New Tool Addresses High Performance in School Facilities

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OGC Standard CityGML Opens Up New Applications in Energy Simulation

By Egbert Casper, Karl-Heinz Häfele and Robert Kaden

In the current market, most design teams already consider the impact of energy performance on buildings and building complexes. Such an "energetic assessment" includes all structural aspects, such as material properties, passive energy, energy infrastructure (heating, ventilation, air conditioning and energy recovery), user behavior and different application scenarios. However, a transition in the energy sector in Europe and other countries, as well as the increasingly decentralized energy production, induced a strong need for even further calculating and simulating building energy demands, energy generation and energy supply. While building information models (BIMs) based on industry foundation classes (IFC) focus on the very detailed planning and construction of individual buildings and their neighborhoods, and two-dimensional (2D) geographic information systems (GIS) spotlight urban areas and more, a gap exists for a three-dimensional (3D) building model that suits the needs of urban energy plans—one that simulates demand, storage and local infrastructure networks, but without the needs of constructing every valve or screw. That opportunity could be based on another standard: the city geographic markup language (CityGML) developed by the Open Geospatial Consortium (OGC).

Different Concepts, Different Purposes

To appreciate the opportunities of CityGML, one must understand the main differences between the most common modeling languages for energy-based BIMs: IFC; green building extended markup language (gbXML); and now CityGML.

IFC, which is the most comprehensive and holistic building model currently available, supports energy simulation for detailed modeled buildings by providing all building elements with all relevant properties, including material information *(see "Figure 1," below, left)* and spaces. Such information also can be aggregated to zones, with defined property schedules, controls and environmental influences (e.g., user behavior, heat gains or climate data, costs and performance history). In principle, IFC is able to model more than one building. Nevertheless, applications in the construction industry often are limited to a small number of buildings (less than 100).

In contrast, **gbXML** has been developed as a data model for the performance analysis of buildings. Designed to bridge the gap between BIMs and engineering analysis tools, gbXML offers spatial elements (campus, building, building stories, zones and spaces), whereas boundary surfaces are assigned to corresponding spaces. For energy simulations, the gbXML model offers nearly all of the necessary properties and allows for the visualization of multiple buildings *(see "Figure 2," below, right)* in stories and zones. Building-related energy infrastructure (ventilation, heating and other data, including schedules, controls, environmental influences and costs) can be considered. Presently, however, the application area of gbXML focuses on one or very few buildings.

Finally, **CityGML** is a comprehensive open data model for the modeling, storage and exchange of virtual, semantically enriched 3D city and landscape models in different levels of detail; buildings are only one aspect. (The building module was not developed for construction purposes and, therefore, is not as detailed as IFC and gbXML.) What is unique to CityGML is its *level of detail* (LoD) concept. It has five dedicated geometrical levels, and the semantical richness of details increases from the lowest level of detail 0 (LoD0) to the highest

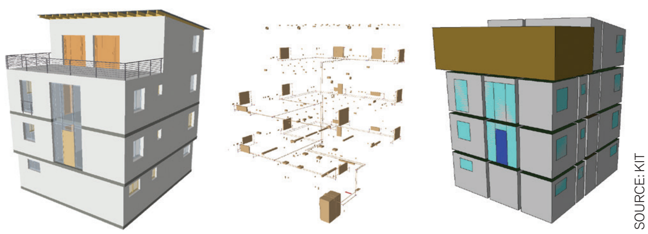

Figure 1: Sample building modeled in IFC, from left to right: architectural model; HVAC model; space boundaries.

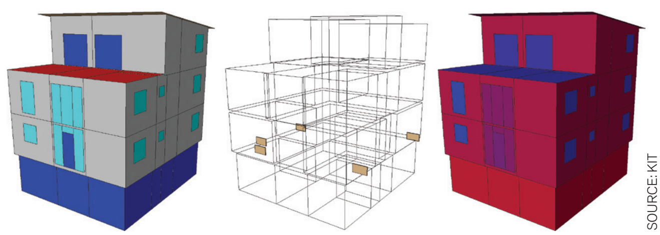

Figure 2: gbXML representation of the same building shown in "Figure 1," from left to right: colored by surface type; hydronic loop with radiators; colored by construction type.

