

Welcome Energy ADE 1.0!

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Smart and resilient cities unit
Vienna - Austria

9th CityGML Energy ADE Workshop
Aachen, 26 June 2018



Overview

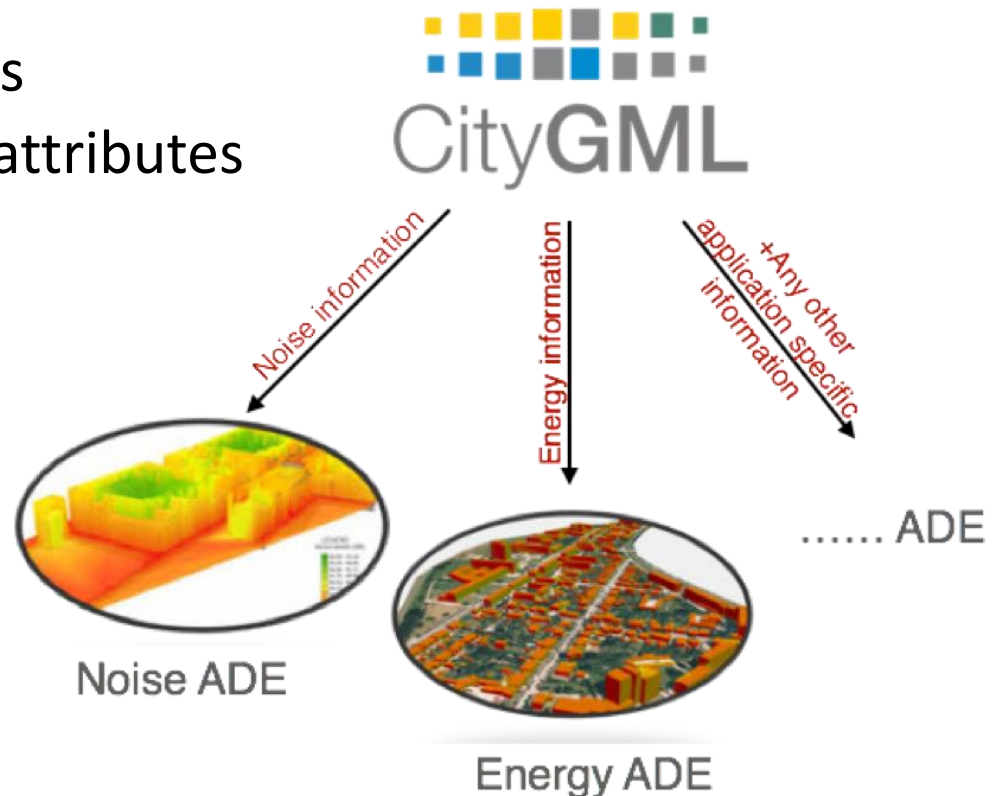
- Where we come from
 - Energy ADE: what, why, when
- Where we are now
 - Energy ADE 1.0
- Where we are heading to
 - Open issues
 - Next steps

Overview

- **Where we come from**
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Energy ADE: what, why, when

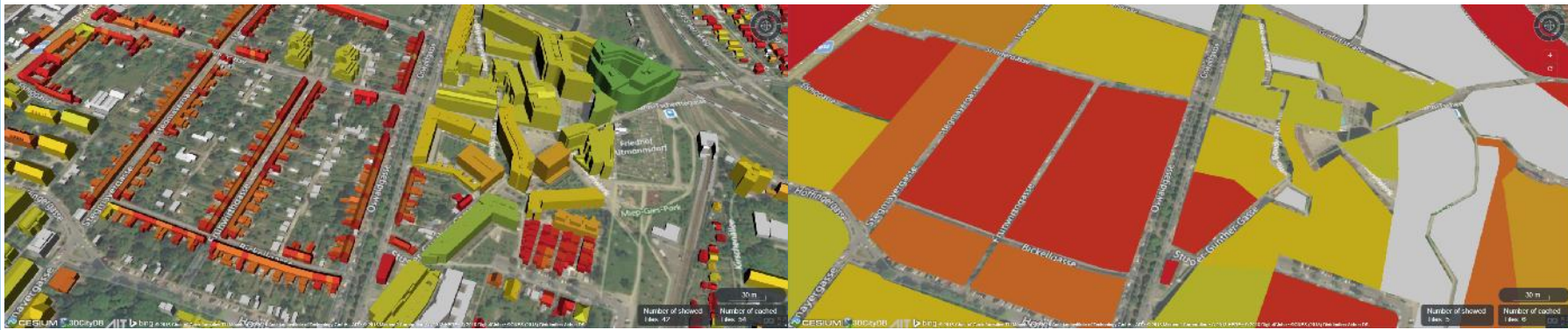
- Extension to the CityGML 2.0 standard
- Exploits the CityGML Application Domain Extension (ADE) mechanism to
 - Extend existing classes
 - Add new classes and attributes



Energy ADE: what, why, when

- Overall goals

1. Ease data interoperability for *Urban Energy Modelling*
 - Among heterogeneous software tools
 - Among heterogeneous stakeholders
 - Define (and store) relevant energy-related data in a standard, open, urban data model
2. Allow for multi-scale energy modelling
 - From “single” building up to whole district/city
 - Both top-down and (preferably) bottom-up approaches
3. Foster interdisciplinary cooperation among CityGML users, data producers, software vendors, ..., and scientists



Energy ADE: what, why, when

- Early work by HFT Stuttgart and TU München
- International consortium started in 2014
 - Ca. 20 institutions, 11+ countries (as of 2018)
 - No direct funding, but through other projects



Energy ADE: what, why, when

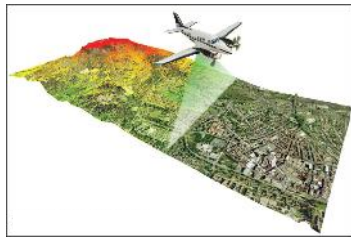
- Open, consensus-based development
 - GitHub: <https://github.com/cstb/citygml-energy>
 - Sig3D Wiki: <http://en.wiki.energy.sig3d.org>
- Open, on-going series of workshops (twice per year)
 - 1st: May 2014 in Stuttgart @ HFT (v. 0.4)
 - 2nd: October 2014 in Karlsruhe @ EIFER
 - 3rd: May 2015 in Sophia Antipolis @ CSTB (v. 0.5)
 - 4th: December 2015 in Munich @ TU München
 - 5th: May 2016 in Vienna @ AIT (v. 0.6)
 - 6th: November 2016 in Ferrara @ DedaGroup (v. 0.7)
 - 7th: May 2017 in Grenoble @ CSTB (v. 0.8)
 - 8th: December 2017 in Karlsruhe @ KIT/EIFER (v. 0.9)
 - **9th: June 2018 in Aachen @ RWTH (v. 1.0)**



Energy ADE: what, why, when

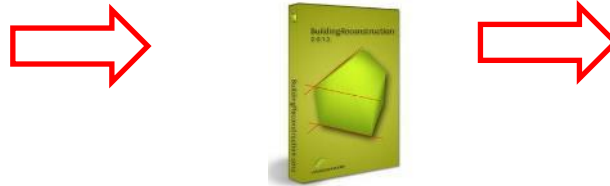
1) Input geodata, e.g.

- Lidar data
- Building footprints



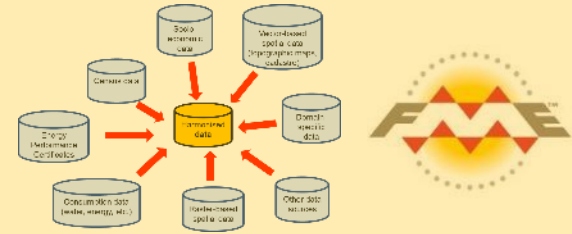
<http://www.directionsmag.com>

2) 3D modelling



**“Classical” workflow
steps with CityGML**

3) Data integration



6) Presentation / visualisation



5) Domain specific applications / simulations



Energy ADE

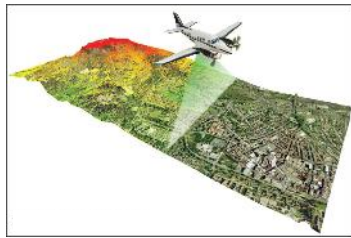
4) Data import/export and management



Energy ADE: what, why, when

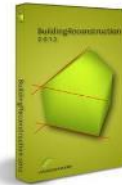
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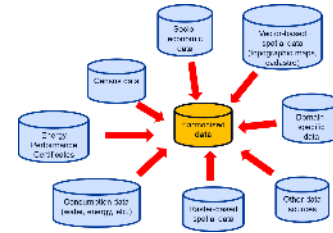
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Energy ADE: what, why, when

- 3DCityDB extension for the Energy ADE
 - For version 0.8, developed at AIT
 - Released on GitHub in 2017
 - (Utility Network ADE also available!)
 - https://github.com/gioagu/3dcitydb_ade



- 3DCityDB support for *any* ADE
 - Work in progress by the 3DCityDB development team
 - Expected release within 2018 (?)



