly_values.py
├── peak_loads.py
├── thermal_zones_creation.py
└── utils.py

3 directories, 35 files
```

5.2 Configuration Helper

class ConfigurationHelper

Inherit: :py:class:object

Configuration class

property cold_water_temperature → float

Get configured cold water temperature in Celsius

Returns 10

property comnet_lighting_convective → float

Get configured convective ratio of internal gains do to lighting used for Comnet (ASHRAE) standard

Returns 0.5

property comnet_lighting_latent → float

Get configured latent ratio of internal gains do to lighting used for Comnet (ASHRAE) standard

Returns 0

property comnet_lighting_radiant → float

Get configured radiant ratio of internal gains do to lighting used for Comnet (ASHRAE) standard

Returns 0.5

property comnet_occupancy_sensible_convective → float

Get configured convective ratio of the sensible part of internal gains do to occupancy used for Comnet (ASHRAE) standard

Returns 0.9

property comnet_occupancy_sensible_radiant → float

Get configured radiant ratio of the sensible part of internal gains do to occupancy used for Comnet (ASHRAE) standard

Returns 0.1

property comnet_plugs_convective → float

Get configured convective ratio of internal gains do to electrical appliances used for Comnet (ASHRAE) standard

Returns 0.75

property comnet_plugs_latent → float

Get configured latent ratio of internal gains do to electrical appliances used for Comnet (ASHRAE) standard

Returns 0

property comnet_plugs_radiant → float

Get configured radiant ratio of internal gains do to electrical appliances used for Comnet (ASHRAE) standard

Returns 0.25

property convective_heat_transfer_coefficient_exterior → float

Get configured convective heat transfer coefficient for surfaces outside the building

Returns 20 W/m²K

property convective_heat_transfer_coefficient_interior → float

Get configured convective heat transfer coefficient for surfaces inside the building

Returns 3.5 W/m²K

property max_coordinate → float

Get configured maximal coordinate value

Returns 1.7976931348623157e+308

property min_coordinate → float

Get configured minimal coordinate value

Returns -1.7976931348623157e+308

property short_wave_reflectance → float

Get configured short wave reflectance for surfaces that don't have construction assigned

Returns 0.3

property soil_conductivity → float

Get configured soil conductivity for surfaces touching the ground

Returns 3 W/mK