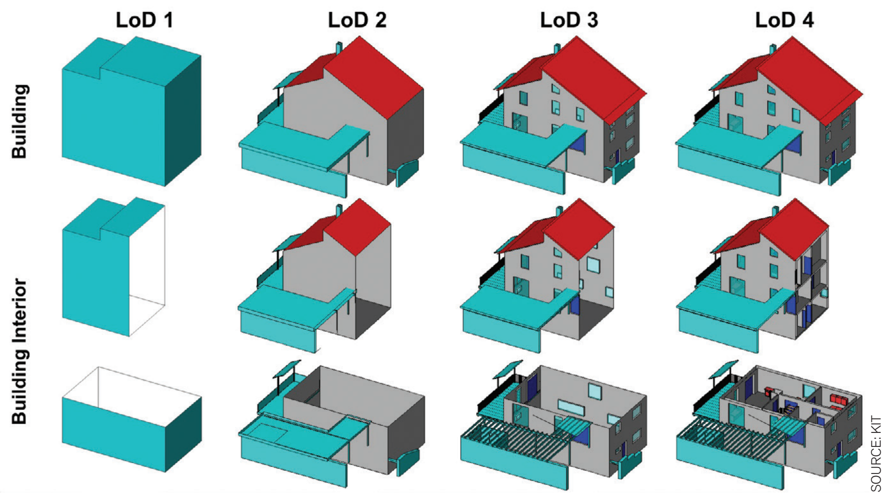

Figure 3: Different levels of detail (LoD) in CityGML.

(LoD4), as noted in "Figure 3" *(see above)*.

As a general-purpose model, CityGML does not offer explicit energy-related features or properties. Nevertheless, some information within CityGML can be directly used for energy simulation, such as the volume and outer shell of a building, its global geometry coordinates, the number of stories and their heights and various properties of the building (e.g., year of construction, as well as function and usage of the building). Interior building installations provide a very brief modeling of building services.

In addition, the semantic information model of CityGML allows for the design of an integrated, shared ontology for the spatio-semantic representation of an urban structure. This extends to energy-related information from different disciplines and considers the requirements of energetic legal provisions.

CityGML for the Energetic Assessment of Buildings

CityGML serves as an excellent central information hub for analyzing and simulating the energetic assessment of buildings (which then are further enriched with thematic information from the involved stakeholders and disciplines).[1],[2] To do so, however, the CityGML information model must and can be extended by a so-called application domain extension (ADE); in this case, an energy-related EnergyADE. The EnergyADE includes building parameters that allow virtual 3D city models as a data pool for the energetic assessment of buildings on a citywide or regional scale.

This includes the definition of virtual spaces and zones, material properties, energy and other infrastructure, user, climate- and cost-related information for defined times (for both static energy computations and time series-related information). One of the greatest advantages of the CityGML approach is the comprehensive topology model that allows the connection between different domains and the modeling of building services without a detailed geometry.