3D City Database extension
for the
CityGML Energy ADE 0.8
PostgreSQL Version

Documentation

Last update: 24 January 2018

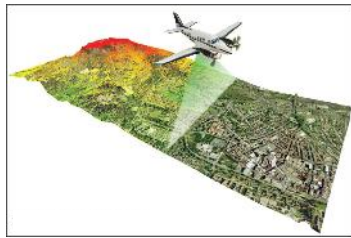


Further details: see previous workshop in Karlsruhe http://en.wiki.energy.sig3d.org/index.php/Workshop_Karlsruhe_2017

Energy ADE: what, why, when

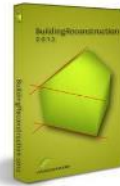
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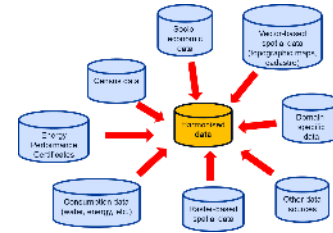
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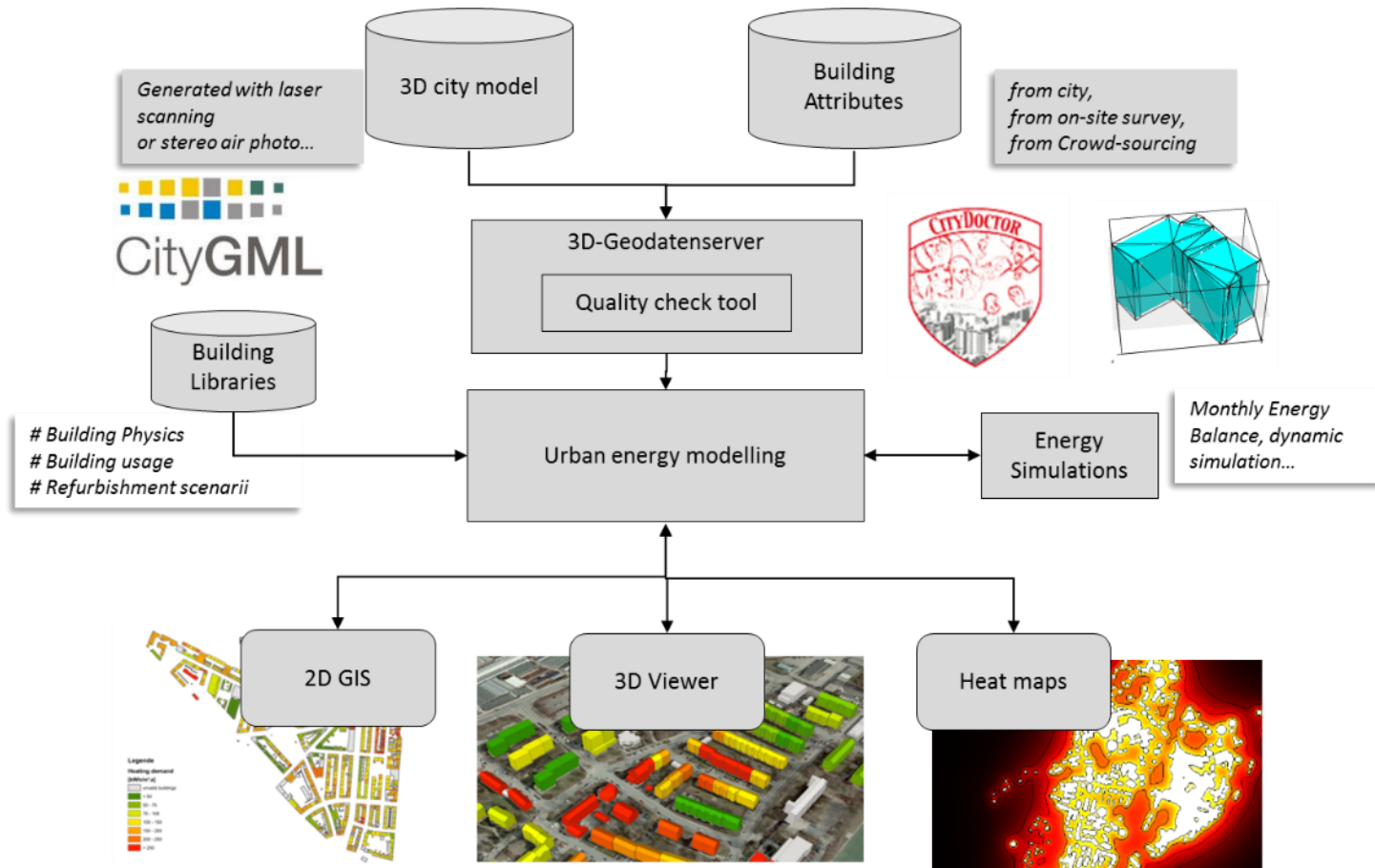
Energy ADE: what, why, when

