Using CityGML as a Platform for Cascading Simulations

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CityGML-dedicated projects with simulations

- Noise Dispersion Simulation
  - for the entire state of North-Rhine Westphalia 2005-2007;
  - project “GDI Grid“, funded by the German Ministry for Research and Education, 2007-2010
- Disaster management
  - project “SIMKAS 3D“, funded by the German Ministry for Research and Education, 2009-2012
- Energy simulation and strategic energy planning
  - project “Energy Atlas Berlin”, funded by the European Institute of Innovation and Technology (EIT) in the Climate KIC, 2011-2013
  - project “Neighbourhood Demonstrators”, funded by the EIT, Climate KIC, 2011-2013
  - project “City System Modeling”, funded by SIEMENS, 2011-2012

Energy Atlas Berlin

Collaboration project (2.5M€) partially funded by the *European Institute of Innovation and Technology EIT*

- located within the *Knowledge & Innovation Center for Climate Change and Mitigation (Climate KIC)*
- Partners:

Berlin University of Technology:

- Innovation Center Energy
- Institute for Geodesy and Geoinformation Science
- **Institute for Energy Technologies**
- Institute for Energy and Automation Technology
- Institute for Architecture
- Institute for Technology and Management
- Center for Technology & Society

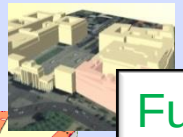
- **Chair of Geoinformatics, Technische Universität München**
- German Research Centre for Geosciences Potsdam (GFZ)
- Vattenfall Europe Berlin AG
- GASAG AG
- Berlin Partner GmbH
- Berlin Senate of Economics, Technology and Research
- City District Administration Charlottenburg-Wilmersdorf in Berlin

Correlation Consumption ⇆ Building param's

Building data

- Volume [m³]
- Floor space [m²]
- Building type
- Building usage
- Year of construction
- (renovation state)
- Number of habitants

- 3D City Model
- Geo Base Data

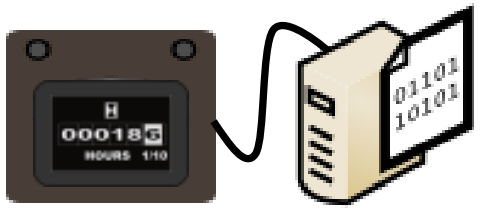


Full coverage of entire cities!

Correlation

What is the relation of consumption with specific building characteristics?

Consumption data



- Electricity
- Water
- Gas
- (Remote) Heating

Only available for a few households (detailed data only where Smart Meters are installed)