property soil_thickness → float

Get configured soil thickness for surfaces touching the ground

Returns 0.5 m

5.3 Constants

KELVIN = 273.15
 HOUR_TO_MINUTES = 60
 MINUTES_TO_SECONDS = 60
 HOUR_TO_SECONDS = 3600
 METERS_TO_FEET = 3.28084
 BTU_H_TO_WATTS = 0.29307107
 KILO_WATTS_HOUR_TO_JULES = 3600000
 WATTS_HOUR_TO_JULES = 3600
 GALLONS_TO_QUBIC_METERS = 0.0037854117954011185
 SECOND = 'second'
 MINUTE = 'minute'
 HOUR = 'hour'
 DAY = 'day'
 WEEK = 'week'
 MONTH = 'month'
 YEAR = 'year'
 MONDAY = 'monday'
 TUESDAY = 'tuesday'
 WEDNESDAY = 'wednesday'
 THURSDAY = 'thursday'
 FRIDAY = 'friday'
 SATURDAY = 'saturday'
 SUNDAY = 'sunday'
 HOLIDAY = 'holiday'
 WINTER_DESIGN_DAY = 'winter_design_day'
 SUMMER_DESIGN_DAY = 'summer_design_day'
 WEEK_DAYS = 'Weekdays'
 WEEK_ENDS = 'Weekends'
 ALL_DAYS = 'Alldays'
 JANUARY = 'January'
 FEBRUARY = 'February'
 MARCH = 'March'
 APRIL = 'April'
 MAY = 'May'
 JUNE = 'June'
 JULY = 'July'
 AUGUST = 'August'
 SEPTEMBER = 'September'
 OCTOBER = 'October'
 NOVEMBER = 'November'
 DECEMBER = 'December'
 MONTHS = [JANUARY, FEBRUARY, MARCH, APRIL, MAY, JUNE, JULY, AUGUST,
 SEPTEMBER, OCTOBER, NOVEMBER, DECEMBER]
 WEEK_DAYS_A_MONTH = {JANUARY: {MONDAY: 5,
 TUESDAY: 5,

WEDNESDAY: 5,
THURSDAY: 4,
FRIDAY: 4,
SATURDAY: 4,
SUNDAY: 4,
HOLIDAY: 0},
FEBRUARY: {MONDAY: 4,
TUESDAY: 4,
WEDNESDAY: 4,
THURSDAY: 4,
FRIDAY: 4,
SATURDAY: 4,
SUNDAY: 4,
HOLIDAY: 0},
MARCH: {MONDAY: 4,
TUESDAY: 4,
WEDNESDAY: 4,
THURSDAY: 5,
FRIDAY: 5,
SATURDAY: 5,
SUNDAY: 4,
HOLIDAY: 0},
APRIL: {MONDAY: 5,
TUESDAY: 4,
WEDNESDAY: 4,
THURSDAY: 4,
FRIDAY: 4,
SATURDAY: 4,
SUNDAY: 5,
HOLIDAY: 0},
MAY: {MONDAY: 4,
TUESDAY: 5,
WEDNESDAY: 5,
THURSDAY: 5,
FRIDAY: 4,
SATURDAY: 4,
SUNDAY: 4,
HOLIDAY: 0},
JUNE: {MONDAY: 4,
TUESDAY: 4,
WEDNESDAY: 4,
THURSDAY: 4,
FRIDAY: 5,
SATURDAY: 5,
SUNDAY: 4,
HOLIDAY: 0},
JULY: {MONDAY: 5,

TUESDAY: 5,
WEDNESDAY: 4,
THURSDAY: 4,
FRIDAY: 4,
SATURDAY: 4,
SUNDAY: 5,
HOLIDAY: 0},
AUGUST: {MONDAY: 4,
TUESDAY: 4,
WEDNESDAY: 5,
THURSDAY: 5,
FRIDAY: 5,
SATURDAY: 4,
SUNDAY: 4,
HOLIDAY: 0},
SEPTEMBER: {MONDAY: 4,
TUESDAY: 4,
WEDNESDAY: 4,
THURSDAY: 4,
FRIDAY: 4,
SATURDAY: 5,
SUNDAY: 5,
HOLIDAY: 0},
OCTOBER: {MONDAY: 5,
TUESDAY: 5,
WEDNESDAY: 5,
THURSDAY: 4,
FRIDAY: 4,
SATURDAY: 4,
SUNDAY: 4,
HOLIDAY: 0},
NOVEMBER: {MONDAY: 4,
TUESDAY: 4,
WEDNESDAY: 4,
THURSDAY: 5,
FRIDAY: 5,
SATURDAY: 4,
SUNDAY: 4,
HOLIDAY: 0},
DECEMBER: {MONDAY: 5,
TUESDAY: 4,
WEDNESDAY: 4,
THURSDAY: 4,
FRIDAY: 4,
SATURDAY: 5,
SUNDAY: 5,
HOLIDAY: 0},