- **SimStadt**



Hochschule
für Technik
Stuttgart

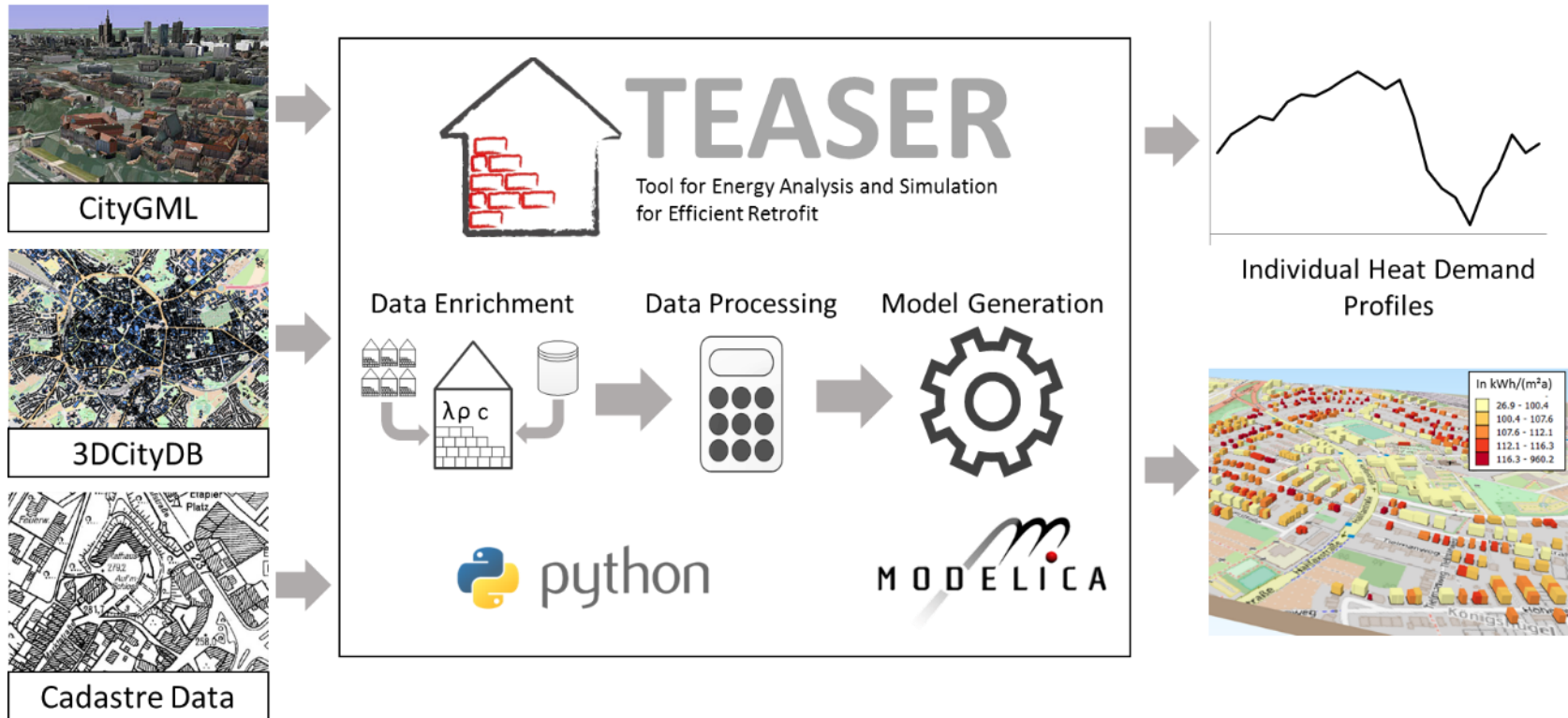
University of Applied Sciences



Energy ADE: what, why, when

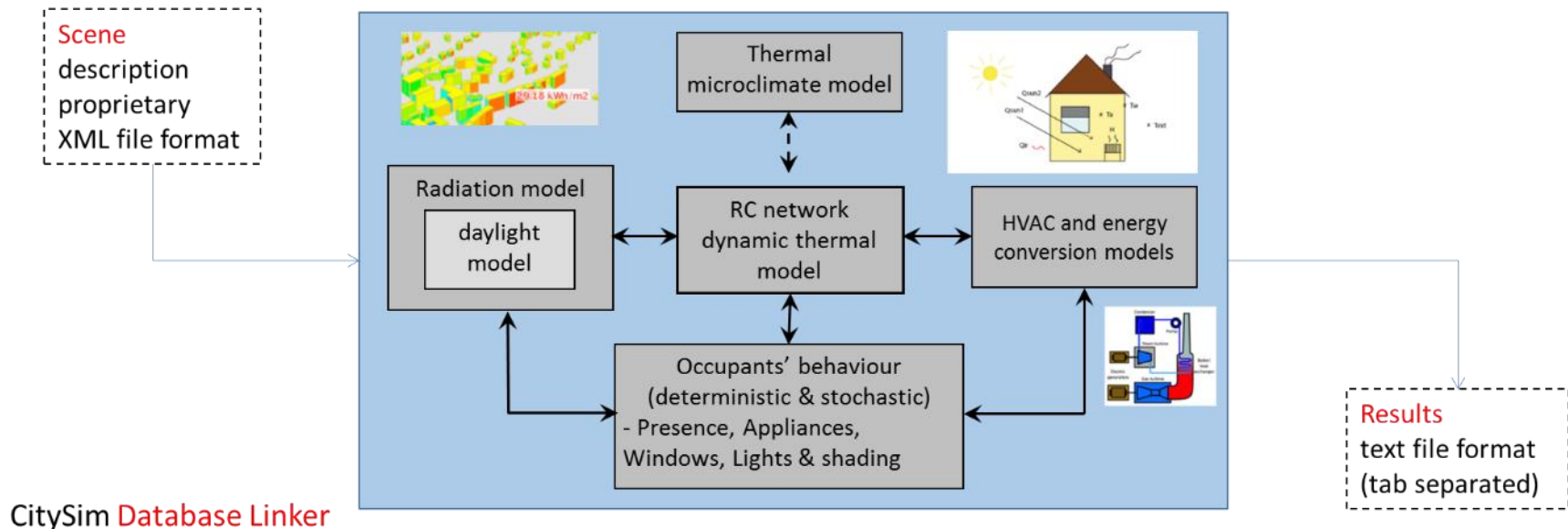
- **TEASER**

EBC | Institute for Energy Efficient
Buildings and Indoor Climate

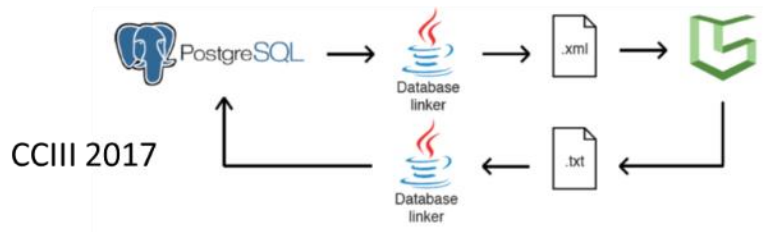


Energy ADE: what, why, when

- CitySim Solver + CitySim Pro



CitySim Database Linker



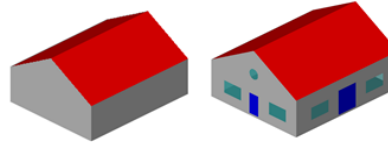
New plug-in
PLEA 2017



Energy ADE: what, why, when

- KIT workflow and toolset

CityGML LoD2 oder
LoD3 Model



GMLToolbox

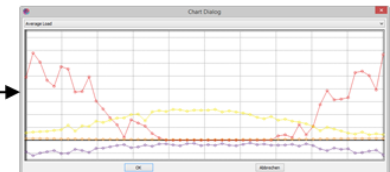
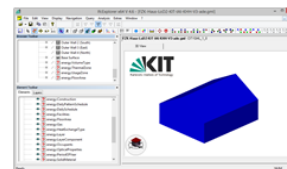


CityGML Energy ADE

```
</core:cityObjectMember>
<core:cityObjectMember>
  <energy:solidMaterial gml:id="GML_04220fde-5499-42c8-9114-a310c0cc2d3">
    <gml:description>Dachziegelstein aus Ton nach DIN 12524</gml:description>
    <gml:name>Dachziegelstein-Ton-DIN-12524</gml:name>
    <energy:conductivity uom="Wm-1k-1">1</energy:conductivity>
    <energy:density uom="kgm-3">2000</energy:density>
    <energy:specificHeat uom="Jkg-1k-1">8</energy:specificHeat>
  </energy:solidMaterial>
</core:cityObjectMember>
<core:cityObjectMember>
```

IFCEExplorer

GebSim

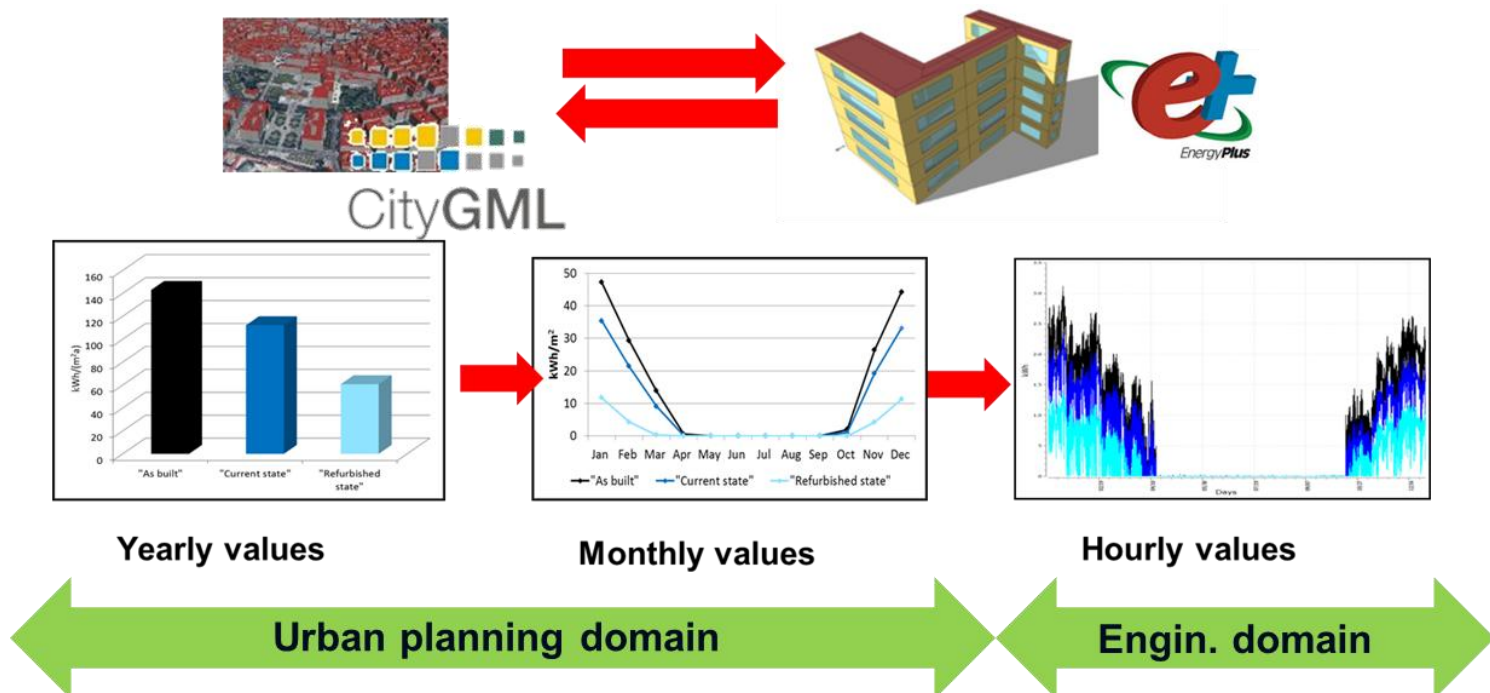


CityGML Energy ADE

Energy ADE: what, why, when

- **CityGML + Energy ADE <-> EnergyPlus**

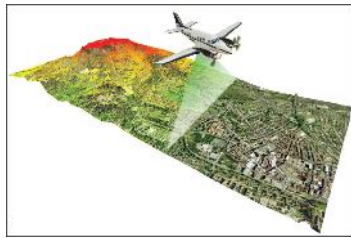
- Development of a bidirectional interface between CityGML + Energy ADE and EnergyPlus



Energy ADE: what, why, when

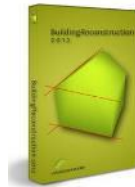
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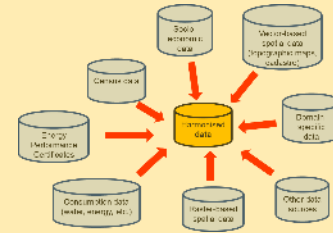
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Energy ADE