Exploration of Building Energy Parameters

Exploration of Building

Building BLDG_0003000a000a07e4

Hertelstr. 25
Berlin

CityGML

Photovoltaic suitability 3

Available area for installations
322,86 m²

CO_2 Savings
25,67 t per year

Solar electricity yield
41,13 MWh/a

Investment volume: 161.350 €

Available area for installations
350,90 m²

CO_2 Savings
32,90 t per year

Heating energy yield
130,56 MWh/a

Solar thermal suitability 1

Estimated heating energy demand
154,25 MWh/a

Scale Levels of the Energy Atlas

City

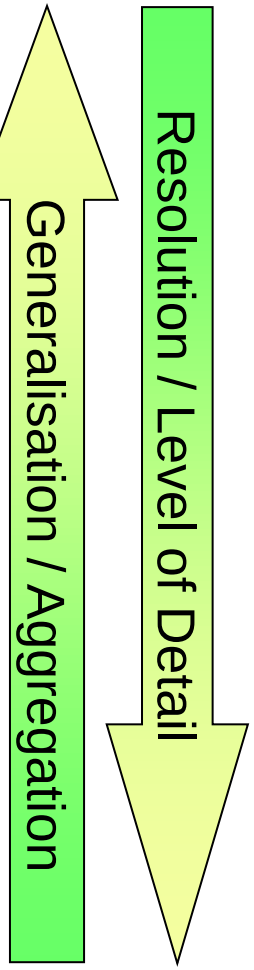
District

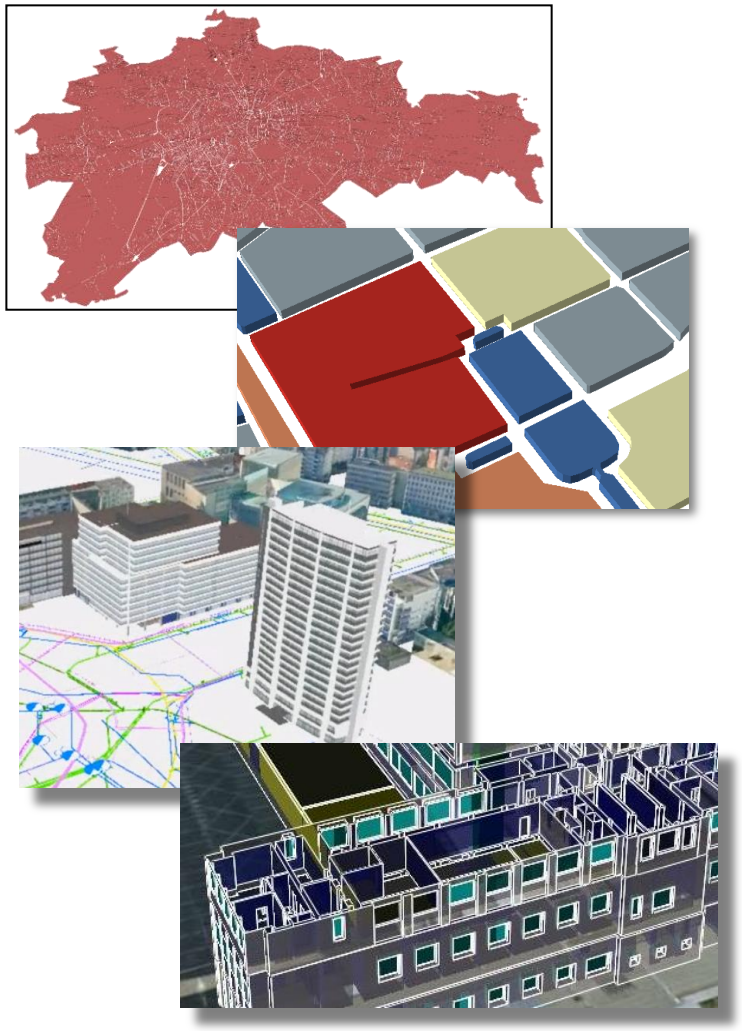
