



# Development of the CityGML ADE Energy

INSPIRE GWF 2015

*Lisbon*

25.05.2015

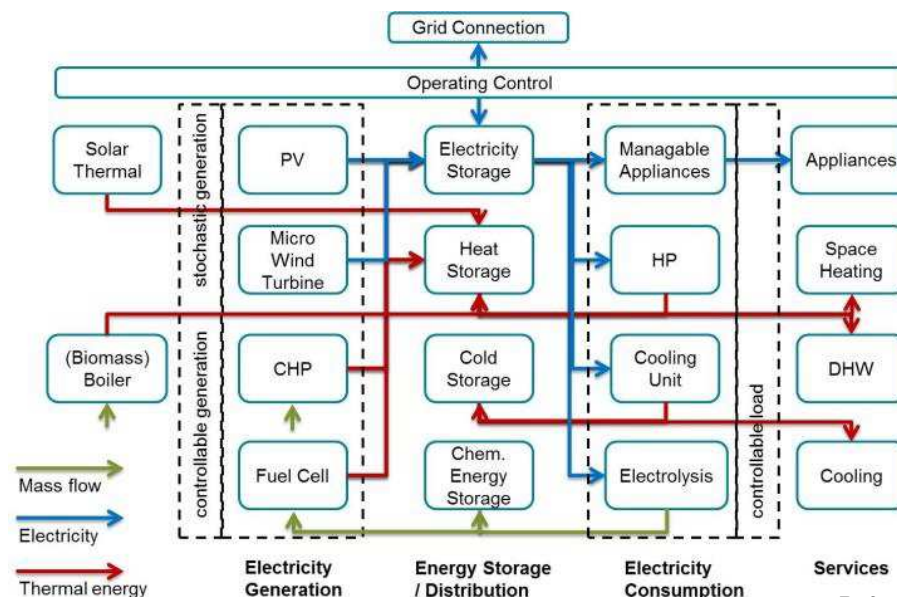
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# Structure

- Introduction
- Our approach
- Energy ADE development process
- Energy ADE content
- Applications
- Conclusion and outlooks

# Urban energy modelling concept

- Urban energy simulation consists in **multi-dimensions**:
  - Multiple energy carriers and end-uses
  - Local and central energy transformation, storage and distribution
  - Multiple system dimensions: spatial and temporal
  - Multiple interactions (building, microclimate, etc.)
- ➔ **Specific requirements** (building, infrastructure, etc.)



*Reference: BAHU et al., 2013*

## Starting point

- No widely applicable open model standard exists until now for Urban Energy Modelling (like IFC or gbXML for buildings)
- CityGML, open standard for exchanging 3D urban data, doesn't contain any **energy-related objects or attributes.**
- CityGML is **extensible** through **ADEs.**
- Urban energy tool developers (CitySim, UMI) have developed their **own tailor-made urban information model**



## Our Objectives

- Store relevant energy-related data in a common open city data model
- ...to offer **data exchange** and **interoperability** possibilities between urban energy stakeholders and tools
- ...as well as with other expert fields (acoustics, statics).  
Combine data collection effort!

➤ **Energy ADE for CityGML**

# Stakes

- **Flexibility:** Following the philosophy of CityGML and its Levels of Detail (LoDs)
- **Compatibility:** Allowing to be used in different urban energy platforms for different analysis methods, using data from different data specification standards
- **Modularity:** connection with other CityGML ADEs, use and extension of ADE Energy in other fields

# A participative development process

- Participative development in an international expert group from 12 organisations



# A participative development process

- Representing the development of 6 urban energy modelling and simulation tools

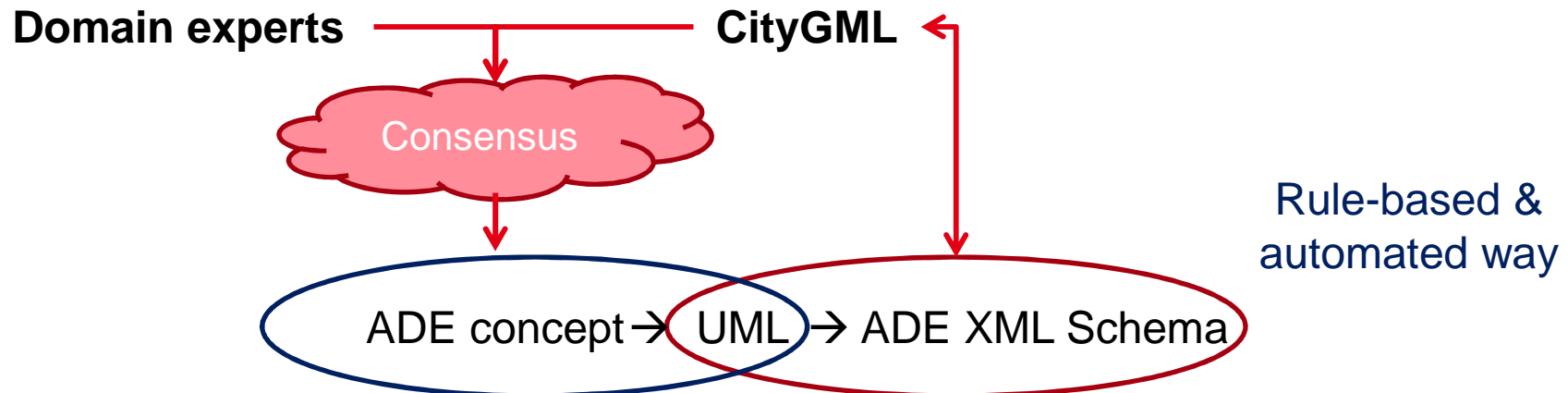


**ENERGIE-ATLAS**  
BAYERN



# CityGML ADE concept

- What is an **ADE**?
  - Extension of the CityGML model for **specific application domains**
  - Formal specification in separate XML schemas referencing the CityGML schemas
- 2 types of ADEs:
  - Extension of existing CityGML feature types
  - Definition of new feature types



- Reference document: *Modeling an application domain extension of CityGML in UML*  
- OGC Best Practice, 2014