6) Presentation / visualisation



Energy ADE: what, why, when

Some scientific publications (2016-2018)

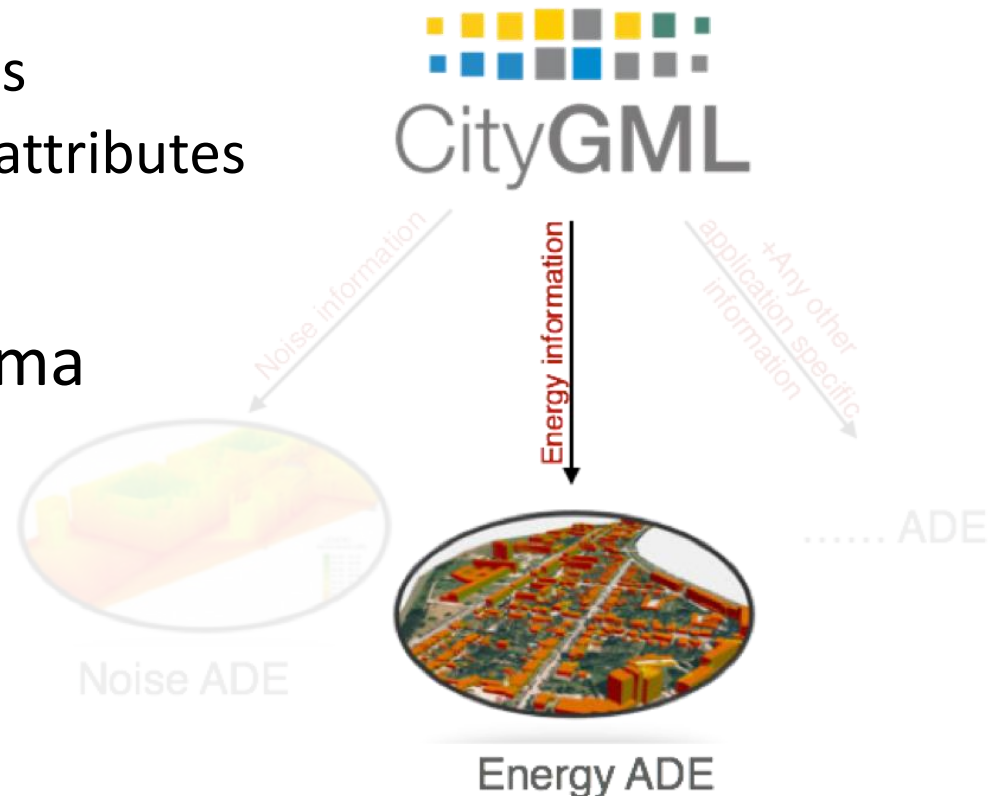
- Agugiaro, G., 2016, **Enabling “energy-awareness” in the semantic 3D city model of Vienna**. ISPRS Ann. Photogramm. Remote Sens. Spatial Inf. Sci., IV-4/W1, pp. 81-88, doi:10.5194/isprs-annals-IV-4-W1-81-2016
<http://www.isprs-ann-photogramm-remote-sens-spatial-inf-sci.net/IV-4-W1/81/2016/isprs-annals-IV-4-W1-81-2016.pdf>
- Remmen, P., Lauster, M., Mans, M., Osterhage, T., Müller, D., 2016, **CityGML Import and Export for Dynamic Building Performance Simulation in Modelica**. Proceedings of Building Simulation and Optimization 2016 : Third IBSPA - England Conference
<http://www.ibpsa.org/proceedings/BSO2016/p1047.pdf>
- Muñoz H., M. E., Dochev, I., Seller, H., Peters, I., 2016, **Enriching the 3D City Model for the Simulation of Urban Heat Demand**. Proceedings REAL CORP Conference 2016, Hamburg
- Benner, J., Geiger, A., Häfele, K.-H., 2016, **Virtual 3D City Model Support for Energy Demand Simulations on City Level - The CityGML Energy Extension**, Proceedings REAL CORP Conference 2016, Hamburg
https://conference.corp.at/archive/CORP2016_20.pdf
- Coccolo, S., Mauree, D., Kämpf, J., Scartezzini, J.-L., 2016, **Integration of outdoor human comfort in a building energy simulation database using CityGML Energy ADE**. In (Habert, G., Schlueter, A. eds) Expanding Boundaries: Systems Thinking for the Built Environment, pp. 84-89
https://repository.corp.at/127/1/CORP2016_108.pdf
- Skarbal, B., Peters-Anders, J., Faizan Malik, A., Agugiaro, G., 2017, **How to pinpoint energy-inefficient buildings? An approach based on the 3D city model of Vienna**. ISPRS Ann. Photogramm. Remote Sens. Spatial Inf. Sci., IV-4-W3, pp. 71-78, doi: 10.5194/isprs-annals-IV-4-W3-71-2017
<https://www.isprs-ann-photogramm-remote-sens-spatial-inf-sci.net/IV-4-W3/71/2017/isprs-annals-IV-4-W3-71-2017.pdf>
- Nouvel, R., Zirak, M., Coors, V., Eicker, U., 2017, **The influence of data quality on urban heating demand modeling using 3D city models**. Computers, Environment and Urban Systems, 64, pp. 68-80, ISSN 0198-9715
- Agugiaro, G., Benner, J., Cipriano, P., Nouvel, R., 2018, **The Energy Application Domain Extension for CityGML: Enhancing interoperability for urban energy simulations**. Open source geospatial tools and technologies for urban and environmental studies. Open Geospatial Data, Software and Standards 2018 3:2
<https://opengeospatialdata.springeropen.com/articles/10.1186/s40965-018-0042-y>

Overview

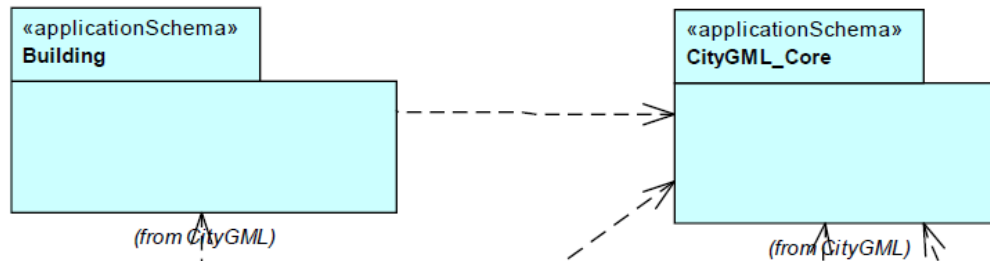
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Energy ADE 1.0

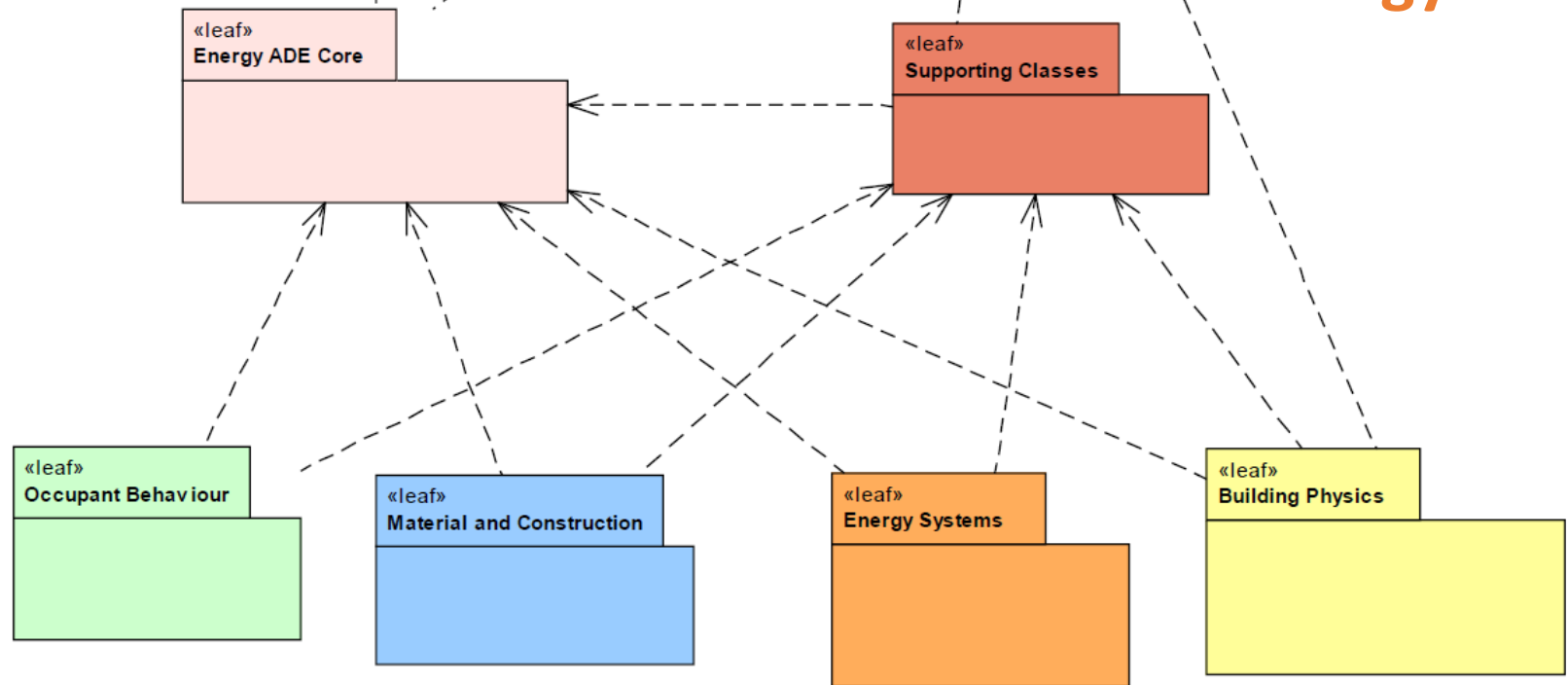
- Extension to the CityGML 2.0 standard
- Exploits the CityGML Application Domain Extension (ADE) mechanism to
 - Extend existing classes
 - Add new classes and attributes
- Modelled in UML
- Available as XSD schema
- Modular structure