Quarter / Block

Building / Street

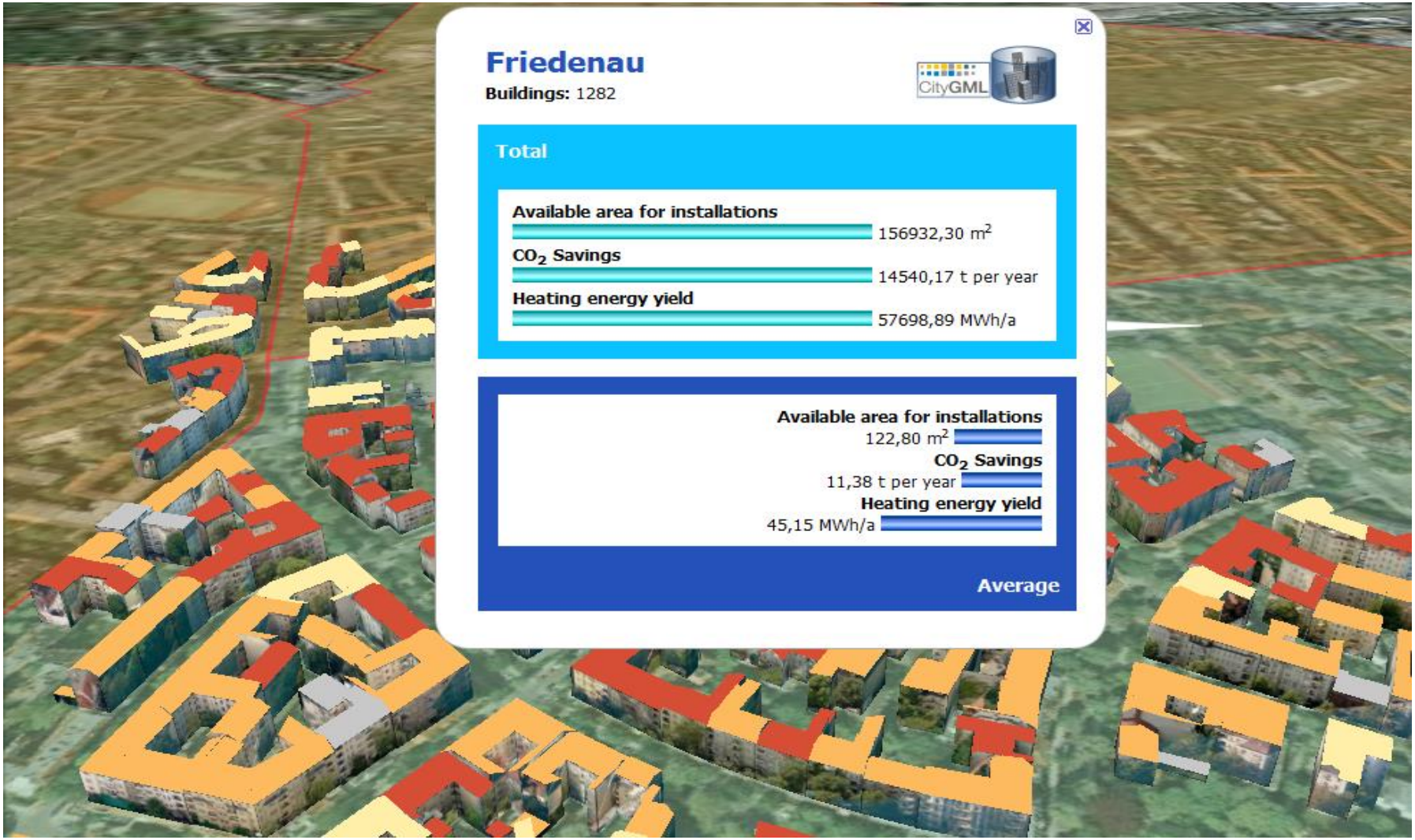
Appartement

Room





Aggregating Energy Indicators for Districts



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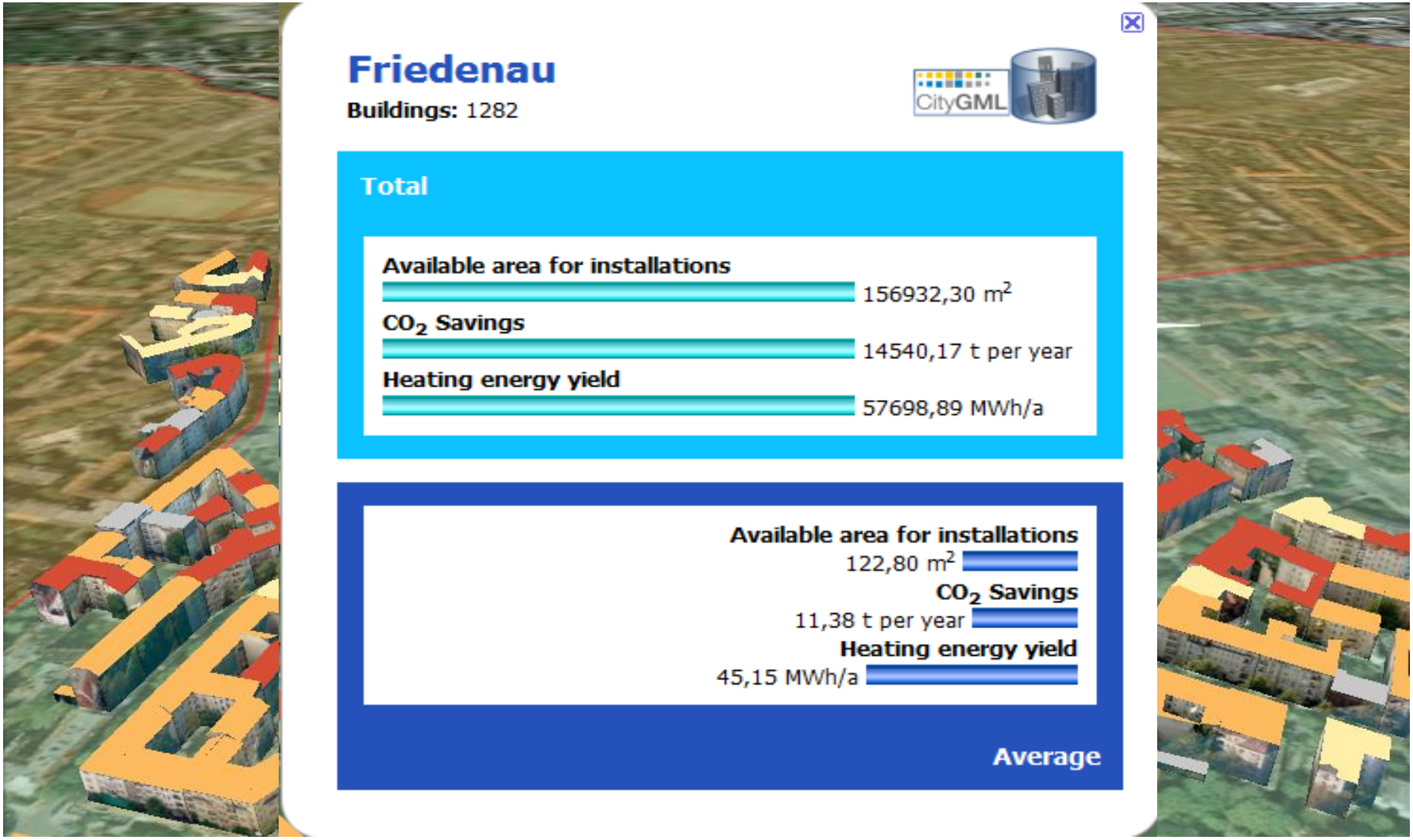
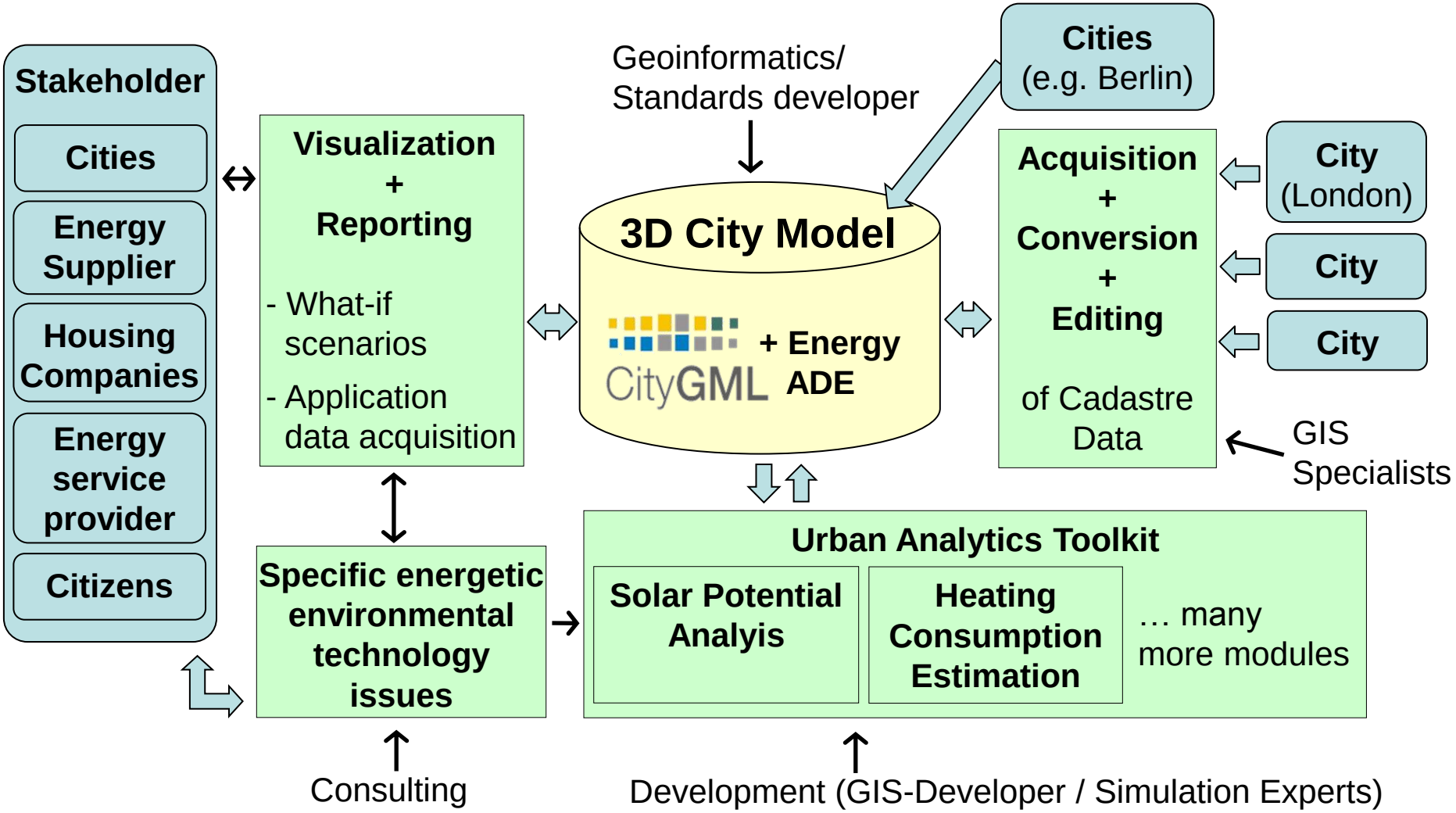


