

IBPSA Project 1

BIM/GIS and Modelica Framework
for
building and community energy system
design and operation

Co-operating agents:
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Christoph van Treeck, RWTH Aachen, Germany

September 12, 2016



Lawrence Berkeley National Laboratory

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The vision of IBPSA Project 1 is to create open-source software that builds the basis of next generation computing tools for the buildings industry

Allow engineers and scientists to

1) drag and drop preconfigured, modifiable and scalable component models of

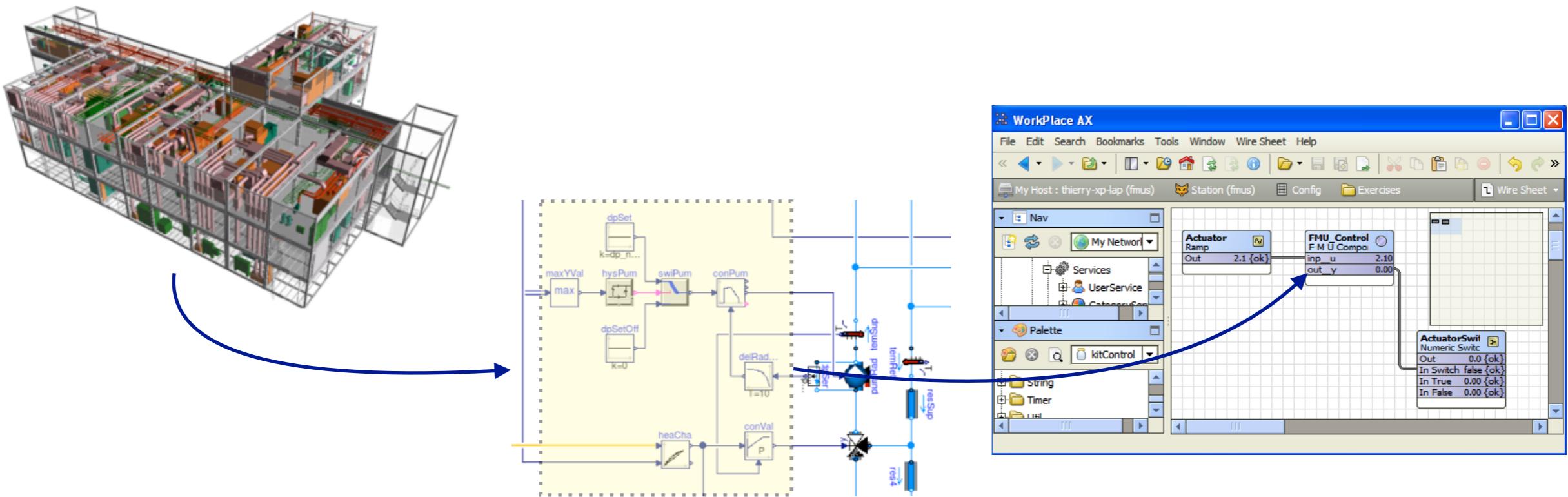
- buildings,
- district heating and cooling,
- HVAC, and
- controls.

2) optimize the performance of technology options and control strategies in simulation, and

3) export models and control algorithms for

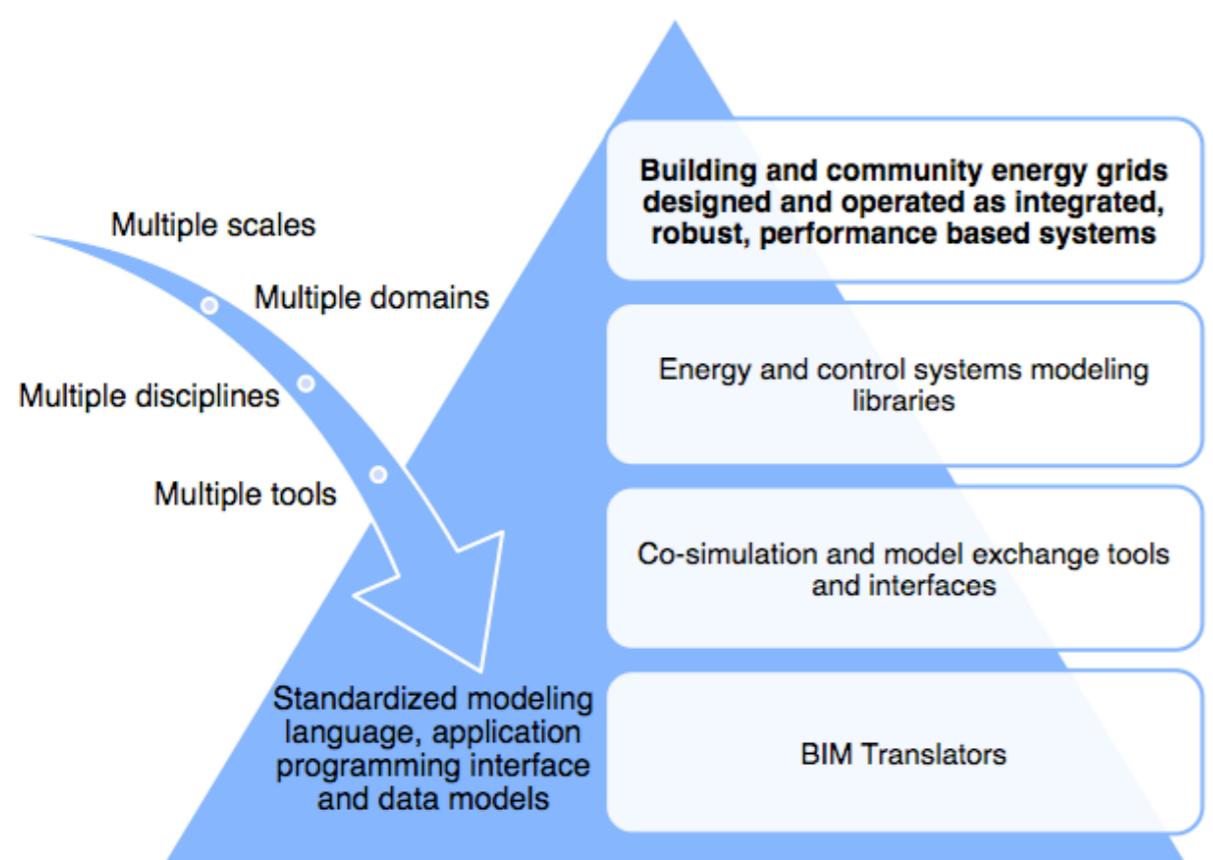
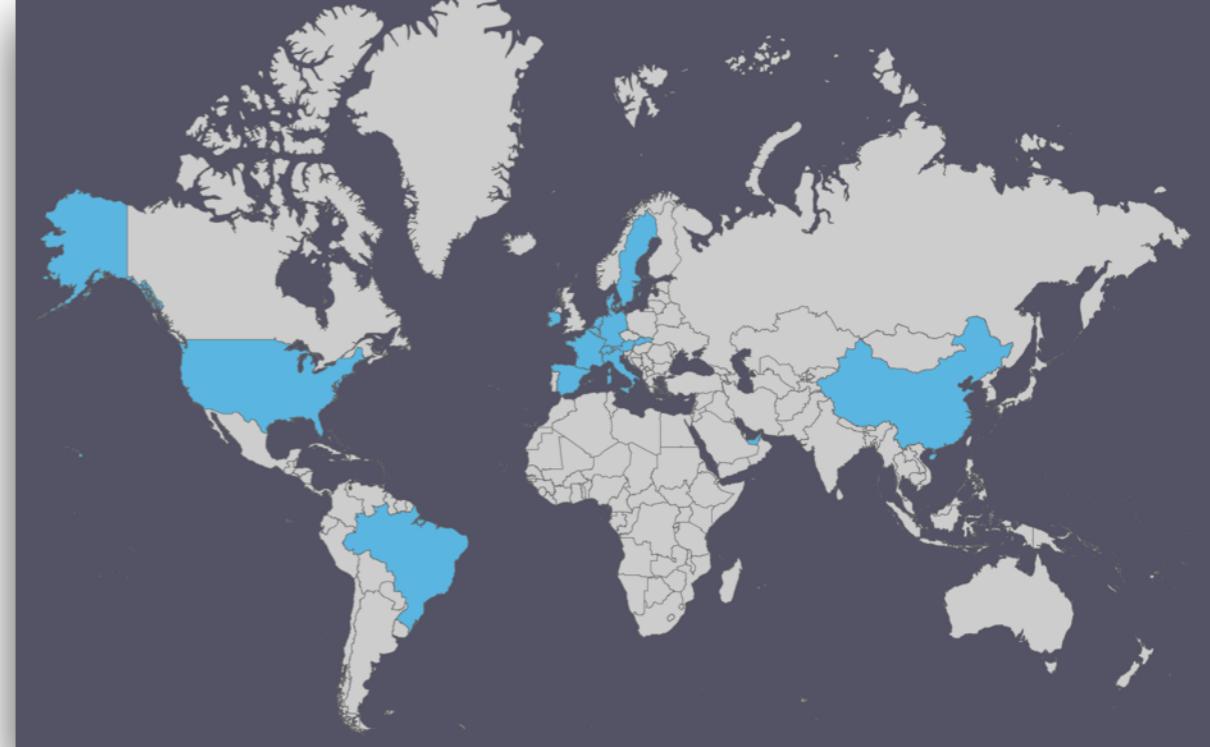
- hardware in the loop testing
- deployment to control systems and embedded hardware, and
- to run as a web service for real time operational support

All developed software is free and open source.