```

}
WEEK_DAYS_A_YEAR = {MONDAY: 51,
    TUESDAY: 50,
    WEDNESDAY: 50,
    THURSDAY: 50,
    FRIDAY: 50,
    SATURDAY: 52,
    SUNDAY: 52,
    HOLIDAY: 10}
DAYS_A_MONTH = {JANUARY: 31,
    FEBRUARY: 28,
    MARCH: 31,
    APRIL: 30,
    MAY: 31,
    JUNE: 30,
    JULY: 31,
    AUGUST: 31,
    SEPTEMBER: 30,
    OCTOBER: 31,
    NOVEMBER: 30,
    DECEMBER: 31}
ANY_NUMBER = 'any_number'
FRACTION = 'fraction'
ON_OFF = 'on_off'
TEMPERATURE = 'temperature'
HUMIDITY = 'humidity'
CONTROL_TYPE = 'control_type'
CONTINUOUS = 'continuous'
DISCRETE = 'discrete'
CONSTANT = 'constant'
INTERNAL_GAINS = 'internal_gains'
WALL = 'Wall'
GROUND_WALL = 'Ground wall'
GROUND = 'Ground'
ATTIC_FLOOR = 'Attic floor'
ROOF = 'Roof'
INTERIOR_SLAB = 'Interior slab'
INTERIOR_WALL = 'Interior wall'
VIRTUAL_INTERNAL = 'Virtual internal'
WINDOW = 'Window'
DOOR = 'Door'
SKYLIGHT = 'Skylight'
RESIDENTIAL = 'residential'
SINGLE_FAMILY_HOUSE = 'single family house'
MULTI_FAMILY_HOUSE = 'multifamily house'
ROW_HOUSE = 'row house'
MID_RISE_APARTMENT = 'mid rise apartment'

```


HIGH_RISE_APARTMENT = 'high rise apartment'
OFFICE_AND_ADMINISTRATION = 'office and administration'
SMALL_OFFICE = 'small office'
MEDIUM_OFFICE = 'medium office'
LARGE_OFFICE = 'large office'
COURTHOUSE = 'courthouse'
FIRE_STATION = 'fire station'
PENITENTIARY = 'penitentiary'
POLICE_STATION = 'police station'
POST_OFFICE = 'post office'
LIBRARY = 'library'
EDUCATION = 'education'
PRIMARY_SCHOOL = 'primary school'
PRIMARY_SCHOOL_WITH_SHOWER = 'school with shower'
SECONDARY_SCHOOL = 'secondary school'
UNIVERSITY = 'university'
LABORATORY_AND_RESEARCH_CENTER = 'laboratory and research centers'
STAND_ALONE_RETAIL = 'stand alone retail'
HOSPITAL = 'hospital'
OUT_PATIENT_HEALTH_CARE = 'out-patient health care'
HEALTH_CARE = 'health care'
RETIREMENT_HOME_OR_ORPHANAGE = 'retirement home or orphanage'
COMMERCIAL = 'commercial'
STRIP_MALL = 'strip mall'
SUPERMARKET = 'supermarket'
RETAIL_SHOP_WITHOUT_REFRIGERATED_FOOD = 'retail shop without refrigerated food'
RETAIL_SHOP_WITH_REFRIGERATED_FOOD = 'retail shop with refrigerated food'
RESTAURANT = 'restaurant'
QUICK_SERVICE_RESTAURANT = 'quick service restaurant'
FULL_SERVICE_RESTAURANT = 'full service restaurant'
HOTEL = 'hotel'
HOTEL_MEDIUM_CLASS = 'hotel medium class'
SMALL_HOTEL = 'small hotel'
LARGE_HOTEL = 'large hotel'
DORMITORY = 'dormitory'
EVENT_LOCATION = 'event location'
CONVENTION_CENTER = 'convention center'
HALL = 'hall'
GREEN_HOUSE = 'green house'
INDUSTRY = 'industry'
WORKSHOP = 'workshop'
WAREHOUSE = 'warehouse'
WAREHOUSE_REFRIGERATED = 'warehouse refrigerated'
SPORTS_LOCATION = 'sports location'
SPORTS_ARENA = 'sports arena'
GYMNASIUM = 'gymnasium'
MOTION_PICTURE_THEATRE = 'motion picture theatre'

MUSEUM = 'museum'
PERFORMING_ARTS_THEATRE = 'performing arts theatre'
TRANSPORTATION = 'transportation'
AUTOMOTIVE_FACILITY = 'automotive facility'
PARKING_GARAGE = 'parking garage'
RELIGIOUS = 'religious'
NON_HEATED = 'non-heated'
DATACENTER = 'datacenter'
FARM = 'farm'
LIGHTING = 'Lights'
OCCUPANCY = 'Occupancy'
APPLIANCES = 'Appliances'
HVAC_AVAILABILITY = 'HVAC Avail'
INFILTRATION = 'Infiltration'
VENTILATION = 'Ventilation'
COOLING_SET_POINT = 'ClgSetPt'
HEATING_SET_POINT = 'HtgSetPt'
EQUIPMENT = 'Equipment'
ACTIVITY = 'Activity'
PEOPLE_ACTIVITY_LEVEL = 'People Activity Level'
DOMESTIC_HOT_WATER = 'Domestic Hot Water'
HEATING = 'Heating'
COOLING = 'Cooling'
ELECTRICITY = 'Electricity'
RENEWABLE = 'Renewable'
WOOD = 'Wood'
GAS = 'Gas'
DIESEL = 'Diesel'
COAL = 'Coal'
BIOMASS = 'Biomass'
AIR = 'Air'
WATER = 'Water'
GEOTHERMAL = 'Geothermal'
DISTRICT_HEATING_NETWORK = 'District Heating'
GRID = 'Grid'
ONSITE_ELECTRICITY = 'Onsite Electricity'
PHOTOVOLTAIC = 'Photovoltaic'
BOILER = 'Boiler'
HEAT_PUMP = 'Heat Pump'
BASEBOARD = 'Baseboard'
ELECTRICITY_GENERATOR = 'Electricity generator'
CHILLER = 'Chiller'
SENSIBLE = 'sensible'
LATENT = 'Latent'
LITHIUMION = 'Lithium Ion'
NICD = 'NiCd'
LEADACID = 'Lead Acid'