Energy ADE 1.0



Energy ADE

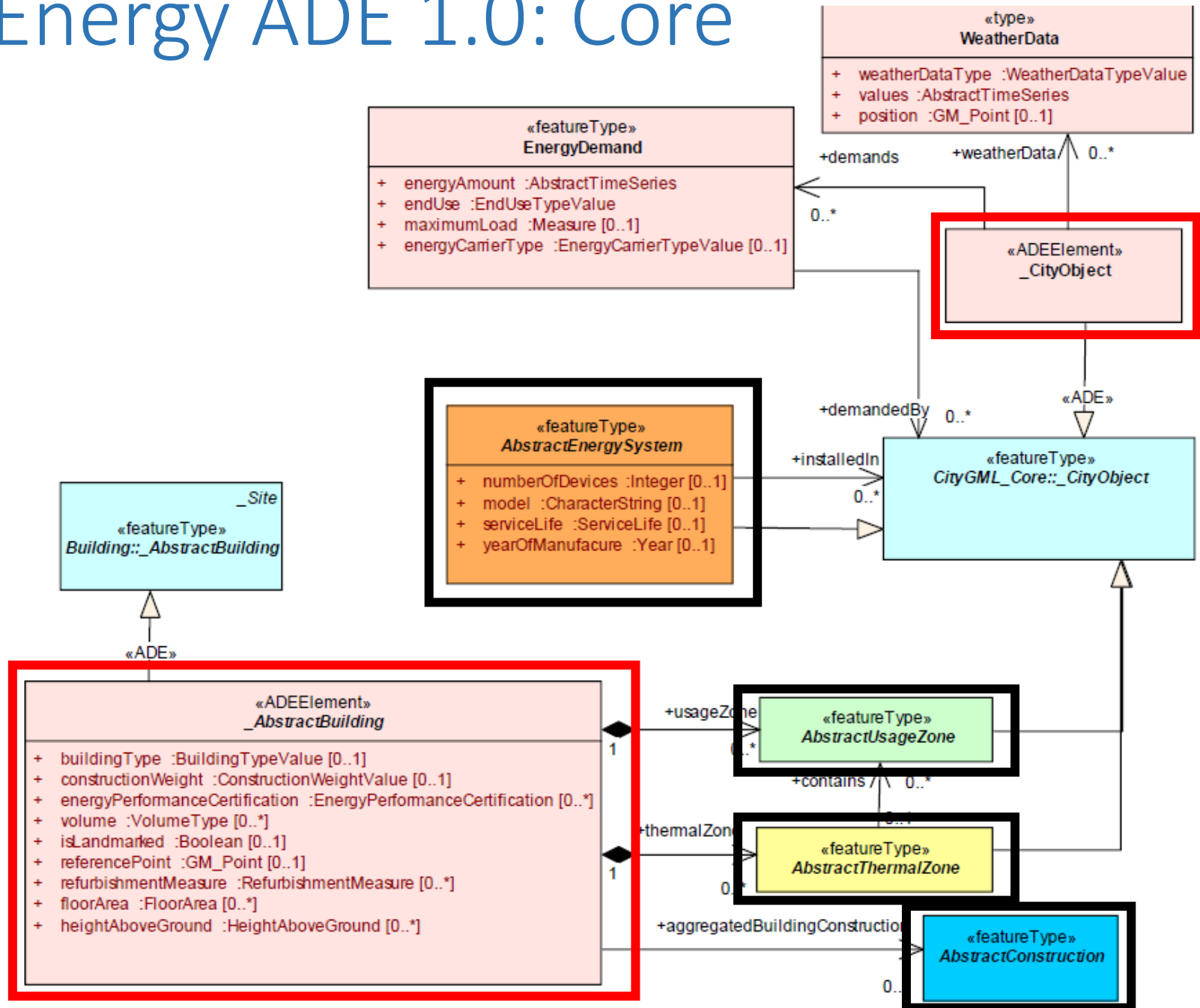


Energy ADE 1.0

- **Core module**

- Extended `_CityObject` and `_AbstractBuilding`
- `EnergyDemand`
- Shared Datatypes, Enumerations and CodeLists
- Abstract classes as link to other modules