## Preliminary development phase

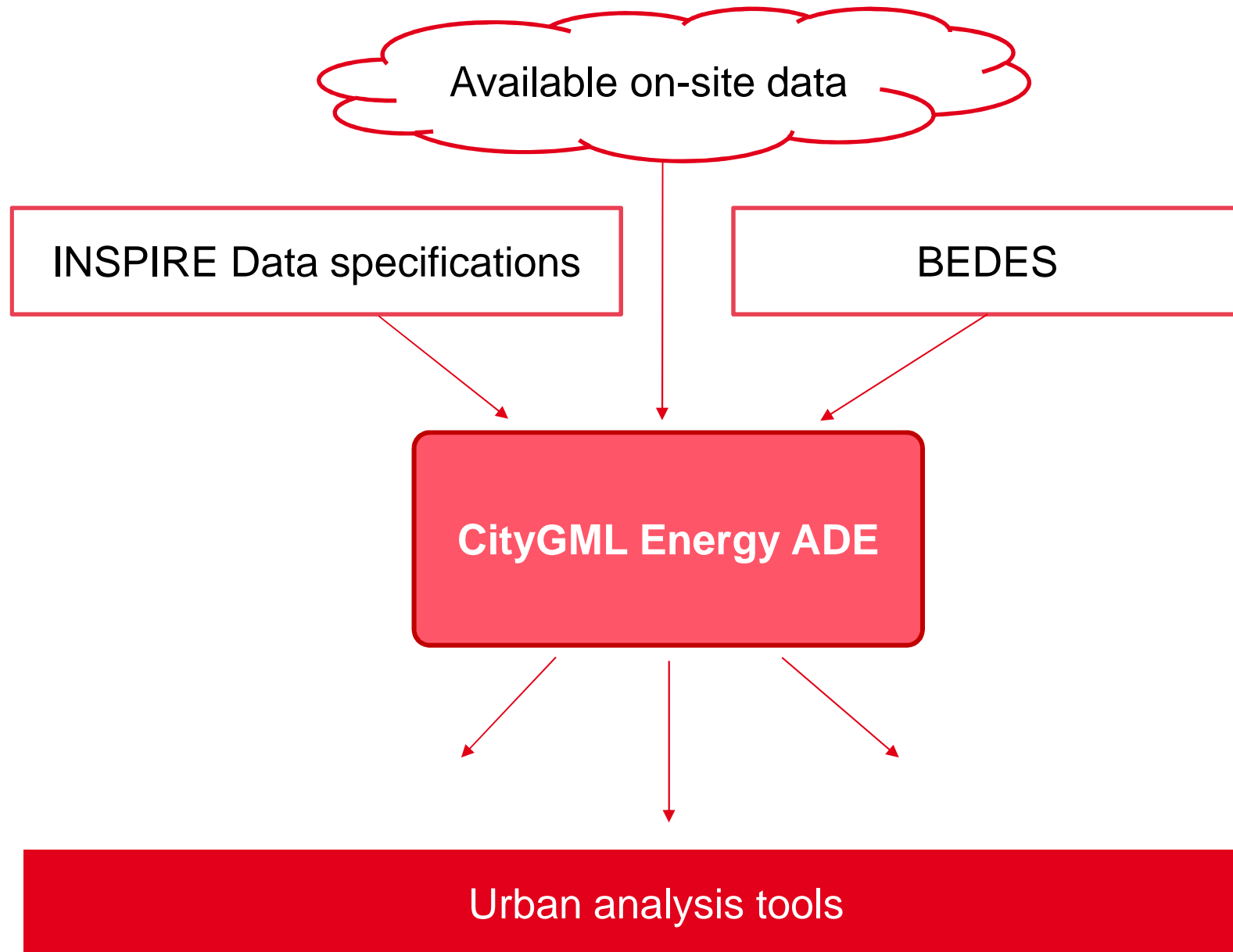
- Study of **existing data specification projects** concerning Building energy at urban scale
- List of **Use cases** (simulation and modelling) from the different partners
- List of **requirements** enabling these Use cases
- Development of class diagramms

# INSPIRE

- Among the 34 spatial themes, INSPIRE proposes **data specifications** for building.
- INSPIRE Building model
  - **4 profiles** (Core2D, **Core3D**, Extended2D, **Extended3D**)
- **Energy related attributes:**
  - Building/BuildingPart (e.g. connectionToElectricity, heatingSource, heatingSystem, energyPerformance, materials, etc.)
  - Wall-/Roof Surfaces (e.g. materialOfRoof/Façade)



# At the interface of Big Geo Data and urban analysis tools



# Time table



## Stuttgart (May 2014) – Kick-off

- Gathering partners
- Organisation of development in Working group
- Requirements collection, identification of other related initiatives

## Karlsruhe (Oct 2014)

- Class diagrams of the different modules
- Unification in one XML scheme
- Organisation of revision process on GitHub repository

## Nice (May 2015)

- Integration of Energy ADE Scheme in softwares
- Testing phase on concrete projects
- Preparation of a documentation, code list definition

## Organisation of the revision process

- A **participative and iterative** process
- Organized in **Working Groups** related to the module structure
- Issues signaled on GitHub, discussed and centralized by the Working Group coordinators
- An **“XML team”** in charge of updating the XML Schema.