Introduction

2012-2017:
IEA EBC Annex 60 resulted in
collaboration among 42 institutes
from 16 countries



Energy in Buildings and
Communities Programme



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2015: Joe Clarke's vision statement



Original Articles

A vision for building performance simulation: a position paper prepared on behalf of the IBPSA Board

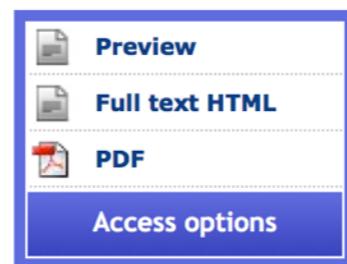
DOI: 10.1080/19401493.2015.1007699

Joe Clarke^{a*}

pages 39-43

[Publishing models and article dates explained](#)

Published online: 17 Feb 2015



Joe Clarke's vision statement 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

- to standardize the approach for how such component and system models are represented,
- to agree upon the physics for specific use cases, and
- to share resources for development, validation and distribution

IBPSA to conduct Project 1

December 2015: Board of IBPSA-World approved Project 1.

May 2016: Registration started at <http://www.iea-annex60.org/news.html>

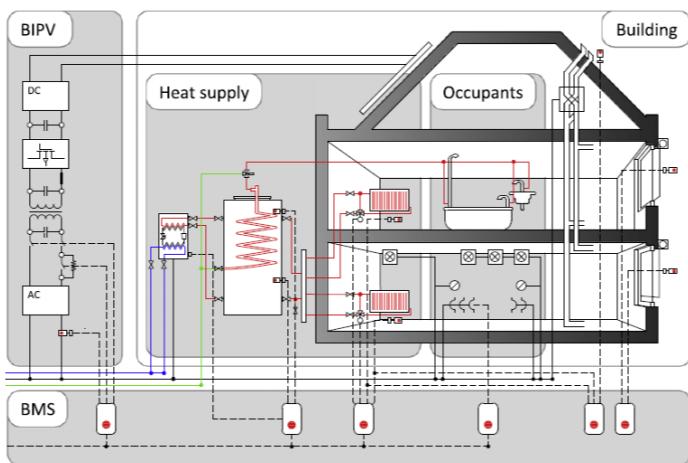
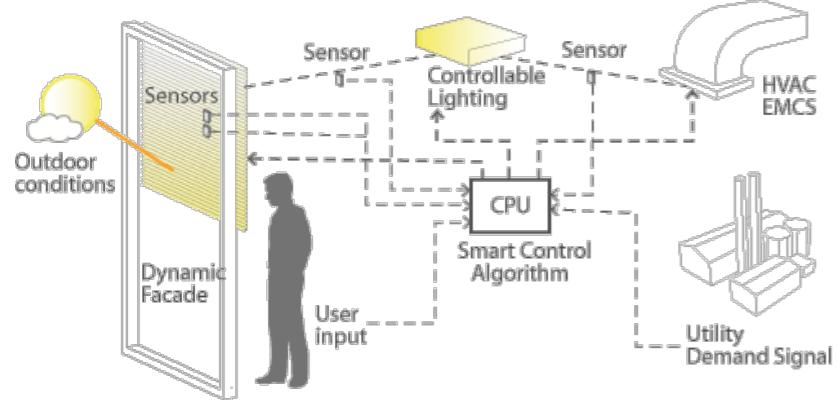
October 2016: Workshop, training and planning session at Corsica, France.

Until July 2017: Planning and team building phase. Start of some of the research.

Aug. 2017: Start of 5-year research phase.

IBPSA Project 1 goals

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 share efforts for, and increase the range of, model validation, and
3. to provide to simulation tool providers stable, well-tested, validated and documented code that they can integrate in their software tools for deployment to design firms, energy service companies, equipment and control manufacturers.
4. to demonstrate through applications capabilities that are enabled through Modelica, and to identify and test through applications research needs and research results.