Energy Atlas System Design



Findings: CityGML and simulations (I)

- CityGML is a very useful / important source of information for different types of simulations (environmental simulations, disaster management, training simulators)
  - (well) defined LODs
  - objects carry geometry, semantics (thematic data), (multiple) appearances
  - full support for all types of 3D coordinate reference systems
  - simulation specific (thematic) data can be represented by standard CityGML feature properties, generic attributes, or by new ADE attributes
  - often the entire source dataset can be represented / exchanged / archived in one single CityGML file → supports maintaining consistency
- The results of simulations can be fed back to the original CityGML data for thematic enrichment and data fusion
  - enrichment of 3D city models by data from different disciplines

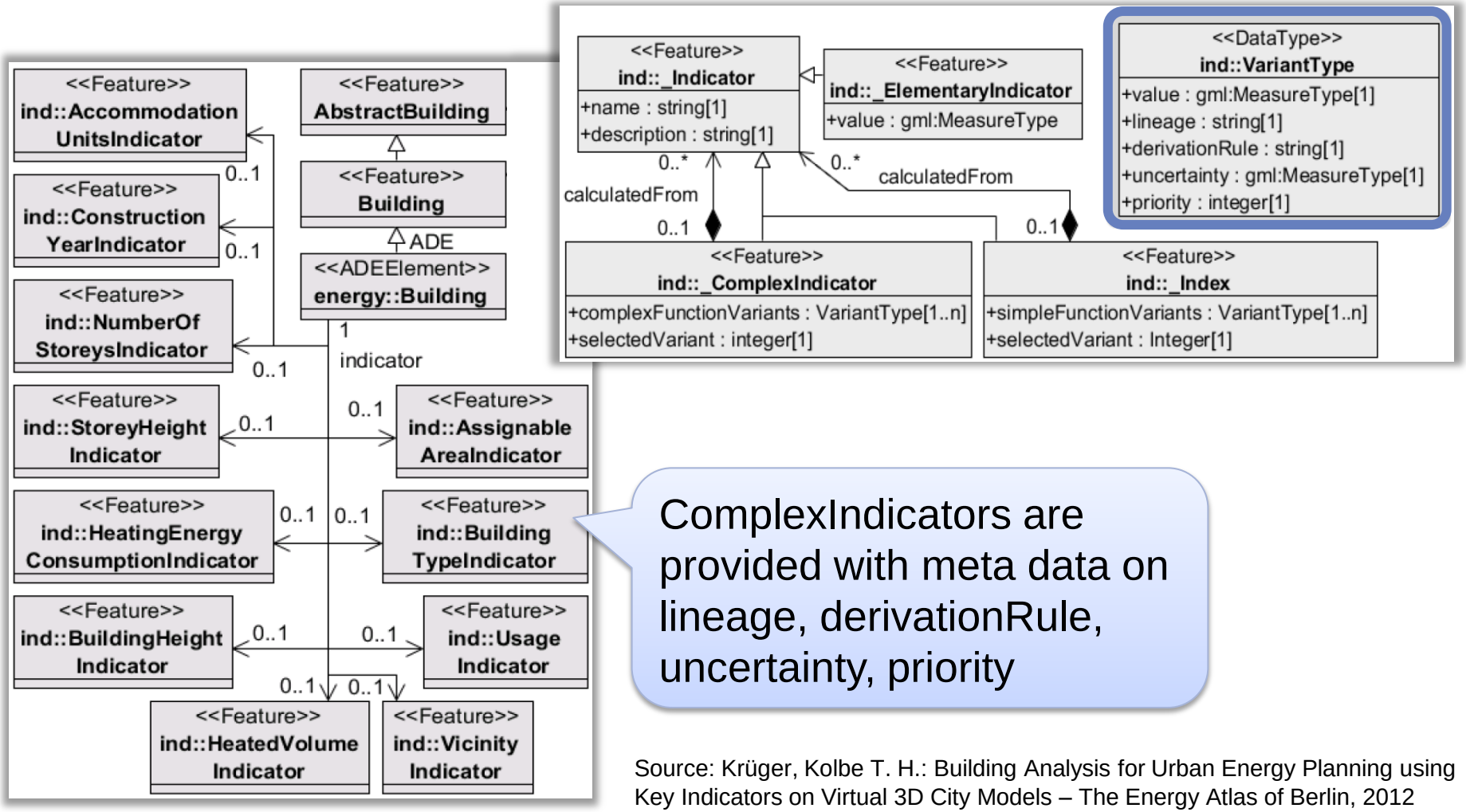
Findings: CityGML and simulations (II)