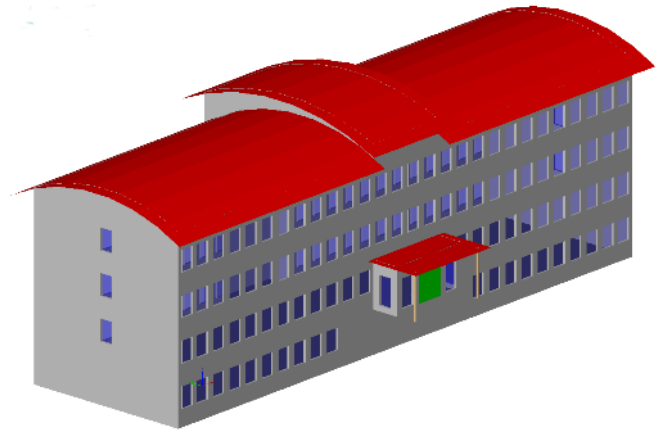
Energy ADE 1.0: Core



Energy ADE 1.0

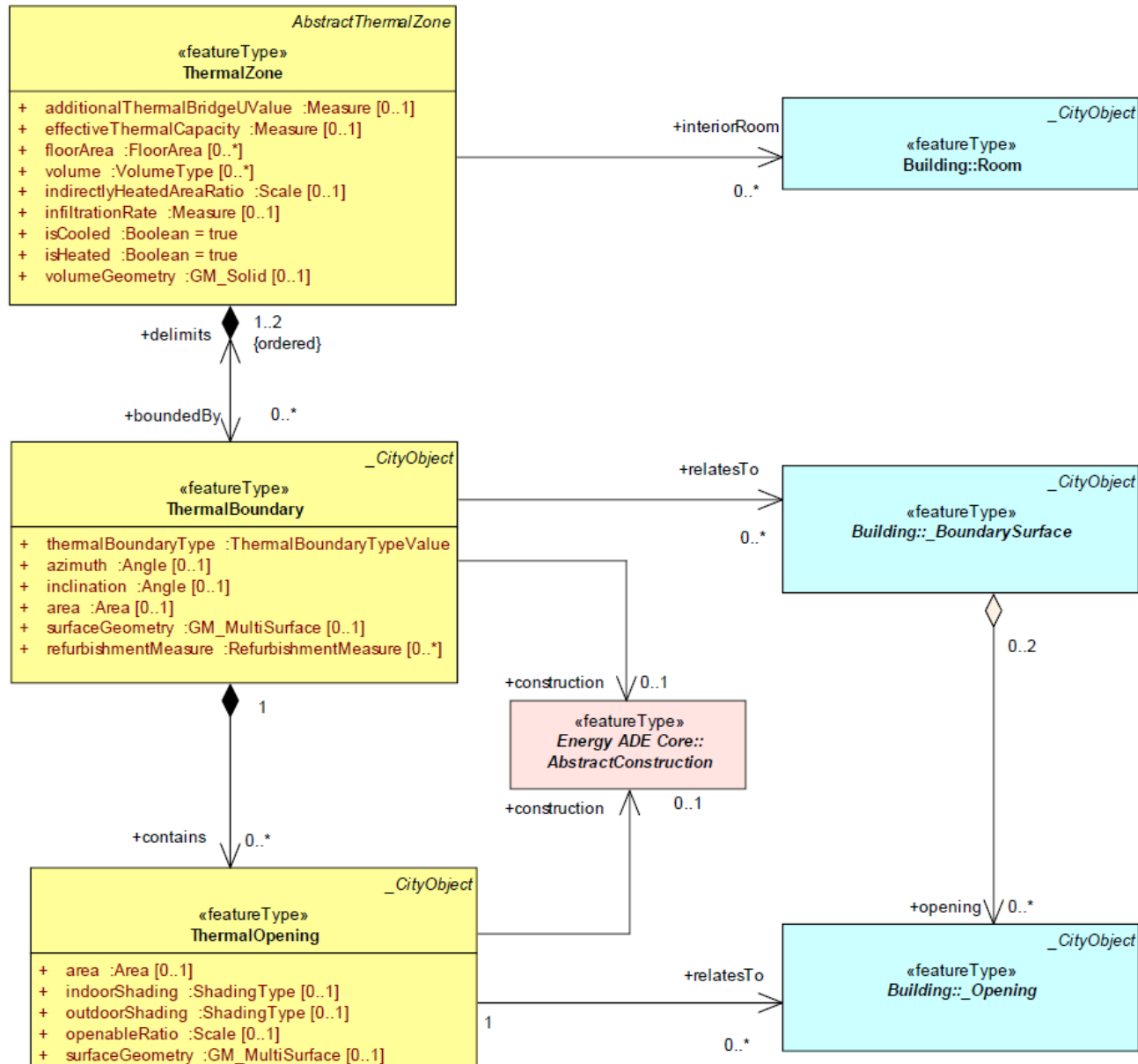
- **Building Physics module**

- ThermalZone
- ThermalBoundary
- ThermalOpening



- Modelling the thermal zone is (intentionally) decoupled from the usual LoD concept
- Thermal boundaries/openings can be modelled alternatively
 - without geometries at all
 - referencing CityGML thematic surfaces/openings
 - using explicit geometries

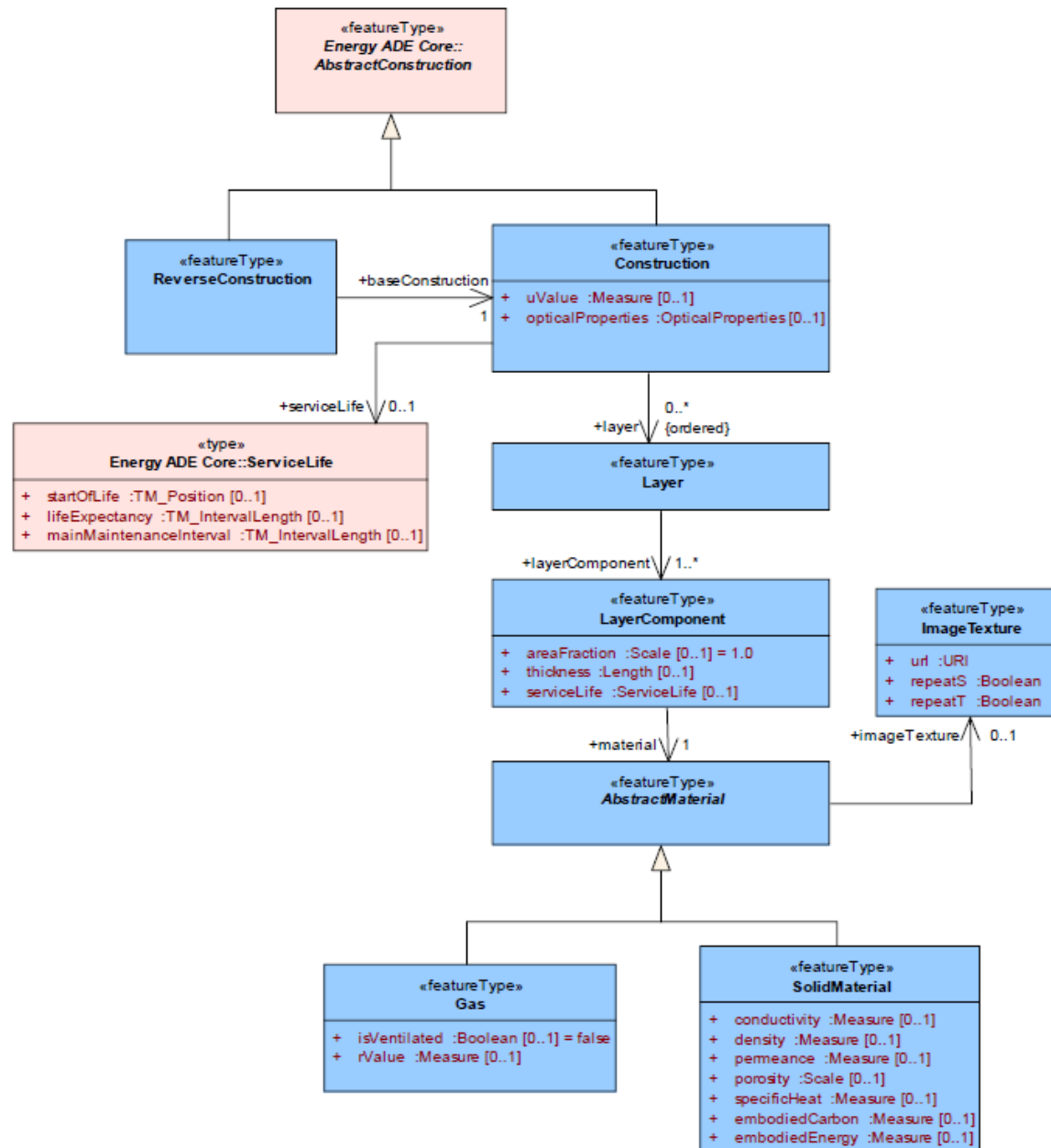
Energy ADE 1.0: Building Physics



Energy ADE 1.0

- **Material and Construction module**
 - Construction
 - Layer
 - Layer component
 - Material
 - Optical properties
- Constructions can be characterized in different ways
 - Simply by means of “global” U-values
 - As complex, multi-layered constructions, each one with specific physical properties

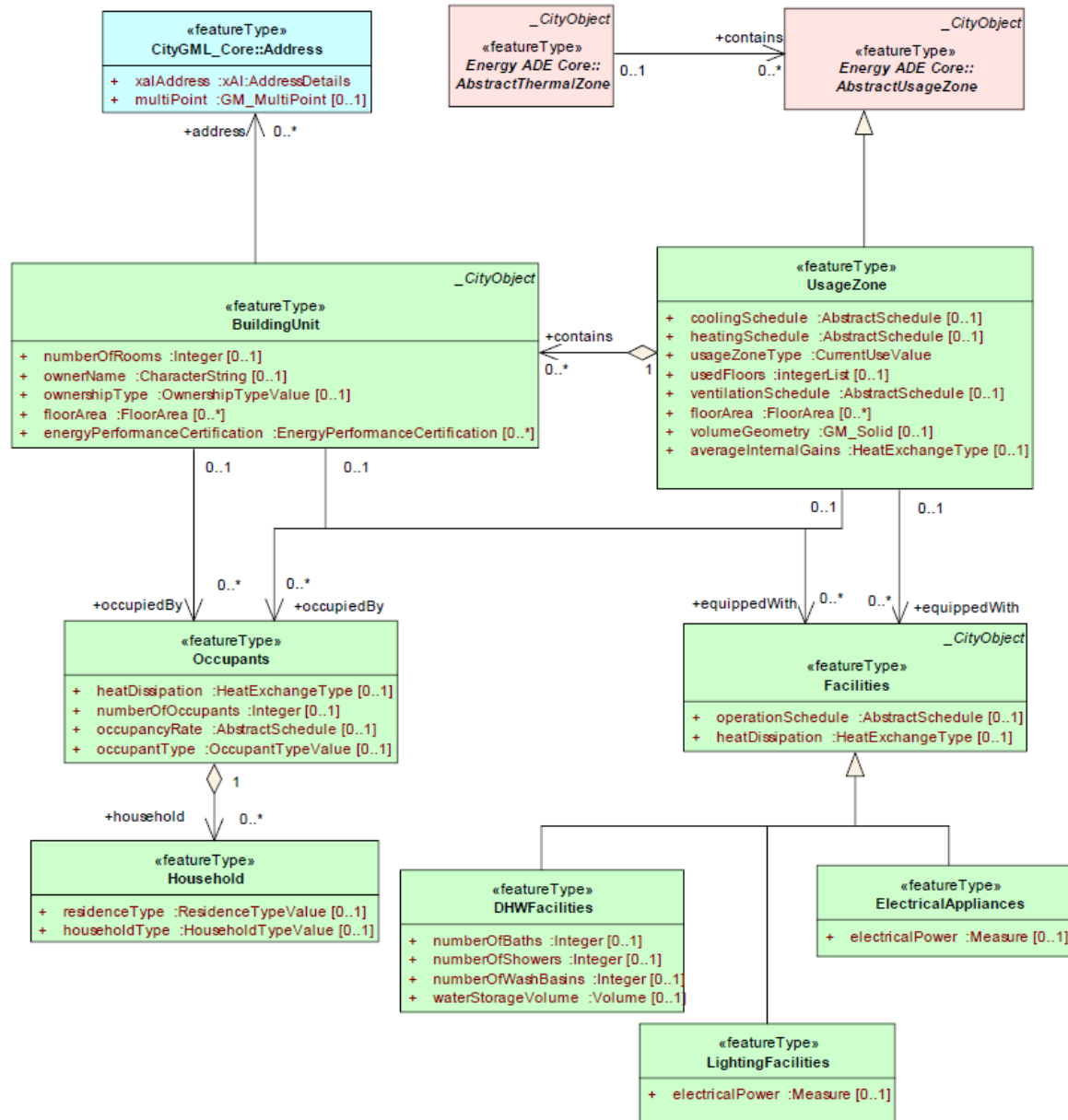
Energy ADE 1.0: Material & Constr.