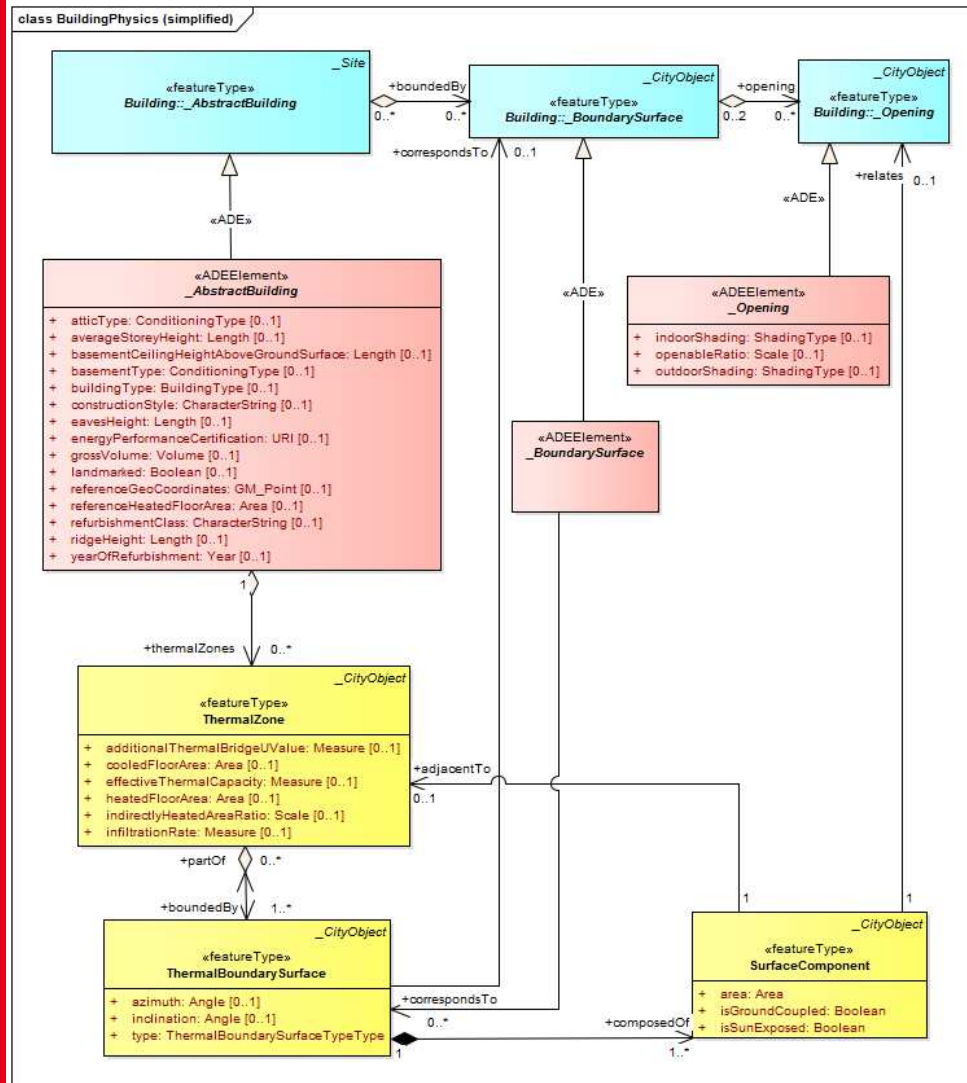
## A modular structure

Structured around an Energy ADE core + 3 modules:

- **Construction and Material**
- **Occupancy**
- **Energy and Systems**

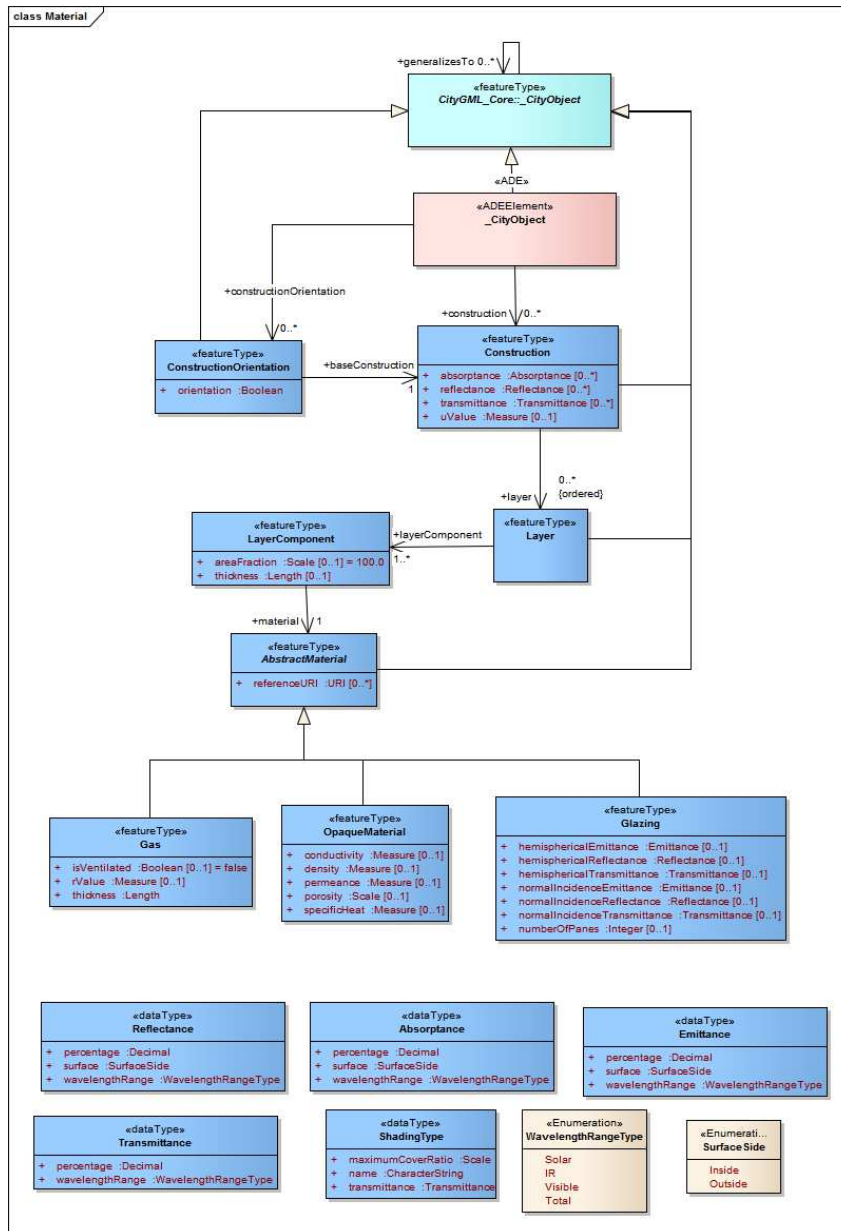
Modules can be potentially used and extended  
in **other fields and applications**

