



Energy in Buildings and  
Communities Programme

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**Proposal for IBPSA Project:  
BIM/GIS and Modelica framework  
for building and community energy system design and operation**

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## 1 Introduction

Joe Clarke’s vision statement [Clarke2015] calls for a consolidation of models for HVAC and controls that can be used for testing, as a review framework and as a library (Propositions 1, 3, 4, 5, 6, 7, 9, 11 and 12). The opportunity is

1. to standardize the approach for how such component and system models should be represented, both as data-model and as mathematical models that formalizes the physics and control algorithms,
2. to agree upon the physics that should be included in such components for specific use cases, and
3. to share resources for development, validation and distribution of such component and system models

Similar objectives have been shared by IEA EBC Annex 60 (<http://www.iea-annex60.org/>), a project in which 41 institutes from 16 countries participate between 2012 and 2017. Annex 60 develops and demonstrates new computational technologies based on the open standards Modelica (as a modeling language), Functional Mockup Interface FMI (for exchange of legacy models or simulators), and Industry Foundation Classes (for Building Information Models).

The primary objectives within the technology-development subtask 1 of Annex 60 are:

1. To develop and distribute a well documented, vetted and validated open-source Modelica library that serves as the core of future building simulation programs.
2. To implement FMI interfaces in building simulation programs for co-simulation and model exchange and to coordinate the development of co-simulation master algorithms.
3. To develop an open-source tool-chain for BIM to Modelica.

## 2 Proposed Work

We propose that IBPSA initiates a project called “BIM/GIS and Modelica framework for building and community energy system design and operation.” The intent is that this project continues and extends technology developments for which a foundation based on collaborative work of domain experts has been laid through Annex 60. Specifically, this project will extend work from Annex 60, and further develop new generation computational tools for the design and operation of building and community energy and control systems based on the non-proprietary standards Industry Foundation Class (IFC), CityGML and Modelica. Data modeling will include standards and transformation algorithms to link object-oriented simulation modeling with building and geoinformation (GIS) systems by adopting standards such as IFC and CityGML. Mathematical modeling will include the development and validation of dynamic models that represent the physics and control logic of components and systems in Modelica, an open-standard for an equation-based, object-oriented modeling language for engineered systems. The anticipated outcomes are open-source, freely available, documented, validated and verified Modelica libraries and BIM/GIS to/from Modelica translators that allow buildings and community energy systems and grids to be designed and operated as integrated, robust, performance based systems with low energy use and low peak power demand.

The primary target audience is the building energy research community, students in building energy related sciences, and providers of computing tools for buildings. The goals are

1. to consolidate the development of these technologies, ranging from equipment to system representations of the data (BIM/GIS) and their dynamic behavior (Modelica),
2. to provide means for model validation through benchmarks, and

3. that tool providers integrate these technologies into their tools for deployment to design firms and energy service companies, equipment and tool manufacturers.

Currently fragmented duplicative activities in modeling, simulation and optimization of building and community energy systems will be coordinated through the use of the open standards IFC/CityGML for BIM/GIS representation, and Modelica for model implementation. It will also be organized through a stable software development process that allows third-party developers to build applications that encapsulate these technologies.

Multi-disciplinary challenges that will be addressed in this project include research and development of the following:

1. Further development of the open-source infrastructure <https://github.com/iea-annex60/modelica-annex60> of models and test suite to coordinate Modelica-based model developments for building performance simulation [3].
2. Tool-chains that link object-oriented CAD systems, geoinformation systems, building and control design tools at various levels of detail with Modelica models, and that allow the deployment of these models to real-time systems in support of building commissioning, building controls and fault detection and diagnostics [2].

Within this initiative, we propose two tasks:

*Task 1 Modelica model libraries*, will develop free open-source libraries of Modelica models for building and community energy and control systems with associated documentation for new and experienced users. This will be accomplished through the further development and validation of the Annex 60 library, which is already used as the core of four other Modelica libraries for buildings and community energy systems. An outcome will be a comprehensive free open-source library that will be used by different simulation tool-providers.

*Task 2 Building and City Quarter Information Models* will develop BIM/GIS data model to Modelica translators for individual building and community energy systems. As in the Annex 60, emphasis was placed on the BIM to Modelica transformation process, Task 2 shall be dedicated to continuing BIM-oriented developments but shall focus on the GIS transformation process for community energy systems. This will be accomplished through the use of existing standards for exchanging energy calculation data, and through extending standards such as CityGML as appropriate. This capability will facilitate the construction of whole building Modelica models, it will integrate energy performance simulation, especially with respect to Modelica, with the developments of BIM/GIS-based tools that are ongoing outside of this project, and provide a path for a next-generation modeling that also specifies control sequences.

### 3 General Provisions

There shall be two levels of participation:

*Organizational participants* are organizations that commit to contribute a minimum of 6 months of a full time employee per calendar year using their own funding. Technical contributors of these organizational participants are expected to contribute to around 5 to 10 web-based coordination meetings annually. *Individual participants* are contributors that participate in the project as is custom in other open-source projects without a pre-determined level of commitment.

Each organizational participant commits to attend an annual expert meeting, generally for two days using

own funding. These meetings are used to coordinate current work and to steer future development. As far as possible, these coordination meetings will be collocated with an international or a national IBPSA conference.

IBPSA, or its regional affiliate, will provide at no cost the rooms for the expert meetings.

The project leader will provide an annual progress report to the IBPSA board, and reapply for continuation of the project every 5 years.

## 4 Intellectual Property

All participating organizations have access to the workshops. All software and its documentation will be open accessible to anyone.

To ensure open collaboration among the participants, Modelica models developed within this project will be open-source and freely available under the Modelica 2 license (or newer versions as applicable).

Code other than Modelica models will use the open-source BSD 3-Clause License (<http://www.opensource.org/licenses/BSD-3-Clause>).

## References

- [1] Joe Clarke. A vision for building performance simulation: a position paper prepared on behalf of the IBPSA Board. *Journal of Building Performance Simulation*, 8(2):39–43, 2015.
- [2] Matthis Thorade, Jörg Rädler, Peter Remmen, Tobias Maile, Reinhard Wimmer, Jun Cao, Moritz Lauster, Christoph Nytsch-Geusen, Dirk Müller, and Christoph van Treeck. An open toolchain for generating modelica code from building information models. In Peter Fritzson and Hilding Elmqvist, editors, *11-th International Modelica Conference*, 383–391. Paris, France, September 2015. Modelica Association.
- [3] Michael Wetter, Marcus Fuchs, Pavel Grozman, Lieve Helsen, Filip Jorissen, Moritz Lauster, Dirk Müller, Christoph Nytsch-Geusen, Damien Picard, Per Sahlin, and Matthis Thorade. IEA EBC Annex 60 Modelica library – an international collaboration to develop a free open-source model library for buildings and community energy systems. In *To appear: Proc. of the 13-th IBPSA Conference*. International Building Performance Simulation Association, December 2015.