Energy ADE 1.0

- **Occupant Behaviour module**
 - UsageZone
 - BuildingUnit
 - Occupants
 - Facilities
- Internal gains (by occupants or facilities) can be modelled
 - As unique value (avarageInternalGains)
 - By means of time-dependent Schedules

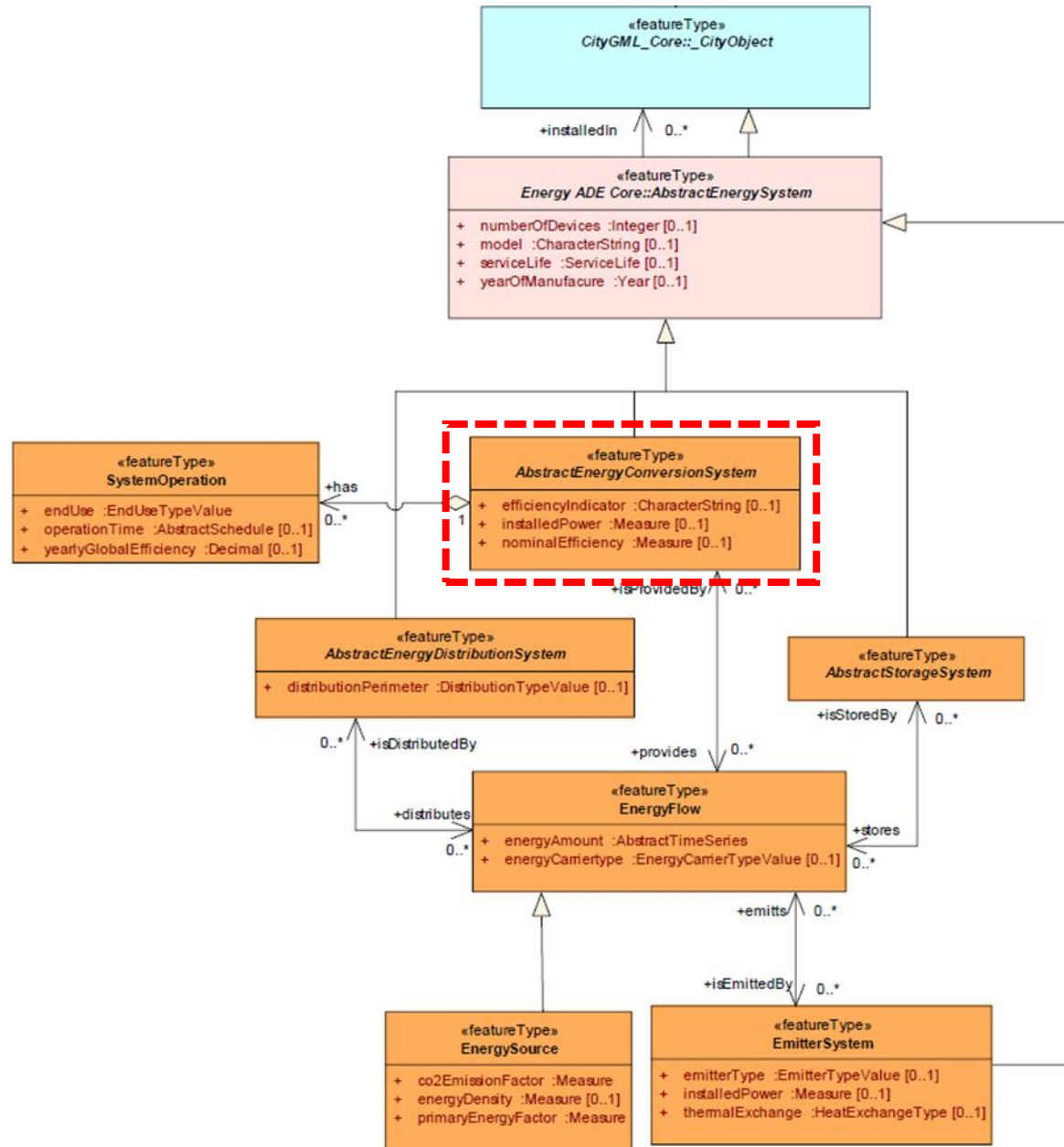
Energy ADE 1.0: Occupant Behav.



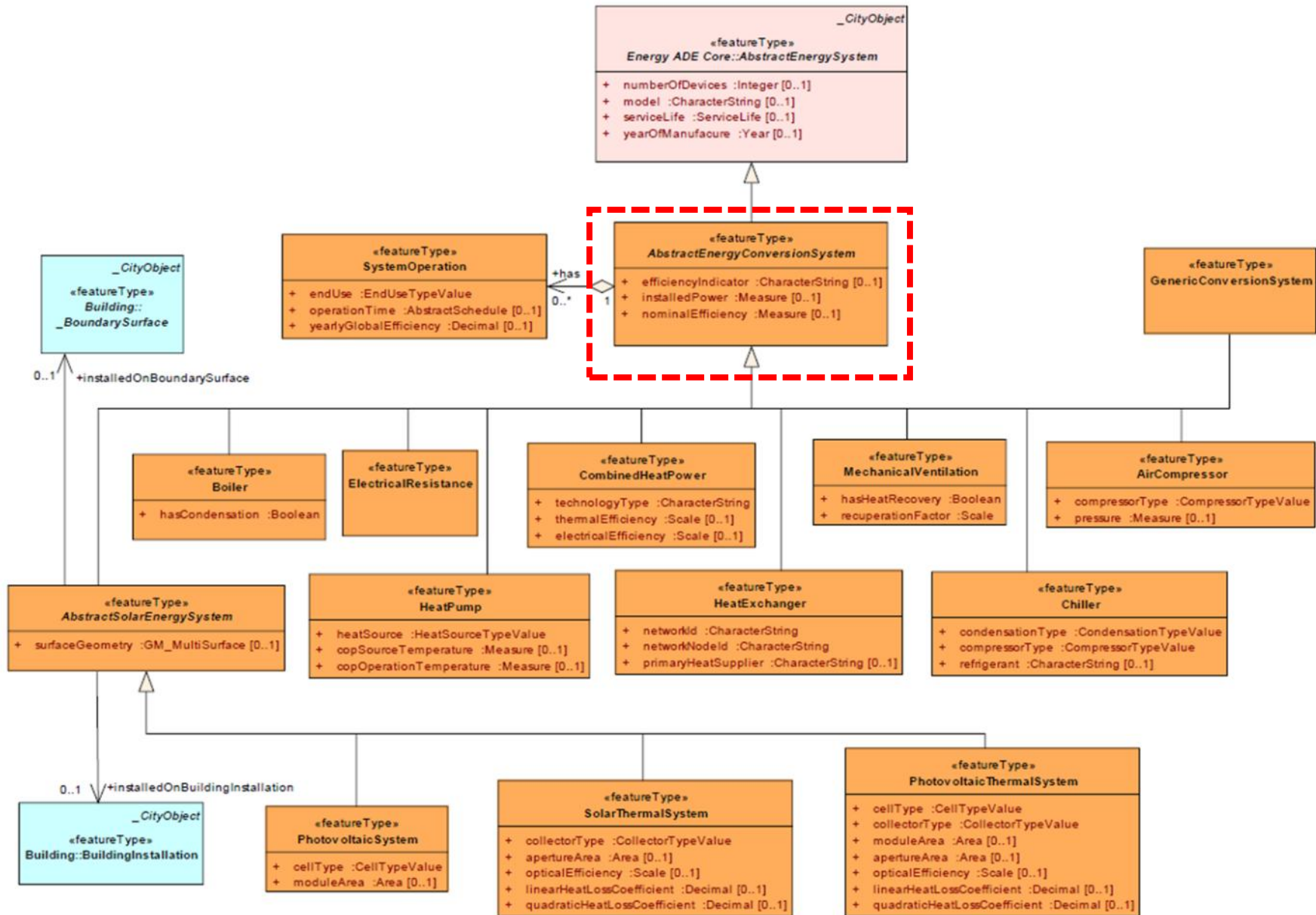
Energy ADE 1.0

- **Energy Systems module**
 - EnergyConversionSystem (+Subclasses)
 - EnergyStorageSystem (+Subclasses)
 - EnergyDistributionSystem (+Subclasses)
 - EnergyEmitter
 - EnergyFlow
- Represents the energy forms and energy systems to perform energy demand and supply analyses
- Allows, for example, to calculate the CO₂ emissions or primary energy balances