- Semantic 3D city models and simulations should (and will!) become tighter coupled in the future
  - establish CityGML also as the data model (and exchange format) for intermediate / partial simulation results
  - time plays an important role in most simulations
    - dynamic / time-dependent properties (e.g. electrical energy demand of a building; solar irradiation on a wall or roof surface)
    - [moving objects, i.e. dynamic / time-dependent geometry]
    - not supported in CityGML yet
  - quality of individual attributes needs to be represented and propagated when different attributes are combined (e.g. multiplied)
    - different properties often are determined at different times
    - metadata on individual attribute level required

Required Extensions / Modifications

- Definition of qualified attributes
  - Representation of (almost) every attribute by its name and a record of simple attributes → meta data at attribute level
  - Similar to INSPIRE complex attributes but definition in a more systematic way
  - Representation of (almost) every attribute by its name and a record of simple attributes
    - Data type should provide more semantics (e.g. Angle, Height, Count)
    - Attribute value according to its data type
    - Unit of measure (for numeric attributes)
    - Type of value (e.g. measured, estimated, default, etc.)
    - Lineage
    - Date of ascertainment
    - Data quality (e.g. standard deviation for numeric attributes)

Definition of Qualified Attributes

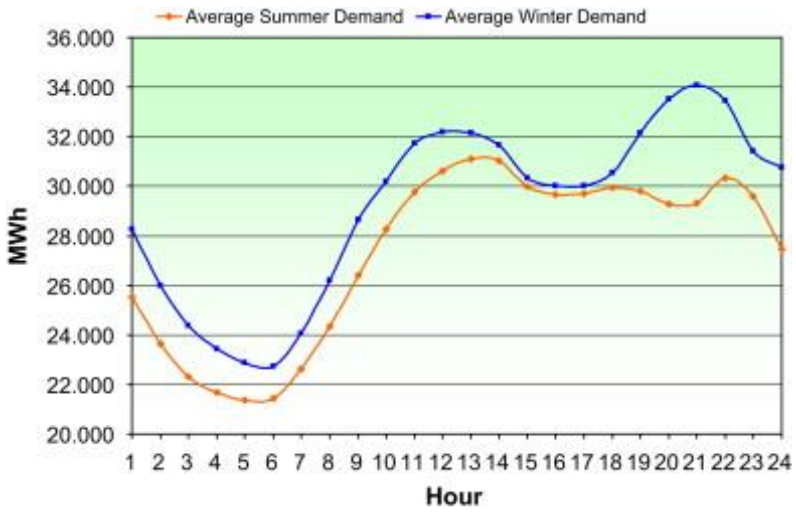


ComplexIndicators are provided with meta data on lineage, derivationRule, uncertainty, priority

Source: Krüger, Kolbe T. H.: Building Analysis for Urban Energy Planning using Key Indicators on Virtual 3D City Models – The Energy Atlas of Berlin, 2012

Required Extensions / Modifications

- Dynamics (time-dependent attributes)
  - Time-dependent model changes / model variations
  - Functional dependency on time (e.g. variation of sea surface level based on tidal hub)
  - Time-discrete representations (e.g. different attribute values or geometries for different time periods)



Source: http://dx.doi.org/10.1016/j.enpol.2009.10.007

Summary: Required CityGML Extensions

- Representation of **dynamic objects, properties + relations**
  - moving objects and object parts
  - time-dependent properties (e.g. energy demand)
- Representation of the **quality of individual information pieces** (metadata on the levels of objects, attributes, relations)
  - lineage / acquisition method, accuracy, age
  - propagation of quality data for aggregations and other types of computations
- Modeling of the **function of objects and functional dependencies** between objects
- Modeling and formal representatin of **measures**