# ADE Energy core



- Contains **thermal building objects** required for building energy simulation
- integrated to the CityGML standard schema through its **AbstractBuilding**, **BoundarySurface** and **Opening** classes.
- Compatible with the **4 LoDs**

# Construction and Materials

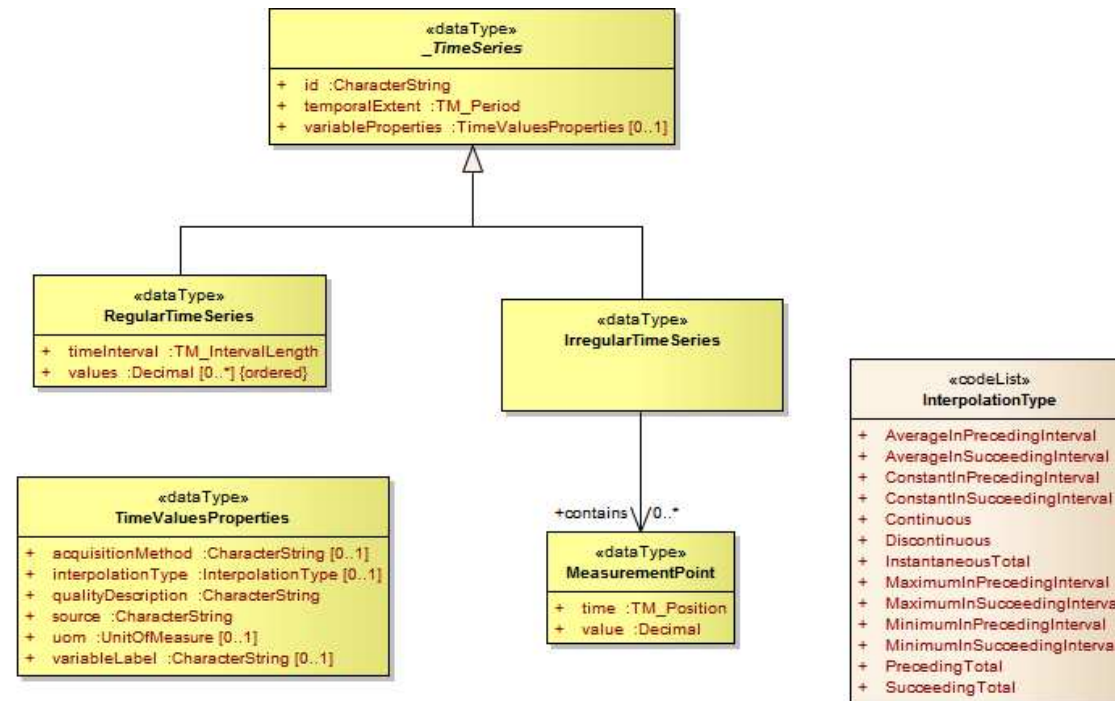


- Contains **physical characterization** of building construction elements
- Compatible with **static energy balance** (U-Values) **AND complex dynamic heat simulation** ( $\lambda$ ,  $\rho$ ,  $c_p$ ).
- May be used and further extended for **multi-field analysis** (e.g. statics, acoustics).