```

EPSILON = 0.0000001
ONLY_HEATING = 'Heating'
ONLY_COOLING = 'Colling'
ONLY_VENTILATION = 'Ventilation'
HEATING_AND_VENTILATION = 'Heating and ventilation'
COOLING_AND_VENTILATION = 'Cooling and ventilation'
HEATING_AND_COLLING = 'Heating and cooling'
FULL_HVAC = 'Heating and cooling and ventilation'
MAX_FLOAT = float('inf')
MIN_FLOAT = float('-inf')
SRA = 'sra'
INSEL_MEB = 'insel meb'
CURRENCY_PER_SQM = 'currency/m2'
CURRENCY_PER_CBM = 'currency/m3'
CURRENCY_PER_KW = 'currency/kW'
CURRENCY_PER_KWH = 'currency/kWh'
CURRENCY_PER_MONTH = 'currency/month'
CURRENCY_PER_LITRE = 'currency/l'
CURRENCY_PER_KG = 'currency/kg'
CURRENCY_PER_CBM_PER_HOUR = 'currency/(m3/h)'
PERCENTAGE = '%'
SUPERSTRUCTURE = 'B_shell'
ENVELOPE = 'D_services'
ALLOWANCES_OVERHEAD_PROFIT = 'Z_allowances_overhead_profit'

```

5.4 Geometry Helper

```
class GeometryHelper(delta=0, area_delta=0)
```

Inherit: :py:class:object

Geometry helper class

```
static city_mapping(city, building_names=None, plot=False) → Dict
```

Parameter city city to be mapped

Parameter building_names list of building names to be mapped or None

Parameter plot True if minimap image should be displayed

Returns shared_information dictionary

```
static coordinate_to_map_point(coordinate, city)
```

Transform a real world coordinate to a minimap one

Parameter coordinate real world coordinate

Parameter city current city

Returns None