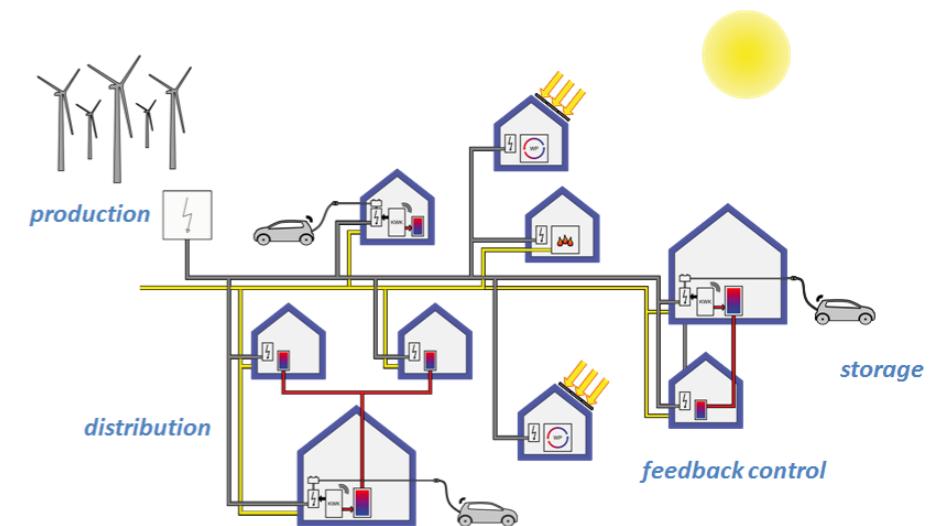
From controls

to

buildings

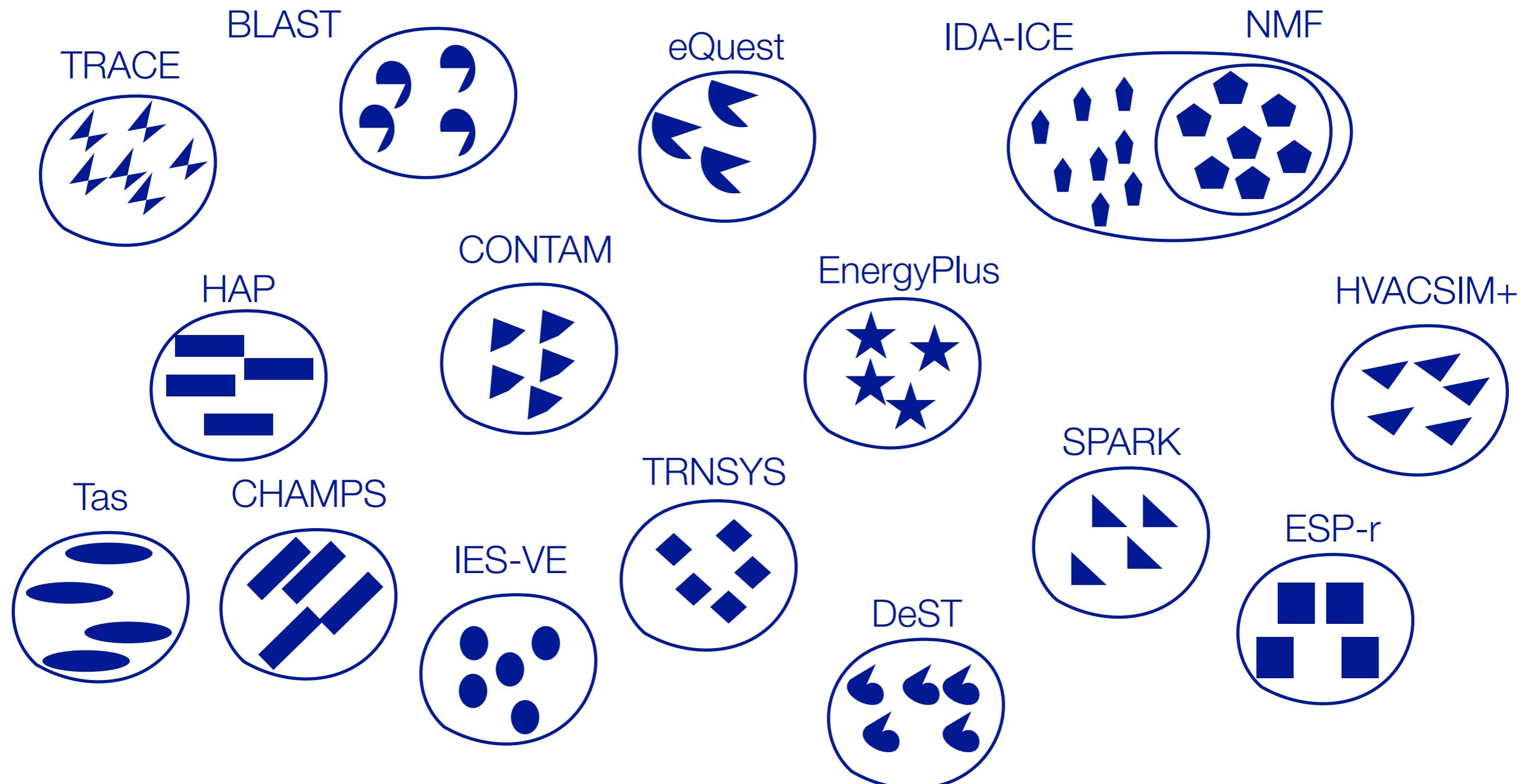
and

communities



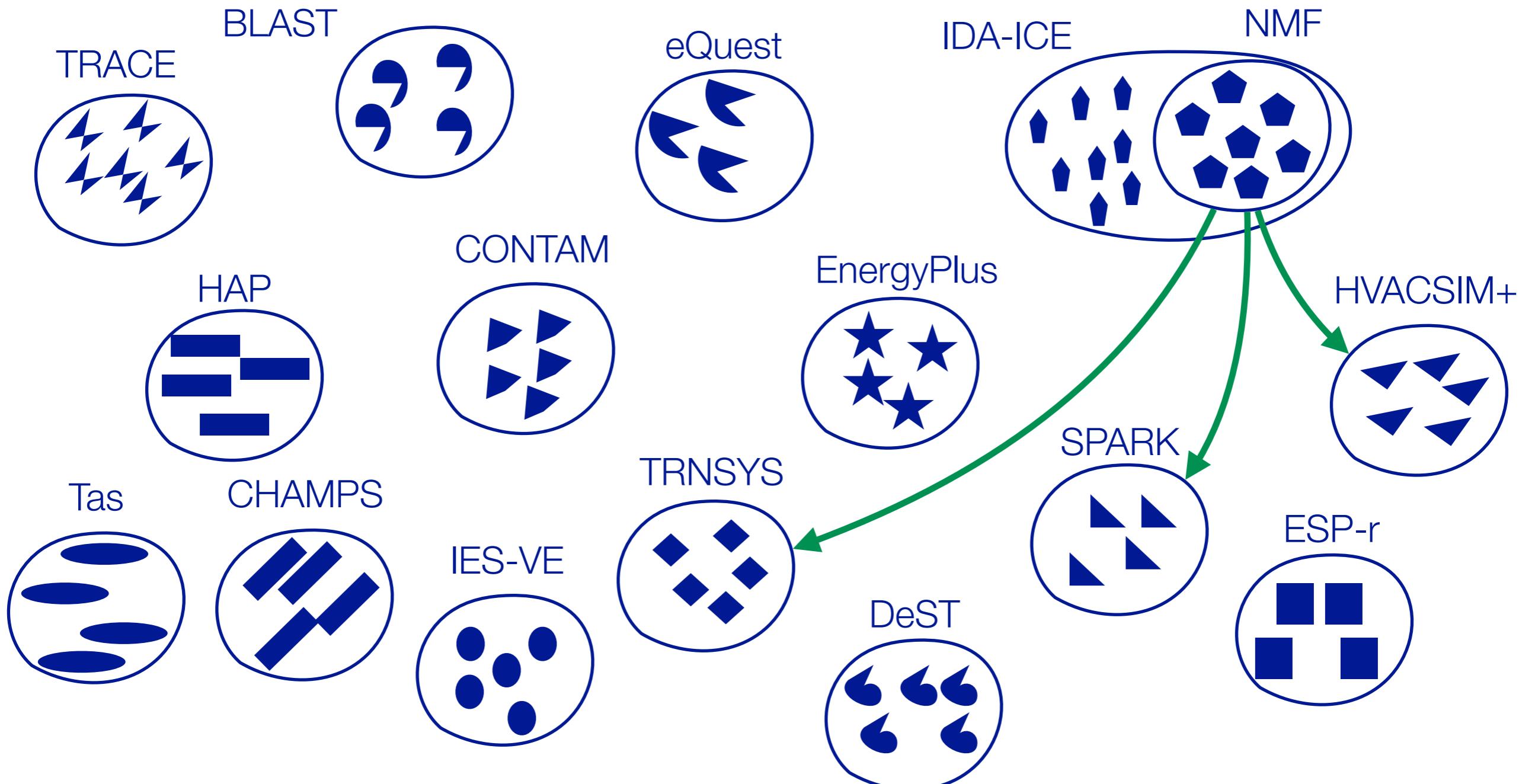
Why standardization — and what exists?

Let us develop building simulation programs, **but** each with a mutually incompatible model format, different semantics and incompatible software architecture...



... and someone is happily paying for the development while users complain about lack of functionality, difficulty to use and non-transparent models that only few experts understand.

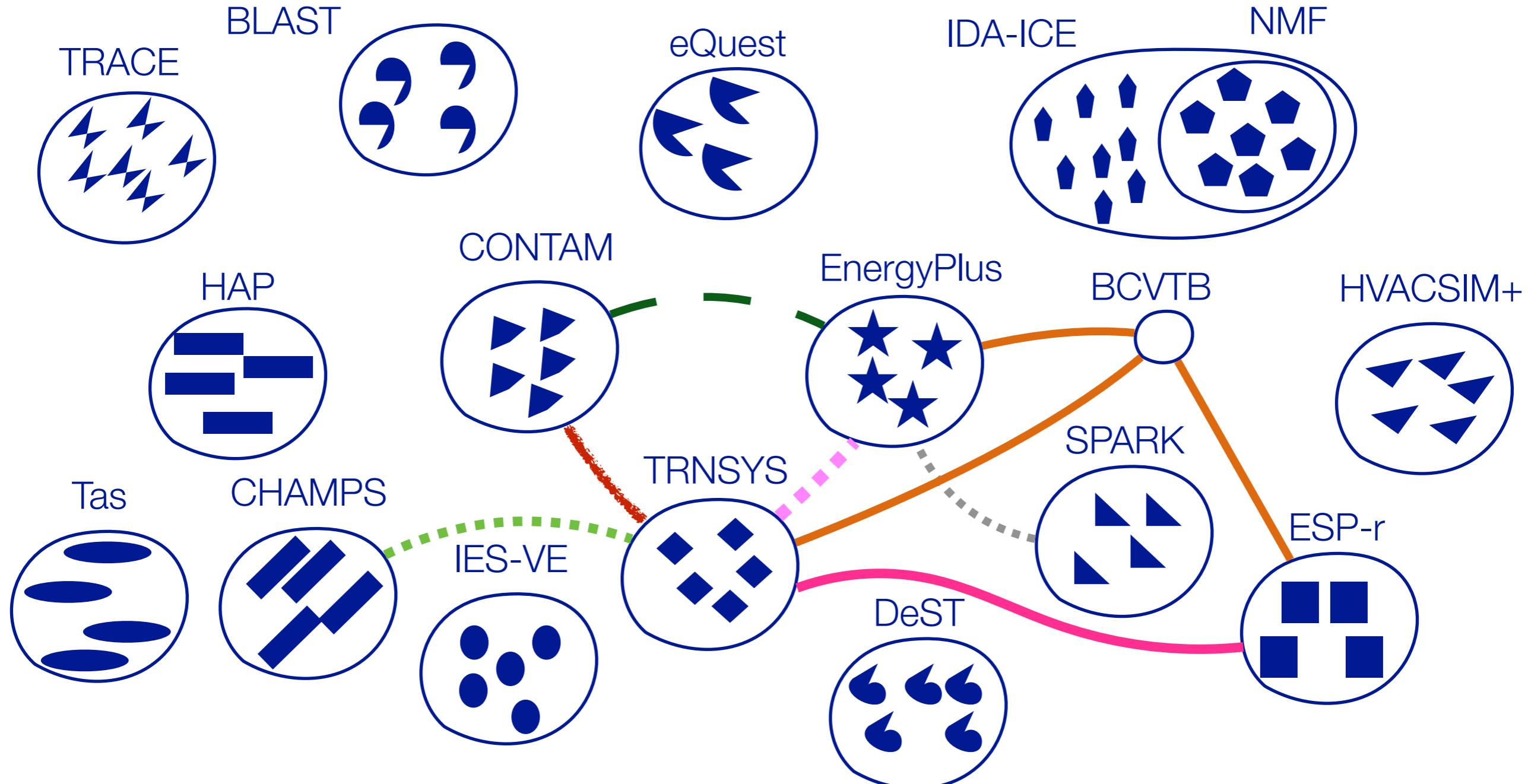
20 years ago, there was a brilliant recognition that models can be developed **once**, stored in a repository and exported to simulators



It probably was ahead of its time, but stopped by ASHRAE TC 4.7.

Per Sahlin and Pavel Grozman. Symbolic Processing and Code Generation of Equation Based HVAC&R Simulation Models. ASHRAE Technical Paper 839, 1996.

In absence of being able to share models, let's co-simulate, but each with a different API and different — if any — semantics....



Looks like a nice idea, but very difficult to realize.

And lacks any standard and rigor until some tools started using FMI.