# Time series

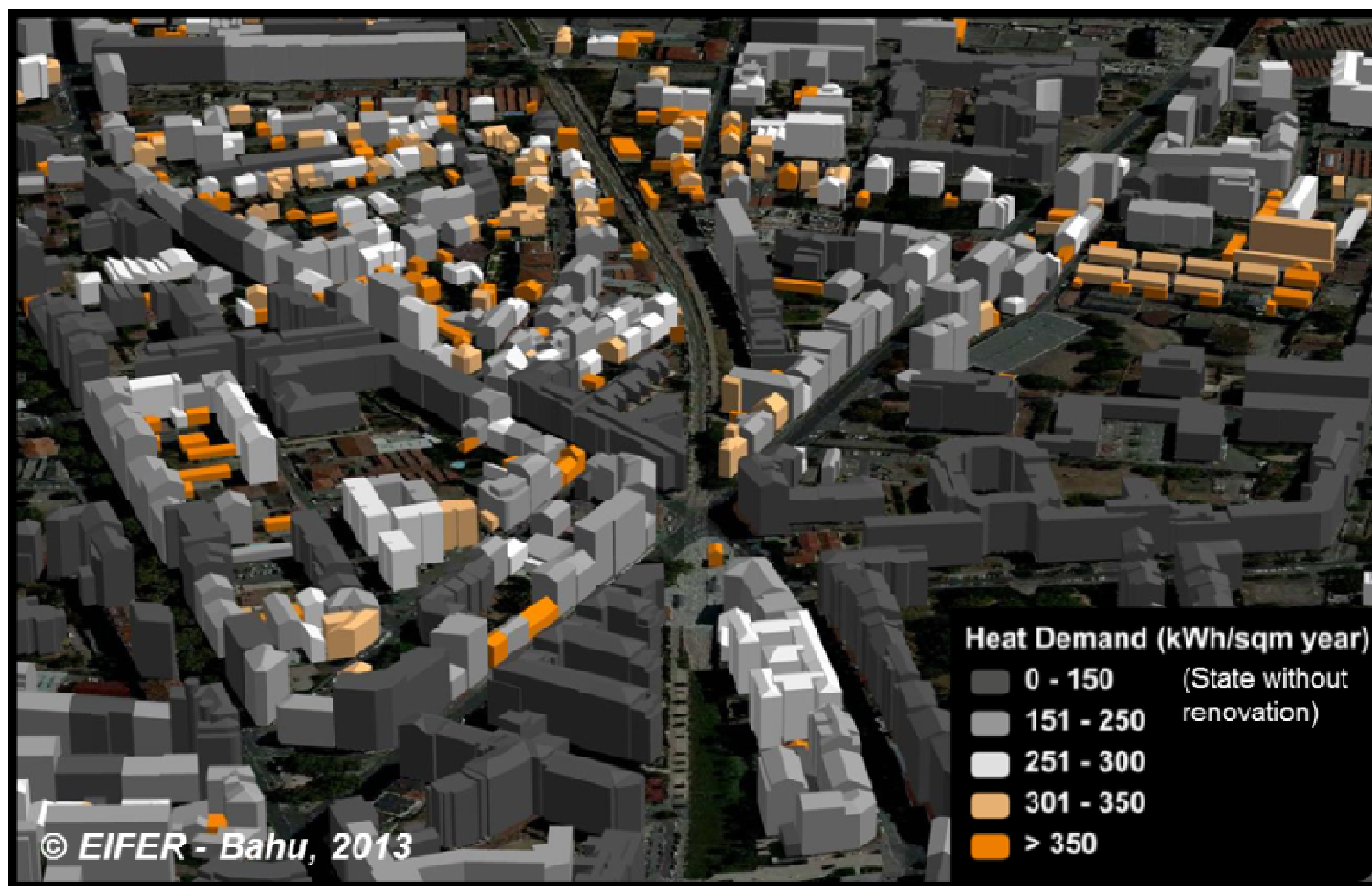


- Inspired from other ADE (WaterML), applied to Energy Amount
- Models both **regular** and **irregular time series**
- May store both **simulation results** and **metering data** for comparison purpose



## Application and test cases

- Heating demand calculation



# Application and test cases

- Dependencies Urban forms / Energy demand

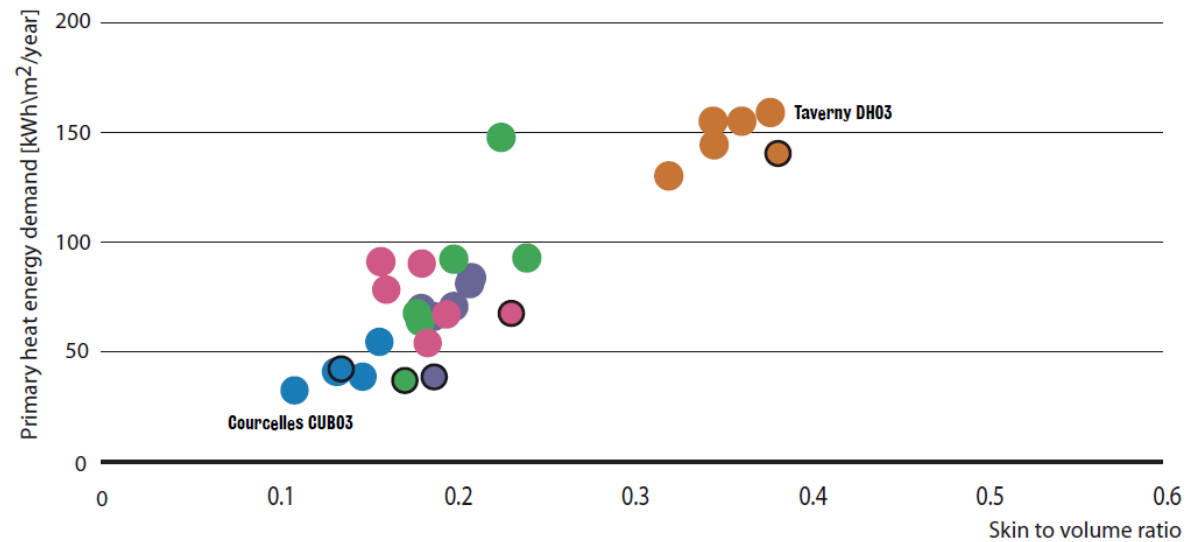


## Paris

Skin to volume ratio and primary heat energy demand interpolation.

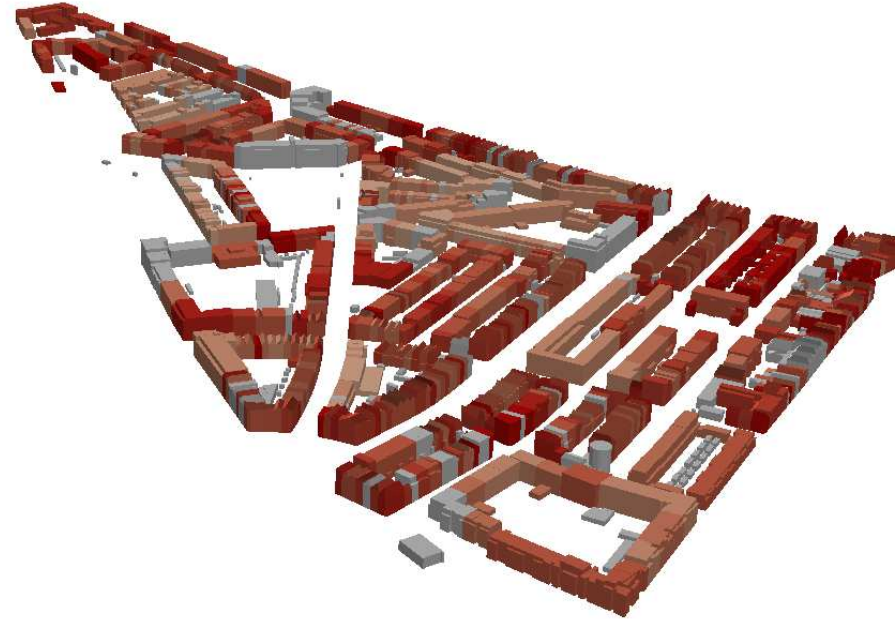
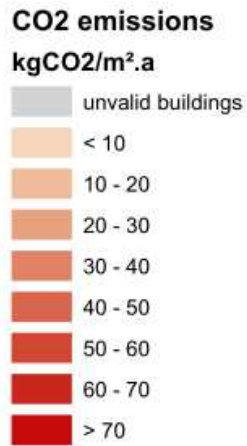
- Detached Housing
- High Rise Apartment
- Slab Housing
- Regular Urban Block
- Compact Urban Block
- Idealized Sample