Energy ADE 1.0: Energy Systems



Energy ADE 1.0: Energy Systems



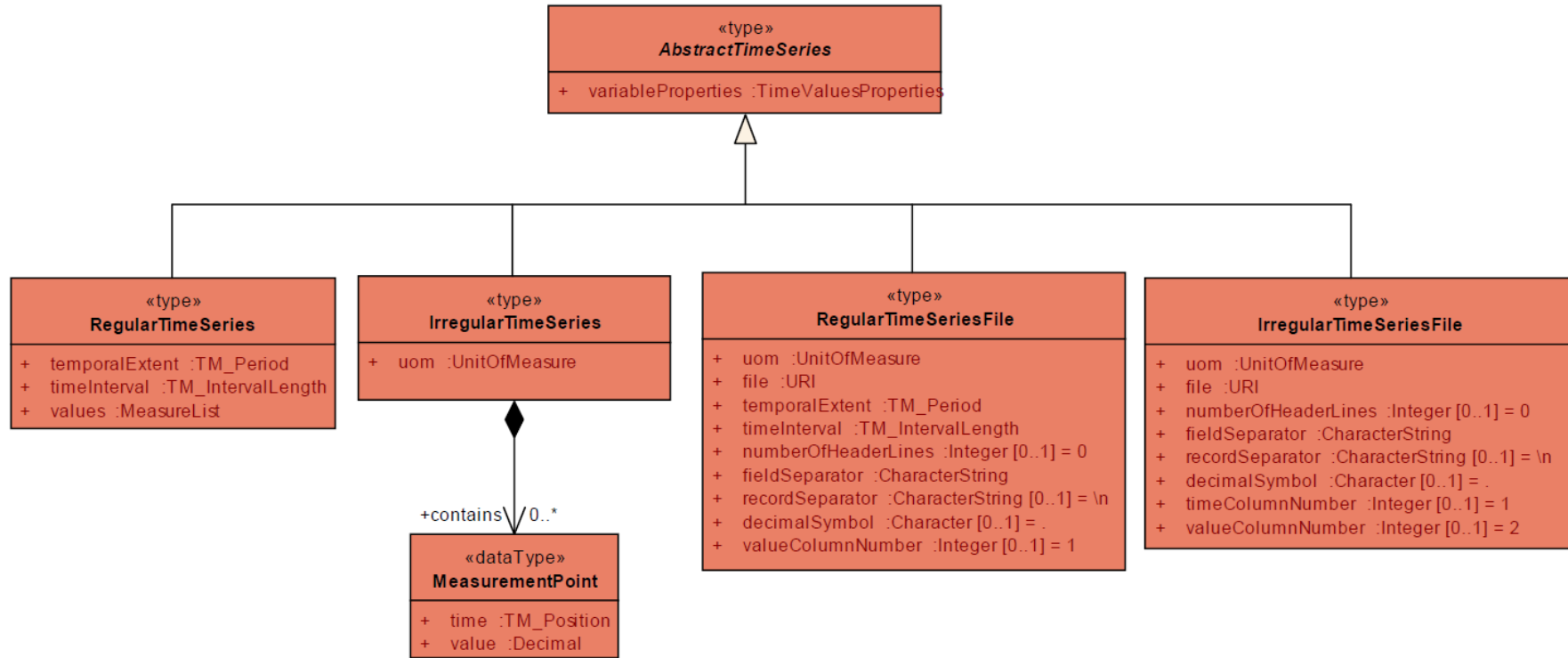
Energy ADE 1.0

- **Supporting Classes**

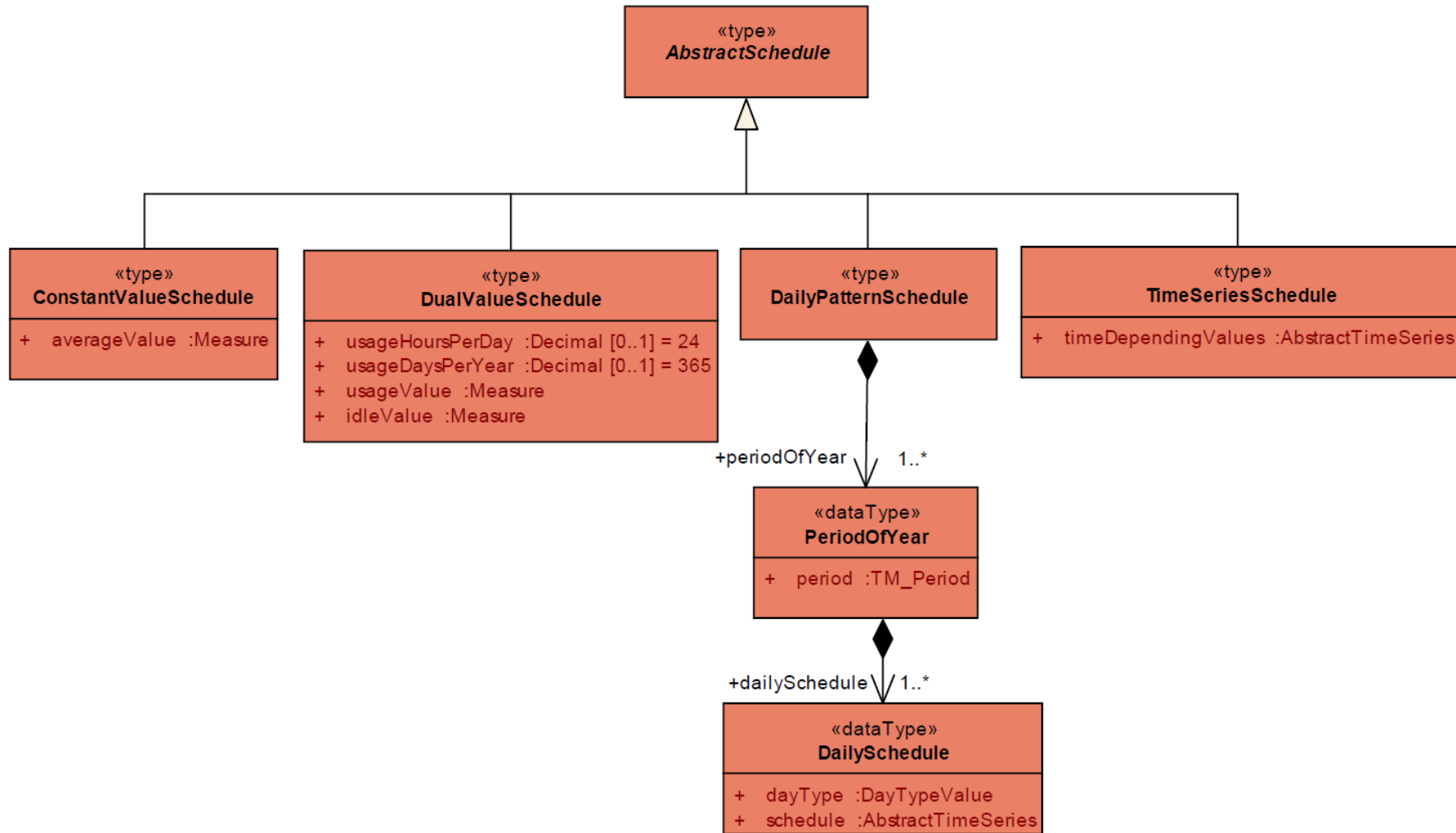
- Time series
- Schedules
- WeatherStation

- Time series can be regular or irregular, possibly stored in external files
- Schedules can be modelled as
 - fixed values
 - dual values
 - daily patterns
 - based on time series

Energy ADE 1.0: Time series



Energy ADE 1.0: Schedules



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Energy ADE: what's next?

- Documentation
 - Revise, update, enrich the existing one
 - Add several clear simple examples (also) for “normal” users
 - Add a number of practical how-tos
 - How to read/write Energy ADE data?
- Prepare and share (open) test datasets
- Complete document to submit Energy ADE 1.0 to OGC
- Keep testing and disseminating!
 - (How mature is the Energy Systems module?)

Energy ADE: what's next?

- Continue harmonization with other ADEs
 - Utility Network ADE
 - Dynamizer ADE
 - ...?
- Little by little, 3DCityDB with ADE support is coming...
- Adopt Energy ADE in new projects and provide constructive feedback for further improvements
 - SUMERA COST-Action project submitted in April 2018
- Start thinking about Energy ADE 2.0?

THANK YOU ALL!



...and sorry if I am missing some logos!

Delft University of Technology

(from 1 August 2018)

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3D Geoinformation Group

TU Delft
Julianalaan 134
Delft 2628BL - The Netherlands