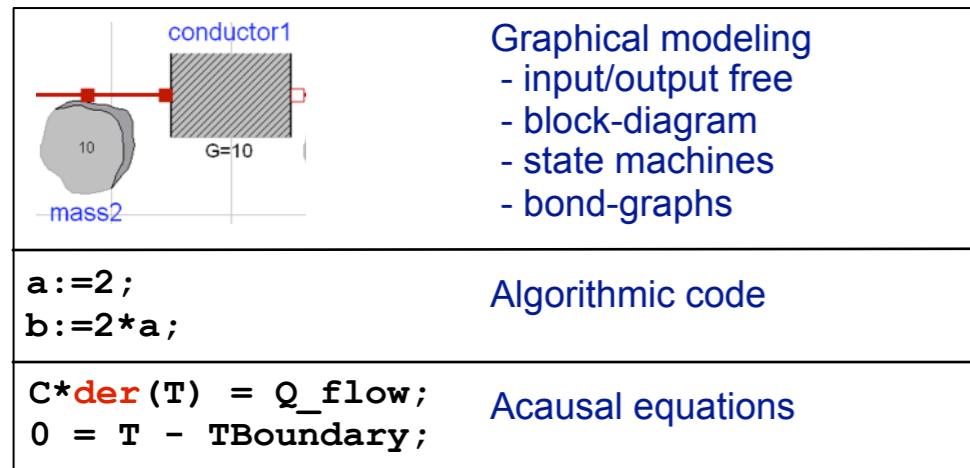
Open standard as underlying technology: Modelica, an open standard for equation-based, object-oriented modeling

Open, industry-driven standard for modeling multi-physics, engineered systems

Developed since 1996 because conventional approach for modeling was inadequate for integrated engineered systems.

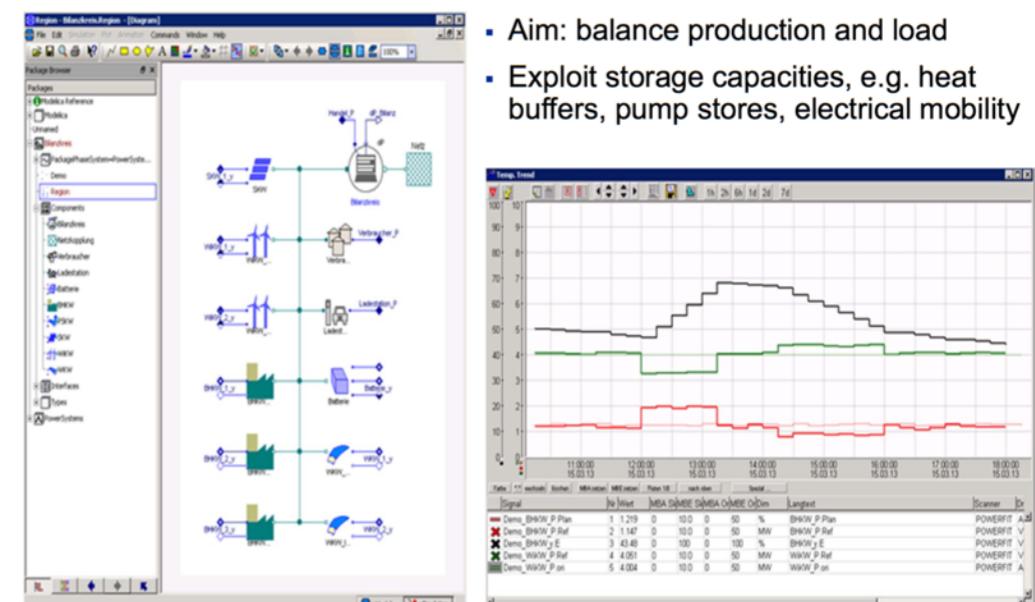
Large eco-system of free and commercial libraries and environment for

- modeling
- simulation
- optimization
- model-based design
- product life cycle management



7% of German power production is optimized based on Modelica

Reference Intraday optimization of municipal power



Source: <http://new.abb.com/power-generation/power-plant-optimization>

Open standard as underlying technology:

The FMI Standard has been developed to encapsulate and link models and simulators for co-simulation of different domains

Initially a 28 million € ITEA2 project with 29 partners, initiated by Daimler Chrysler.

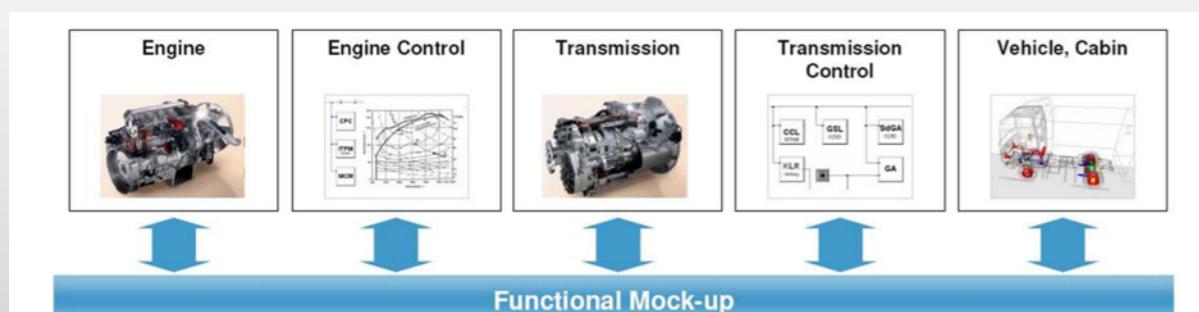
Standardizes C API and encapsulation for simulator and model interoperability.

Scales from embedded systems to high performance computers.

First version published in 2010. Second version published in 2014.

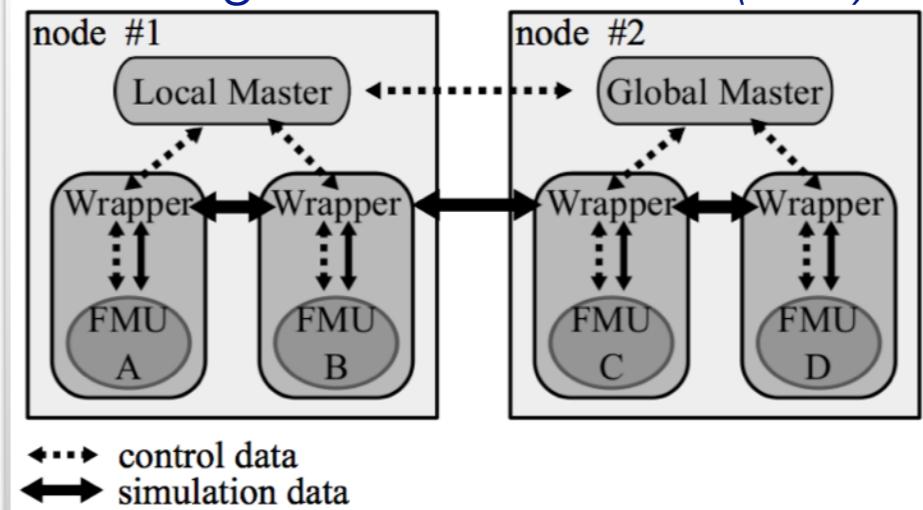
Supported by 80 tools.

Automotive co-simulation



Cosimulation of the behavioral models and the embedded controller software

Smart-grid co-simulation (EdF)

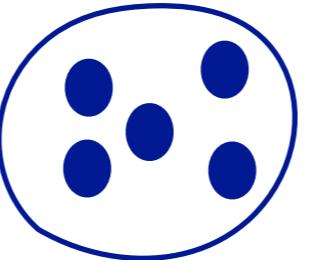


Cosimulation of the behavioral models and the embedded controller software

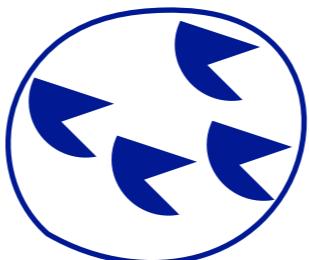


10 years ago, a similar fragmentation happened again. Now, same language, but incompatible interfaces for models that sometimes complement and more often replicate each other