Source: LSE Cities and EIFER Research

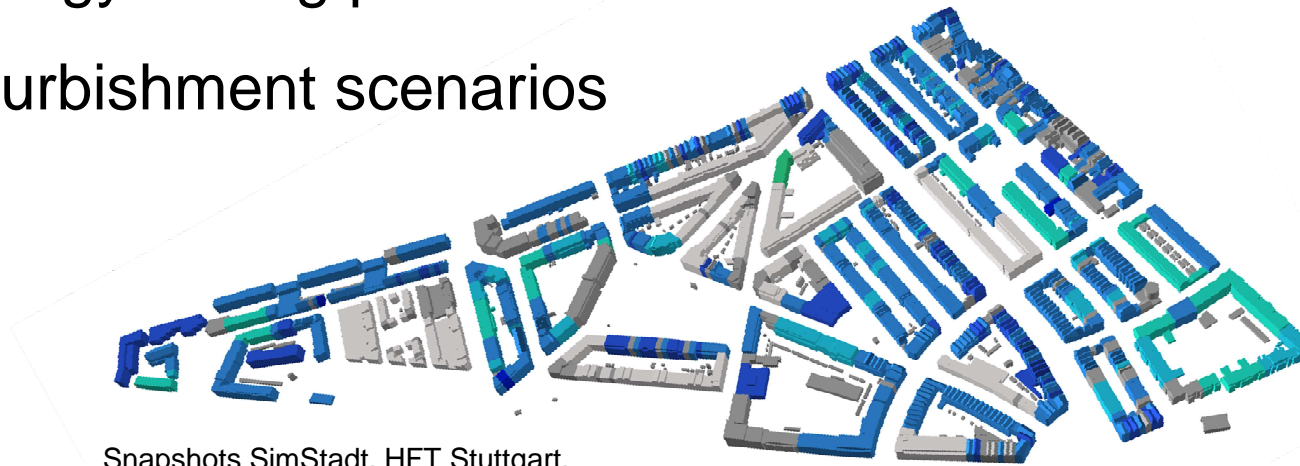
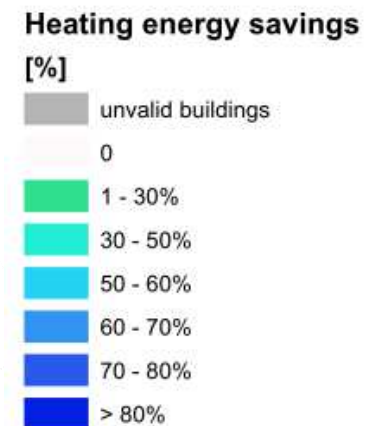


# Application and test cases

- CO2 emissions / Primary Energy



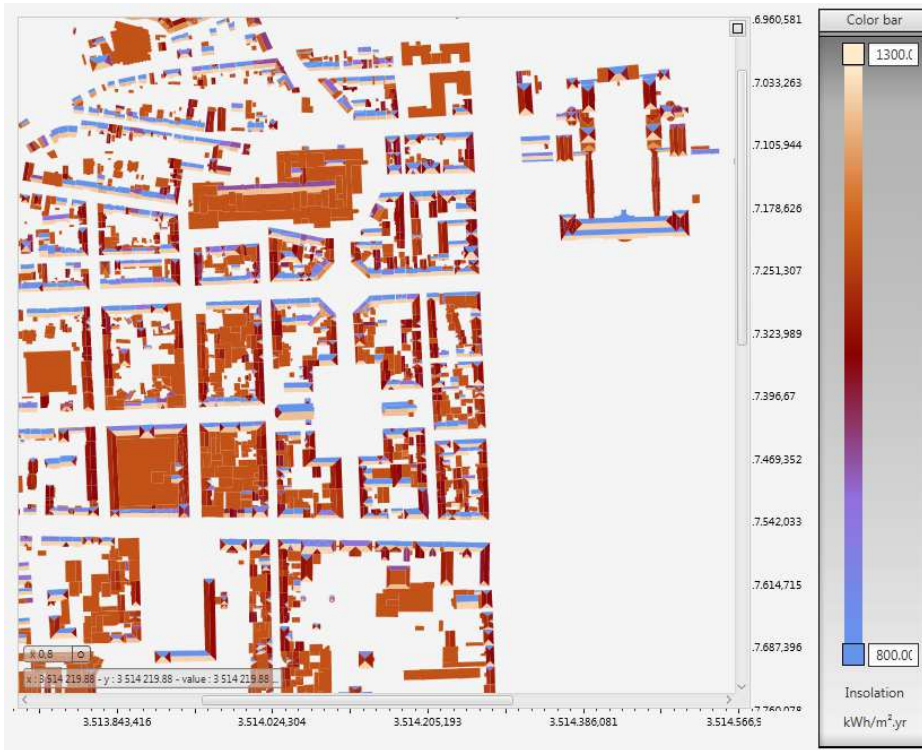
- Energy saving potentials and refurbishment scenarios



Snapshots SimStadt, HFT Stuttgart.

# Application and test cases

- Solar and renewable potential studies



Irradiance potential  
on roofs and facades

Roof suitability for  
Photovoltaic panels

Snapshots SimStadt, HFT Stuttgart.