```
static distance_between_points(vertex1, vertex2)
```

distance between points in an n-D Euclidean space

Parameter vertex1 point or vertex

Parameter vertex2 point or vertex

Returns float

static divide_mesh_by_plane(*trimesh, normal_plane, point_plane*)

Divide a mesh by a plane

Parameter trimesh Trimesh

Parameter normal_plane [x, y, z]

Parameter point_plane [x, y, z]

Returns [Trimesh]

static factor()

Set minimap resolution

Returns None

static get_location(*latitude, longitude*) → *Location*

Get Location from latitude and longitude

Parameter latitude Latitude

Parameter longitude Longitude

Returns Location

static segment_list_to_trimesh(*lines*) → Trimesh

Parameter lines lines

Returns Transform a list of segments into a Trimesh

5.5 Location

class Location(*country, city, region_code, climate_reference_city_latitude, climate_reference_city_longitude*)

Inherit: :py:class:object

property city

Get city name

property climate_reference_city_latitude

Get climate-reference-city latitude

property climate_reference_city_longitude

Get climate-reference-city longitude

property country

Get country code

property region_code

Get region

5.6 Dictionaries

class Dictionaries

Inherit: :py:class:object

Dictionaries class

property alkis_function_to_hub_function → dict

Get Alkis function to hub function, transformation dictionary

property eilat_function_to_hub_function → dict

Get Eilat's function to hub function, transformation dictionary

property hft_function_to_hub_function → dict

Get Hft function to hub function, transformation dictionary

Returns dict

property hub_function_to_eilat_construction_function → dict

Get hub function to NRCAN construction function, transformation dictionary

Returns dict

property hub_function_to_montreal_custom_costs_function → dict

Get hub function to Montreal custom costs function, transformation dictionary

Returns dict

property hub_function_to_nrcan_construction_function → dict

Get hub function to NRCAN construction function, transformation dictionary

Returns dict

property hub_function_to_nrel_construction_function → dict

Get hub function to NREL construction function, transformation dictionary

Returns dict

property hub_usage_to_comnet_usage → dict

Hub usage to Comnet usage, transformation dictionary

Returns dict

property hub_usage_to_eilat_usage → dict

Hub usage to Eilat usage, transformation dictionary

Returns dict

property hub_usage_to_hft_usage → dict

Hub usage to HfT usage, transformation dictionary

Returns dict

property hub_usage_to_nrcan_usage → dict

Get hub usage to NRCAN usage, transformation dictionary

Returns dict

property montreal_custom_fuel_to_hub_fuel → dict

Get hub fuel from montreal_custom catalog fuel

property montreal_demand_type_to_hub_energy_demand_type

Get montreal custom system demand type to hub energy demand type, transformation dictionary

property montreal_function_to_hub_function → dict

Get Montreal function to hub function, transformation dictionary

property montreal_generation_system_to_hub_energy_generation_system

Get montreal custom generation system names to hub energy system names, transformation dictionary

property montreal_system_to_hub_energy_generation_system

Get montreal custom system names to hub energy system names, transformation dictionary

property north_america_custom_fuel_to_hub_fuel → dict

Get hub fuel from north_america catalog fuel

property north_america_demand_type_to_hub_energy_demand_type

Get north america system demand type to hub energy demand type, transformation dictionary

property north_america_storage_system_to_hub_storage

Get montreal custom system names to hub storage system

property north_america_system_to_hub_energy_generation_system

Get north america system names to hub energy system names, transformation dictionary

property pluto_function_to_hub_function → dict

Get Pluto function to hub function, transformation dictionary

Returns dict

ADDITIONAL FILES

6.1 Readme

README.md

6.2 License

LICENSE.md

6.3 Code of conduct

CODE_OF_CONDUCT.md

6.4 How to contribute

CONTRIBUTING.md

6.5 Coding style

PYGUIDE.md

Symbols

_cesiumjs_tileset (*hub.exports.exports_factory* :property: ExportsFactory property), 47
 _cityxml (*hub.imports.geometry_factory* :property: GeometryFactory property), 45
 _comnet (*hub.catalog_factories.usage_catalog_factory* :property: UsageCatalogFactory property), 72
 _comnet () (*hub.imports.usage_factory* UsageFactory method), 46
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