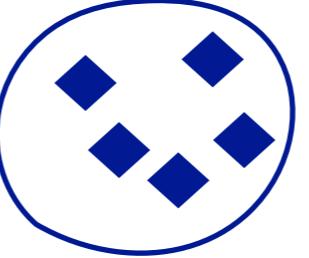
RWTH Aachen - AixLib



UdK - BuildingSystems



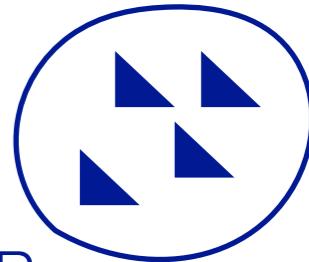
LBNL-Buildings



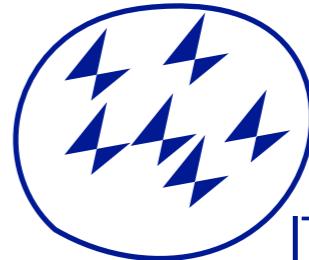
KU Leuven - IDEAS



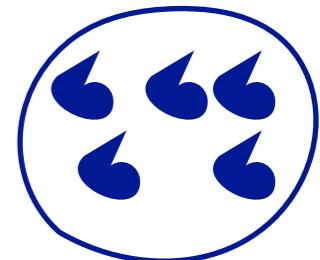
XRG – HVAC



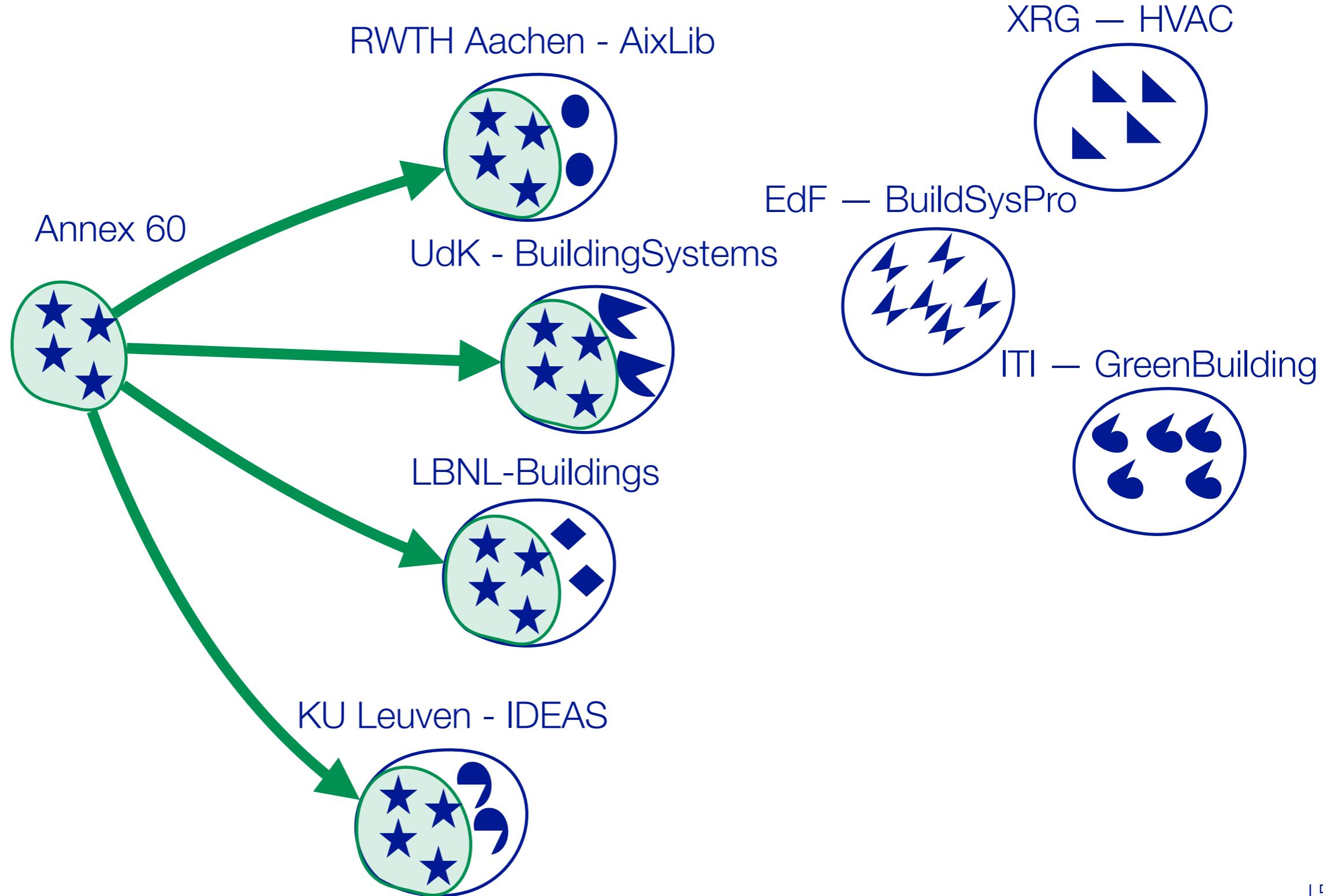
EdF – BuildSysPro



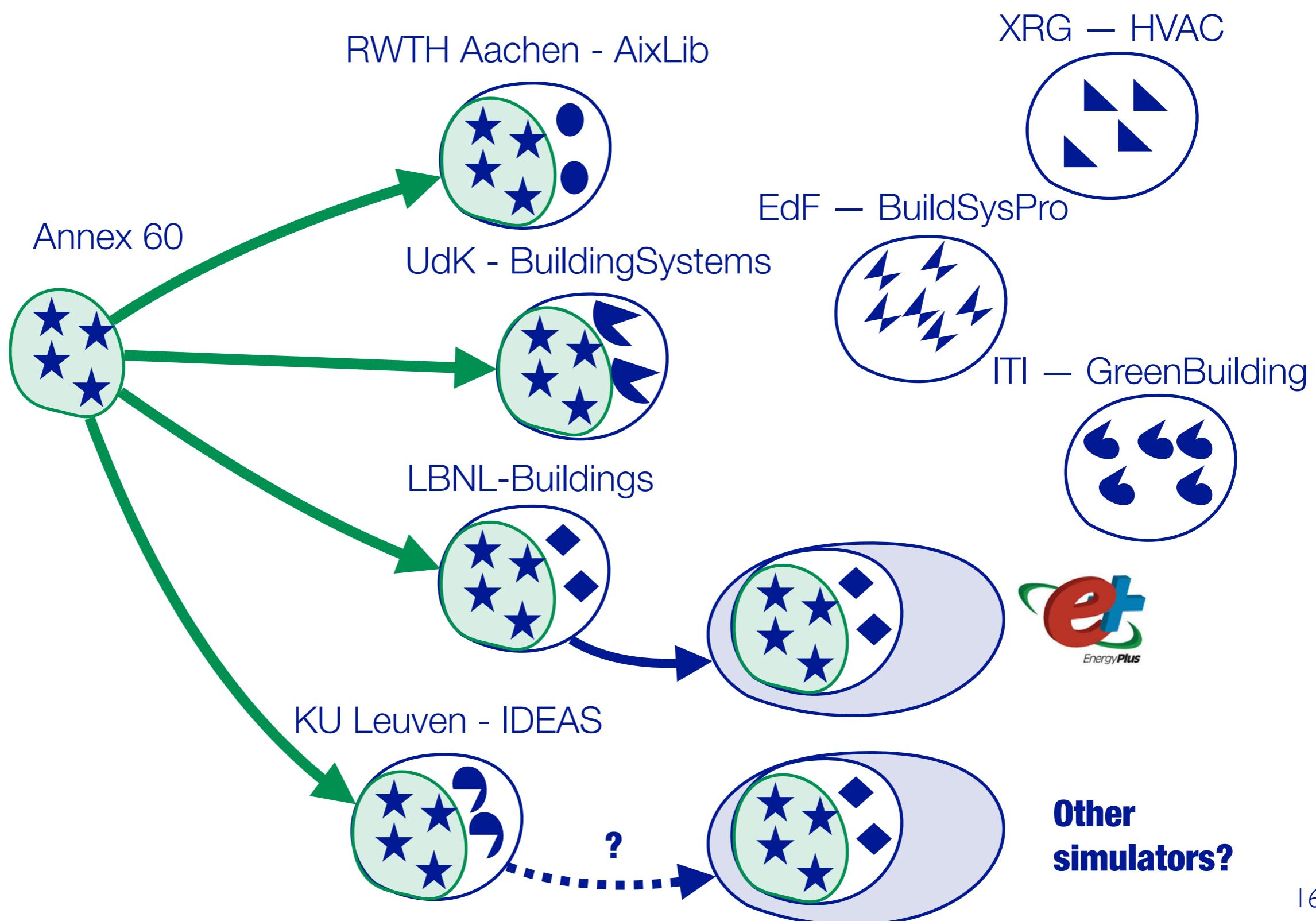
ITI – GreenBuilding



At Building Simulation 2011, a joint effort started to avoid fragmentation, collaborate on development, implement best practices and share everything open-source and free



In 2016, tight integration of Modelica into EnergyPlus started.