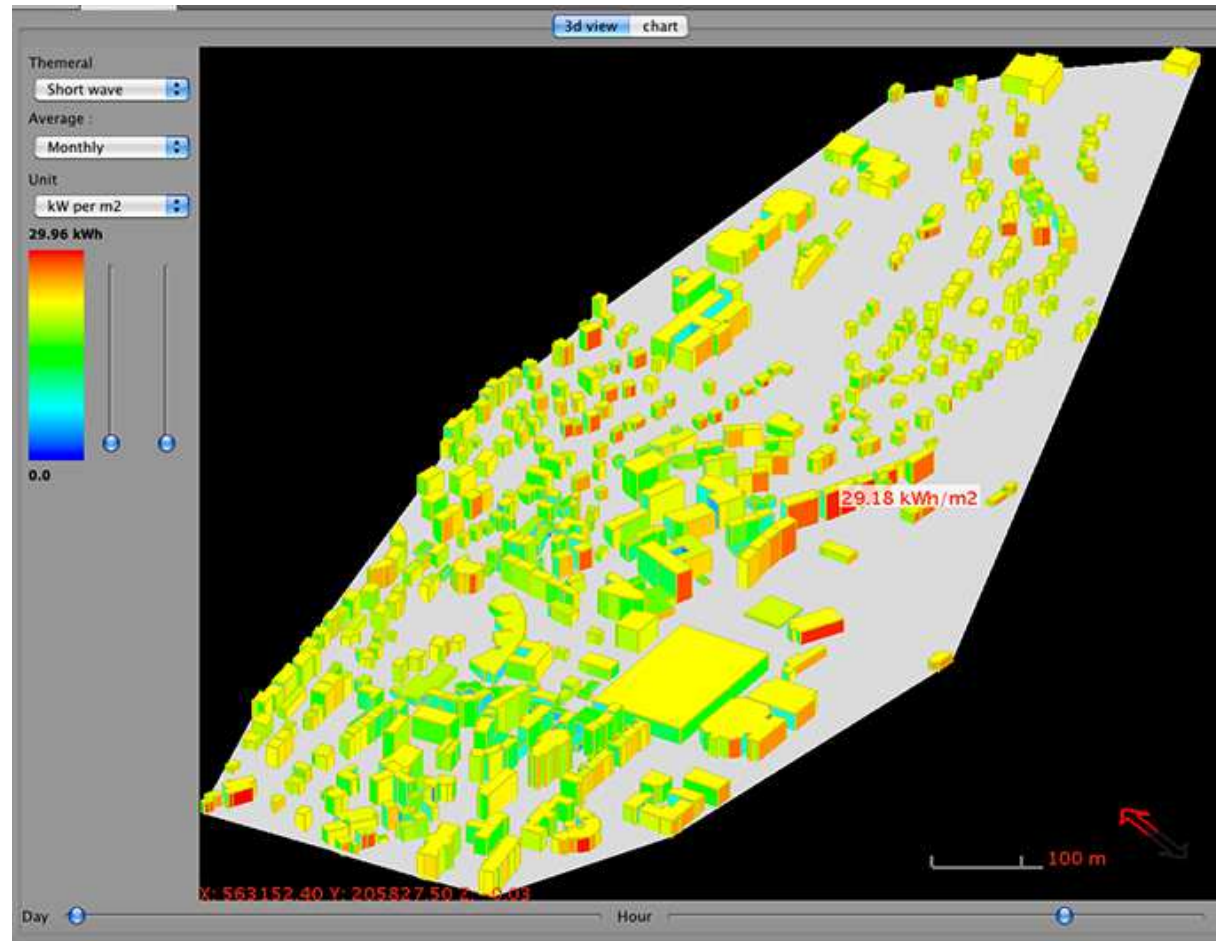
## Application and test cases

- PV cadaster based on 3D City models



# Application and test cases

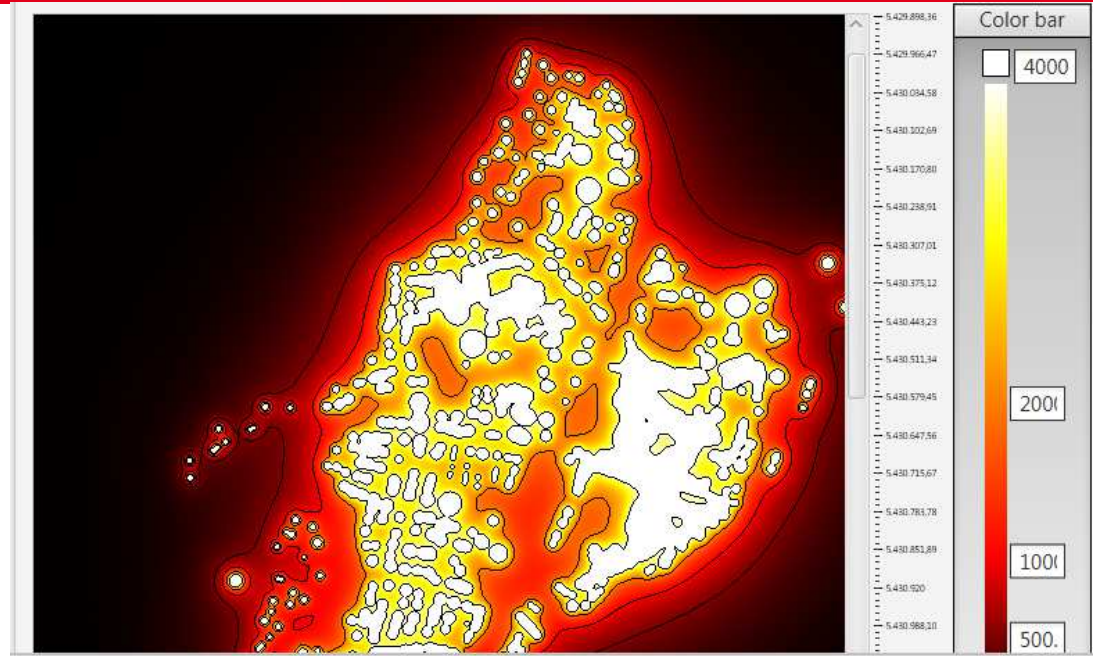
- Micro-climate studies



Snapshots CitySim, EPFL

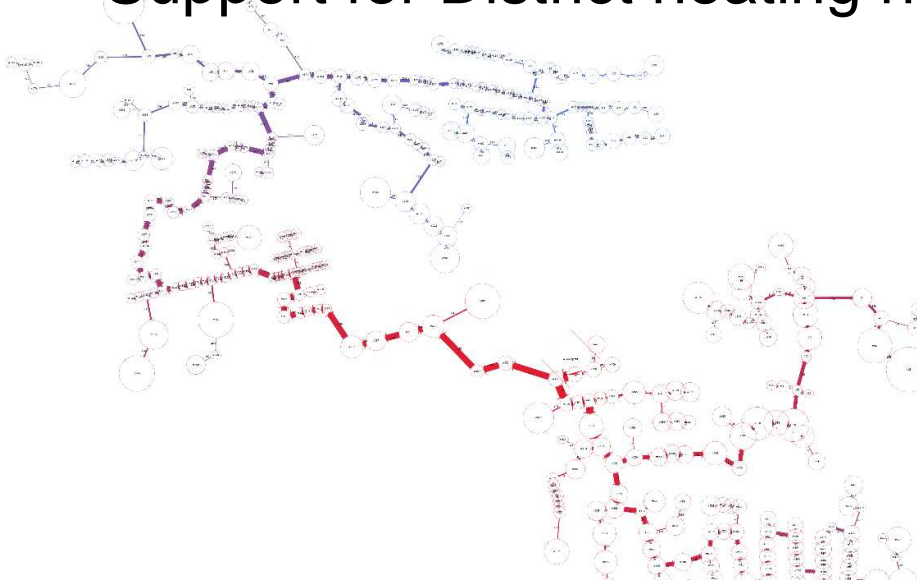
# Application and test cases

- Heat density map



Snapshot SimStadt, HFT Stuttgart.

- Support for District heating network layout



Snapshot SimStadt, HFT Stuttgart.



CityGML + Energy ADE has the potential to enable **many further urban energy analyses**

- Impact of occupancy / behavior
- Comparison of actual and standard consumption
- Daylighting analysis
- Impact of energy-efficient measures
- Life cycle analysis
- ....

# Collaboration with CityGML 3.0 development team

Collaboration with **CityGML 3.0** and **INSPIRE Building** development teams to harmonize some module/concepts

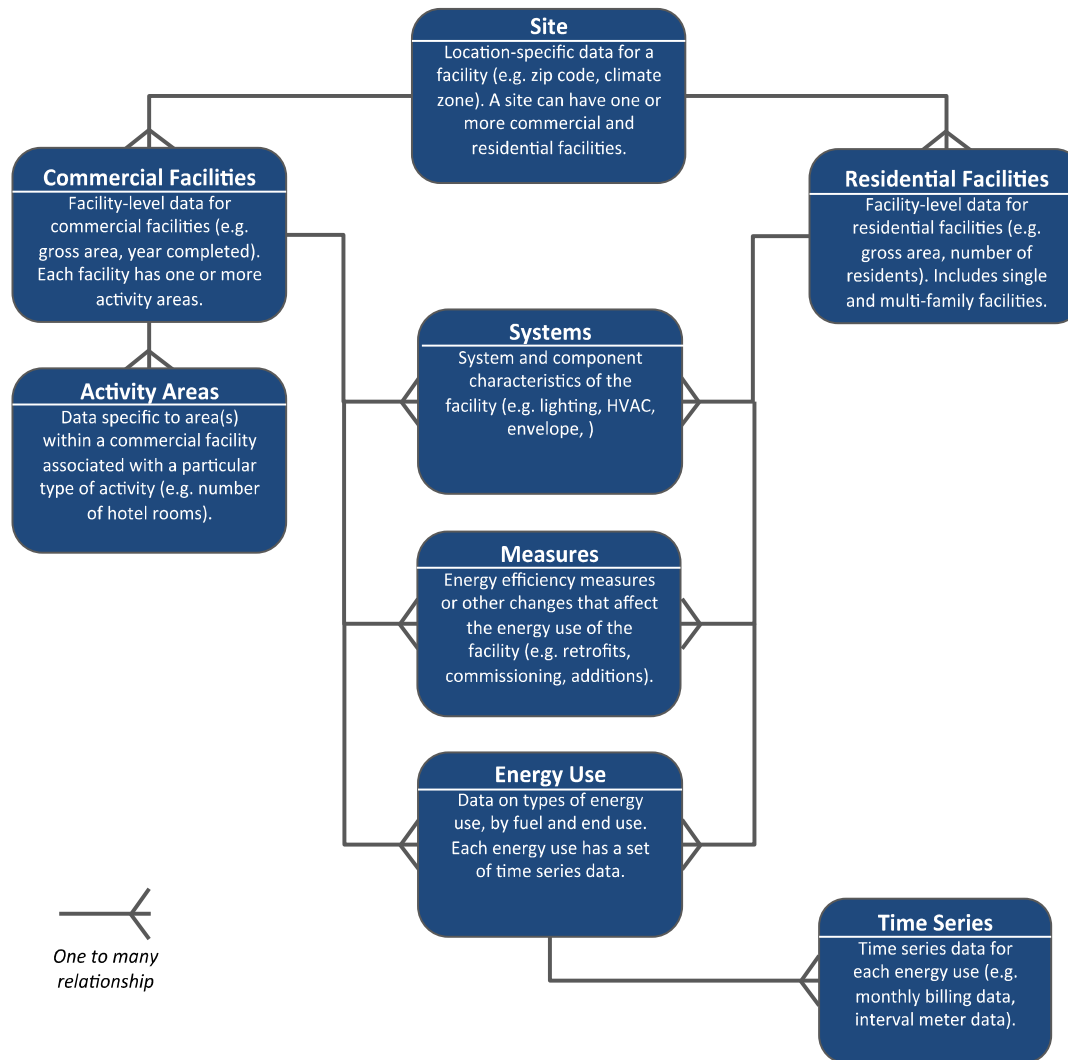
- Materials
- Time Series
- Metadata
- ....

## CityGML 3.0 Work Packages

WP3 LOD concept	WP6 Time series	WP7 Materials	WP8 Land administrat.
WP9 Other construct.	WP10 Utility networks	WP12 Metadata	WP13 Stories

## Conclusion and outlooks

- After 1 year of collaborative development, the first version Energy ADE has been released, **freely available online**  
<http://www.sig3d.org/citygml/2.0/energy/>
- **Guidelines** soon available for Energy ADE users (data providers and urban tool developers)
- **Test phase** on urban energy analyses has just started
- We are very open to **feedbacks** and further active developers



- Support a **wide range** of existing data sources (from manufacturers, installers, operators, measurements)
- Structure splitted between **residential** and **commercial** facilities
- Many **code lists** which may be reused in CityGML
- Actual version: 2.3 (feb. 2013)