In 2014, the OGC; the Special Interest Group 3D (SIG 3D) of the

Continued on page 32

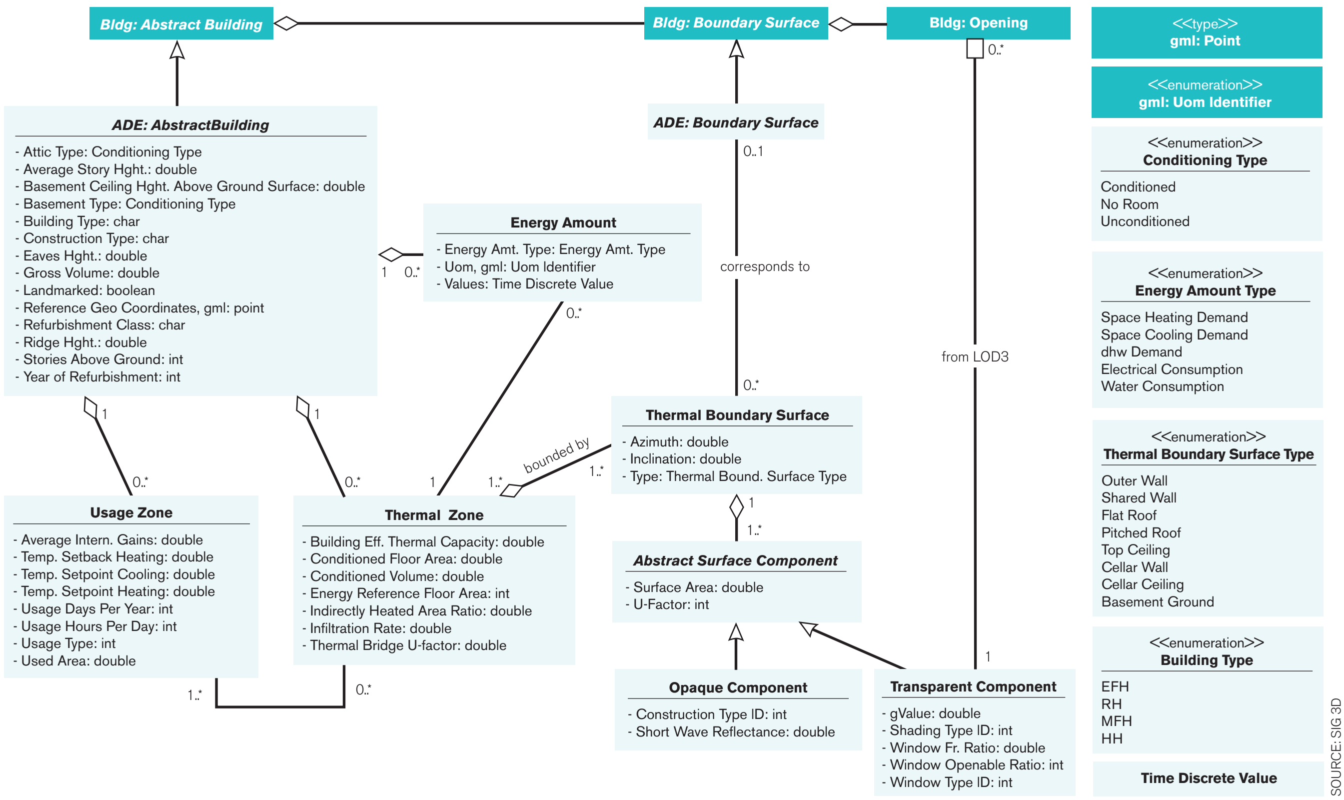

Figure 4: Excerpt draft UML diagram of the CityGML energy application domain extension (EnergyADE).
Key: ◊ = UML aggregation; △ = UML generalization; □ = UML navigable end.

Spatial Data Infrastructure Germany; and the Stuttgart University of Applied Sciences (HFT) held the first in a series of workshops on the harmonization of a CityGML EnergyADE. Although different approaches for an EnergyADE had already been developed by different parties, such as the Munich Technical University (TUM) and the HFT, the collaboration resulted in a harmonized draft of the EnergyADE. Technically speaking, the darker-blue classes illustrated in "Figure 4" *(see page 31)* represent CityGML native classes of buildings, while the lighter-blue ADE classes enrich the building model with further energy-specific information. Each building receives further attributes by specializing the CityGML, including different usage and thermal zones, etc. Dynamic building simulation methods can be used to estimate the heat demand and the savings potential. Results of changes or corrections of input values, such as the U-factor of construction components or the degree of heat gain on roofs, can be indicated in real time. By selecting a retrofit configuration, the energy savings, potential costs and the amortization of costs can be estimated in real time for a single building or a selection of buildings.

Based on a collaboration across disciplines using the OGC standard CityGML and the EnergyADE, a variety of new applications for energy models (and beyond) are possible. At press time, a final version of the EnergyADE is expected to be completed at the end of 2014 and will be published by the SIG 3D. Look for even more relevant data in the next version of CityGML, which is currently under development. JNIBS

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