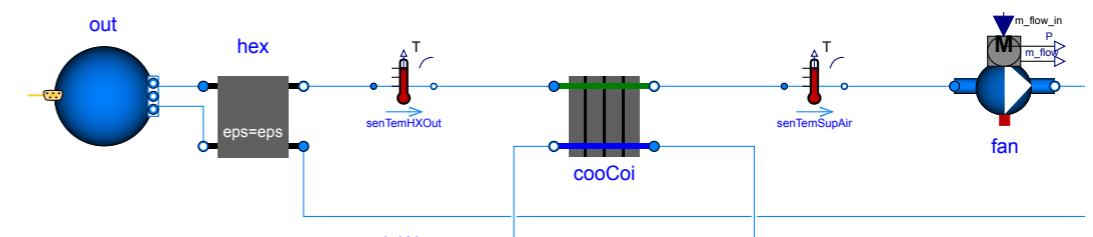


Structure

Tasks span from buildings to communities, and design to operation

Task 1: Modelica libraries for building and community energy systems

- WP 1.1: Library for design and operation
- WP 1.2: Library for Model Predictive Control



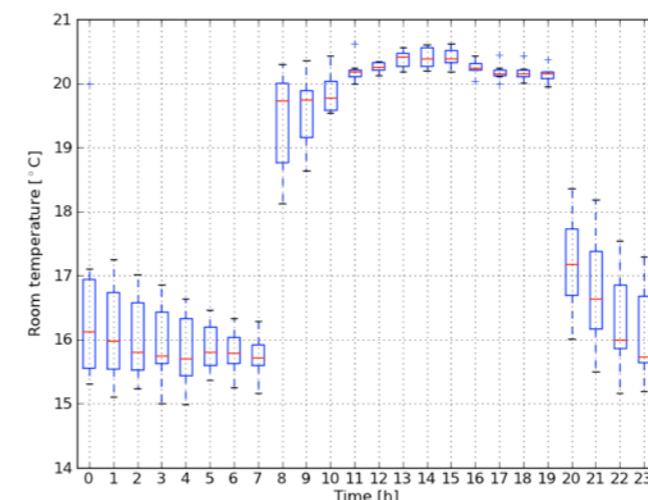
Task 2: Building and City Quarter Models

- WP 2.1: City Quarter Information Modeling
- WP 2.2: Building Information Modeling



Task 3: Application and Dissemination

- WP 3.1: Application
- WP 3.2: Dissemination



Levels of participation

Sponsoring participant

- Cash \$5k per year.

Organizational participants

- minimum 0.5 full time employee per year, over the 5 year project
- contribute to 5 to 10 web-based coordination meetings annually
- attend semi-annual expert meeting, generally lasting 2 days

Individual participants

- no predetermined level of commitment, but needs to provide substantial contributions

Intellectual property

IBPSA is the copyright and license holder.

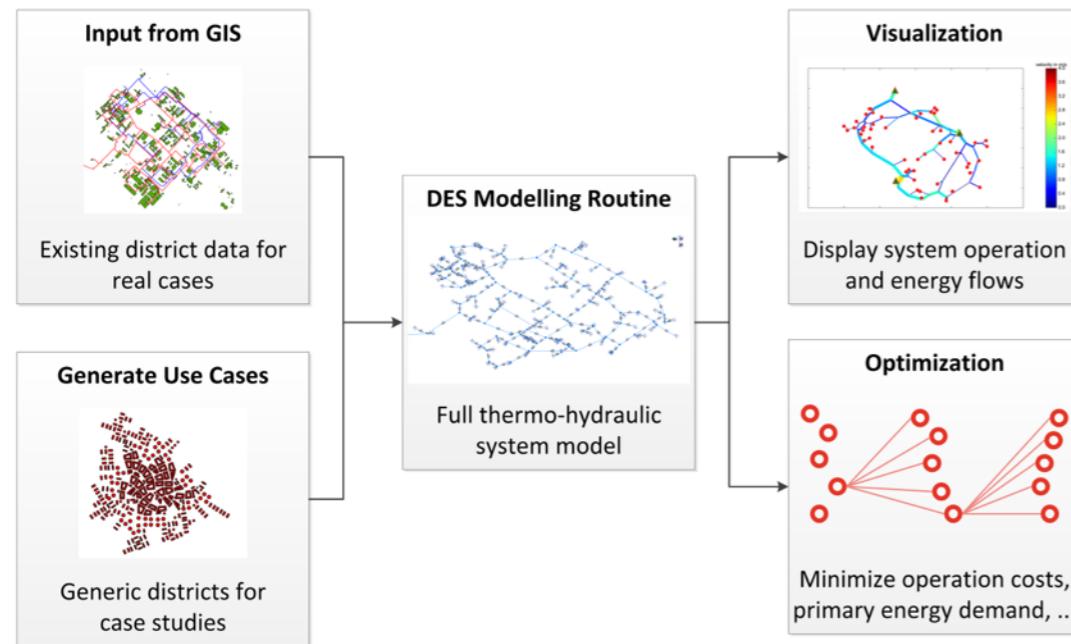
All workshops, software and documentation will be open accessible to anyone.

Modelica models will use a slightly modified version of the Modelica 2 license.

Code other than Modelica models will use the open-source BSD 3-Clause License.

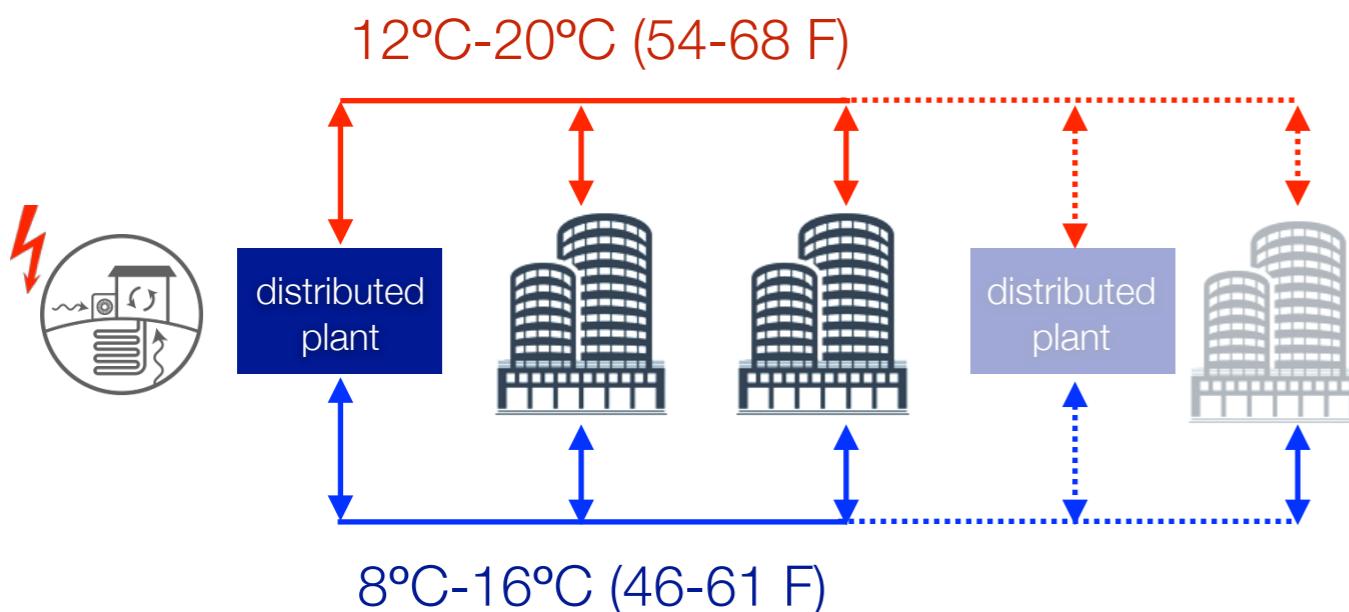
Example applications

District energy systems — building tools needed by urban developers and cities to prioritize investment and policy decisions



GIS to Modelica for performance analysis, visualization and optimization of district energy systems.

Source: RWTH Aachen

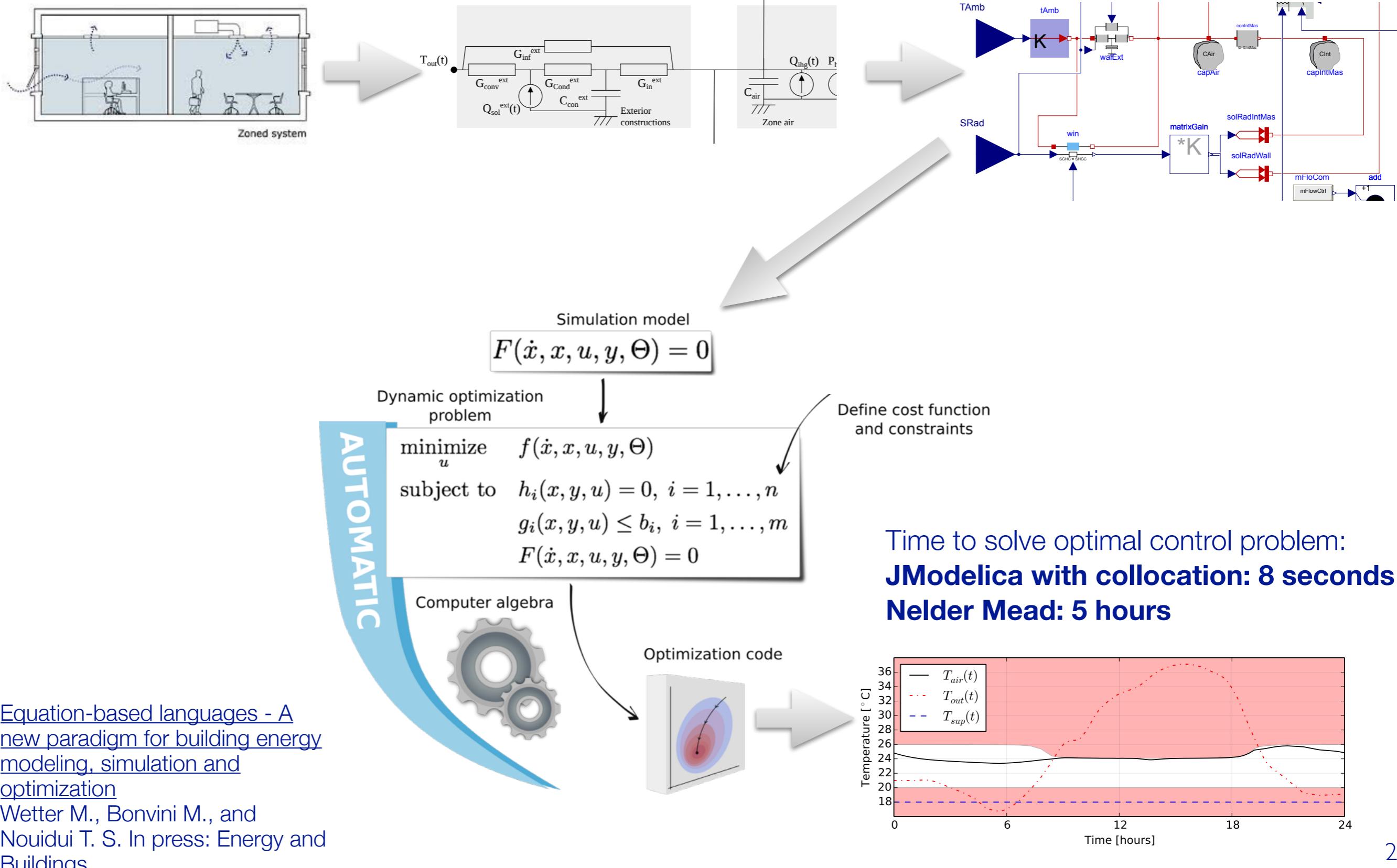


Analysis of novel, modular extensible energy networks with decentralized energy hubs and bi-directional flow networks that share heating, cooling and waste heat among energy hubs and buildings.

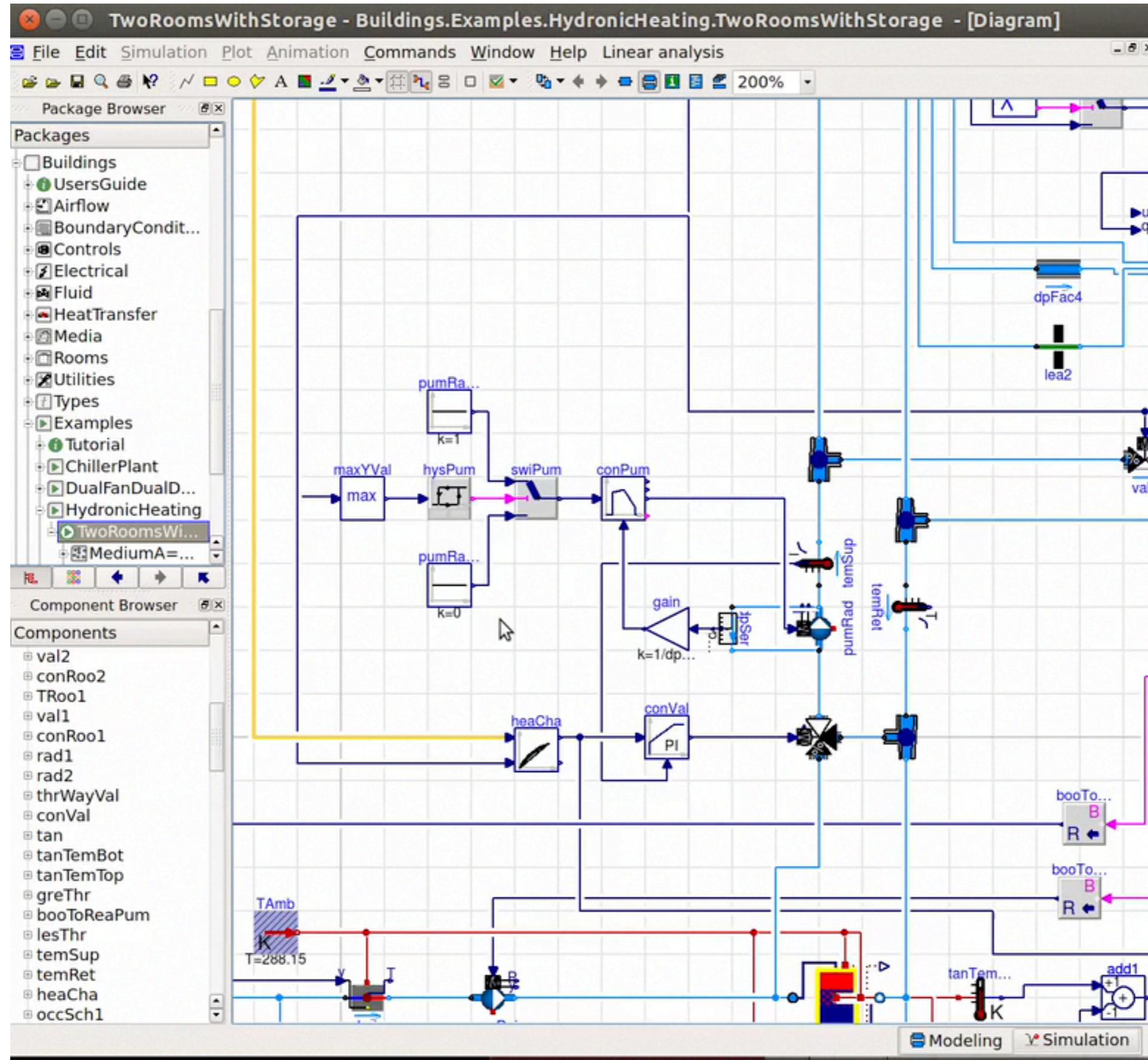
Source: LBNL

Optimization: 2200 times speed up for optimization through use of computer algebra

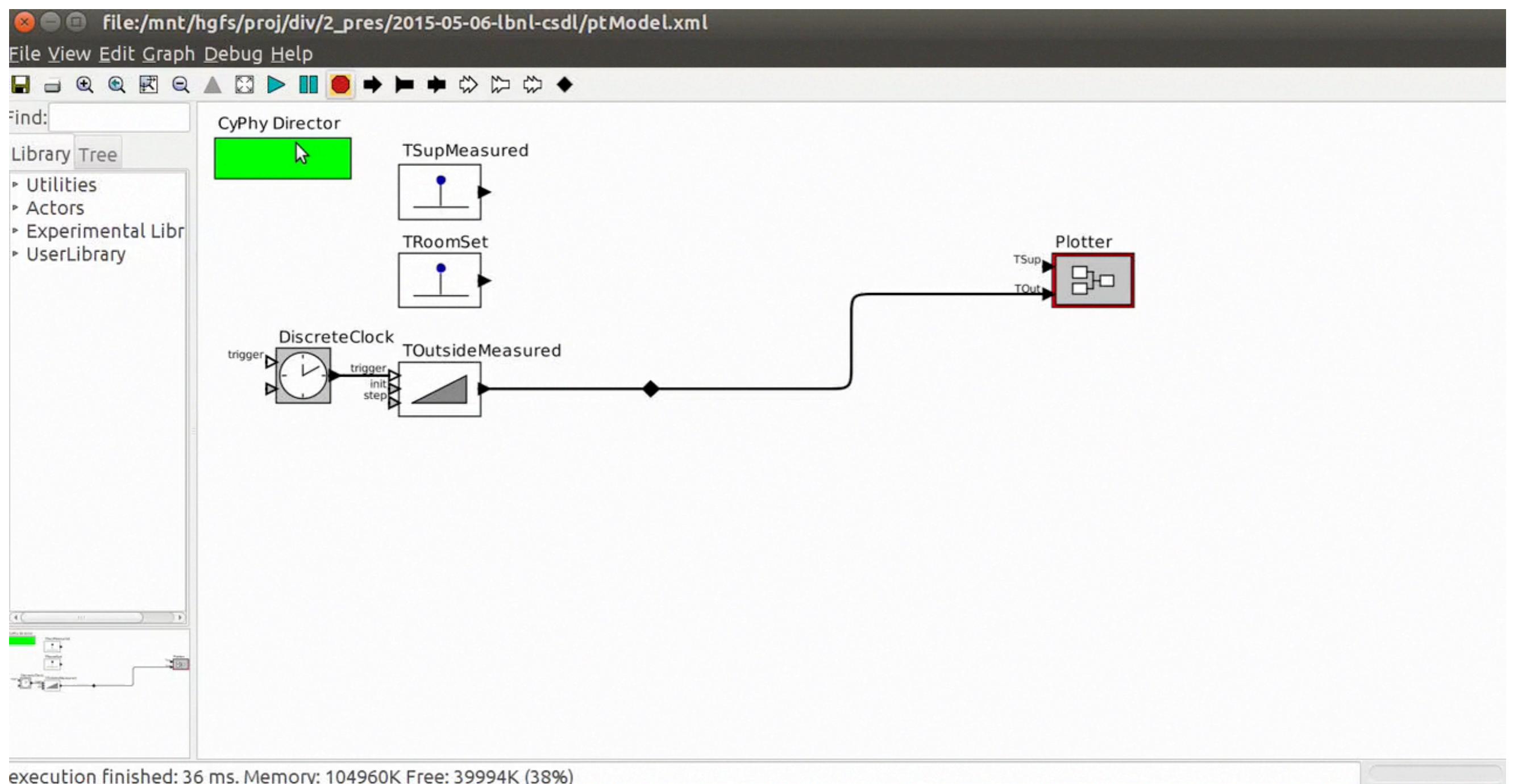
MODELICA



Exporting control sequence in standardized format (FMI)



Importing this control sequence into another simulator or a building automation system

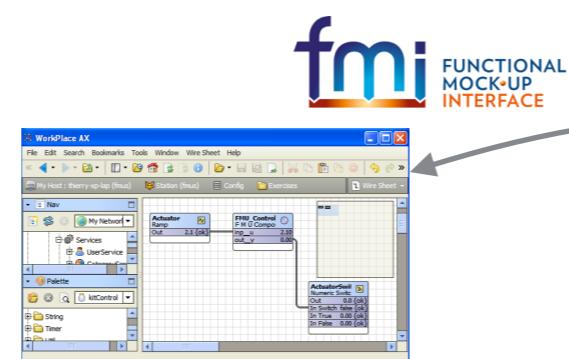
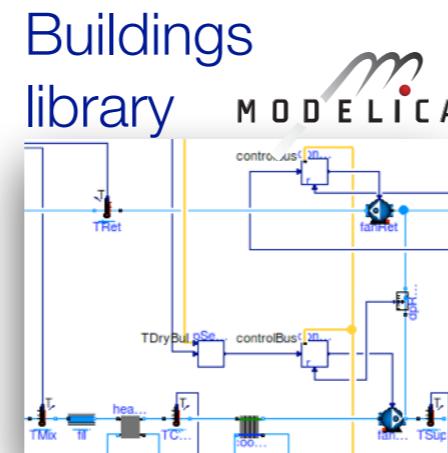


Spawn of EnergyPlus – Modularize EnergyPlus, base it on standardized open technologies that better address very low energy systems and operation

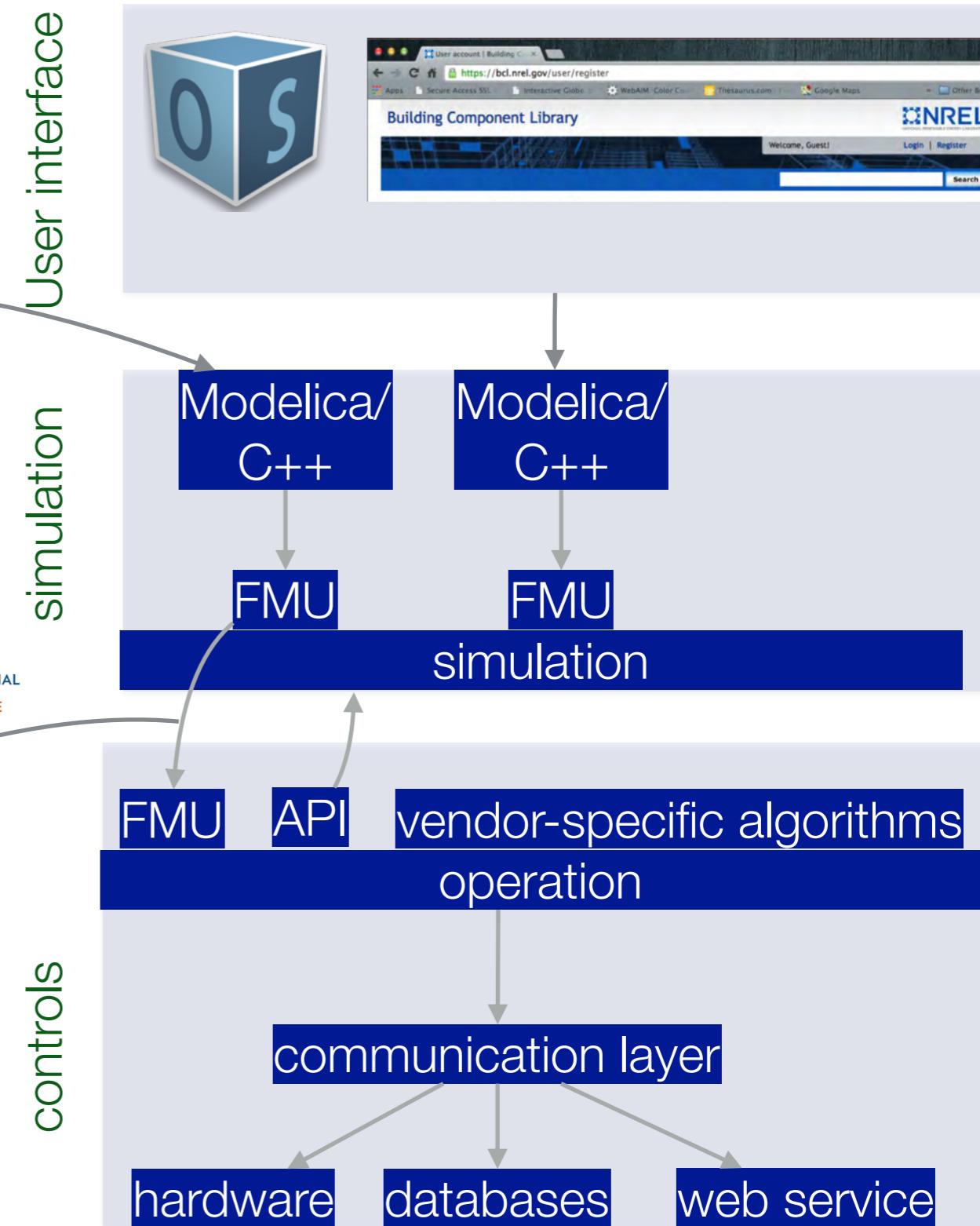


Spawn-of-EnergyPlus

- Inter-operability with control workflows and product development
- Flexible to model innovative non-standard approaches for heating, cooling and controls
- Modular
- Standard interface (FMI) and language (Modelica)



Automatic code generation from Modelica to, e.g., Niagara

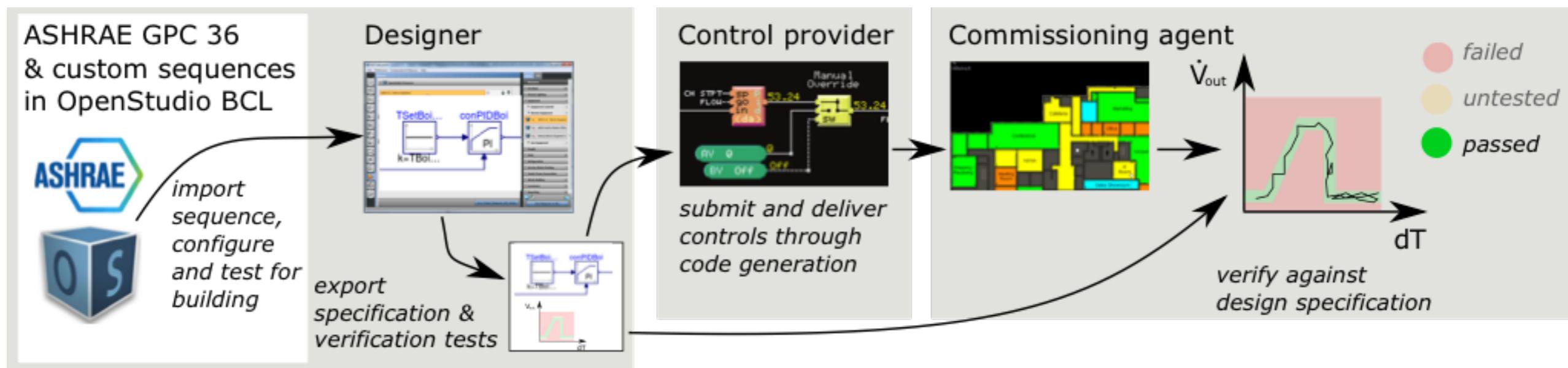


OpenBuildingControl

Provide process and integrated set of tools for design, deployment and end-to-end quality assurance of control sequences.

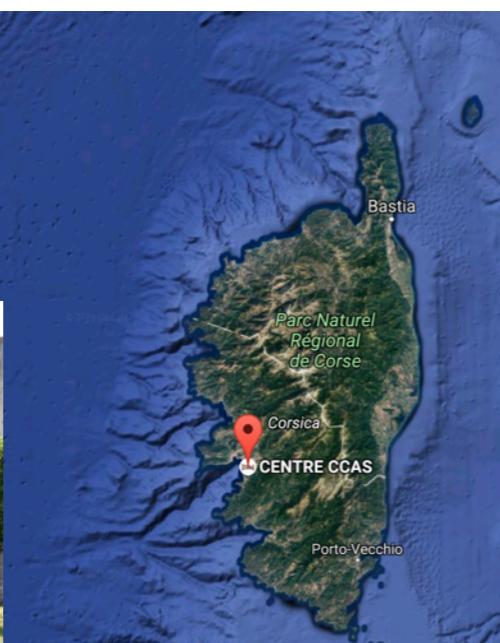
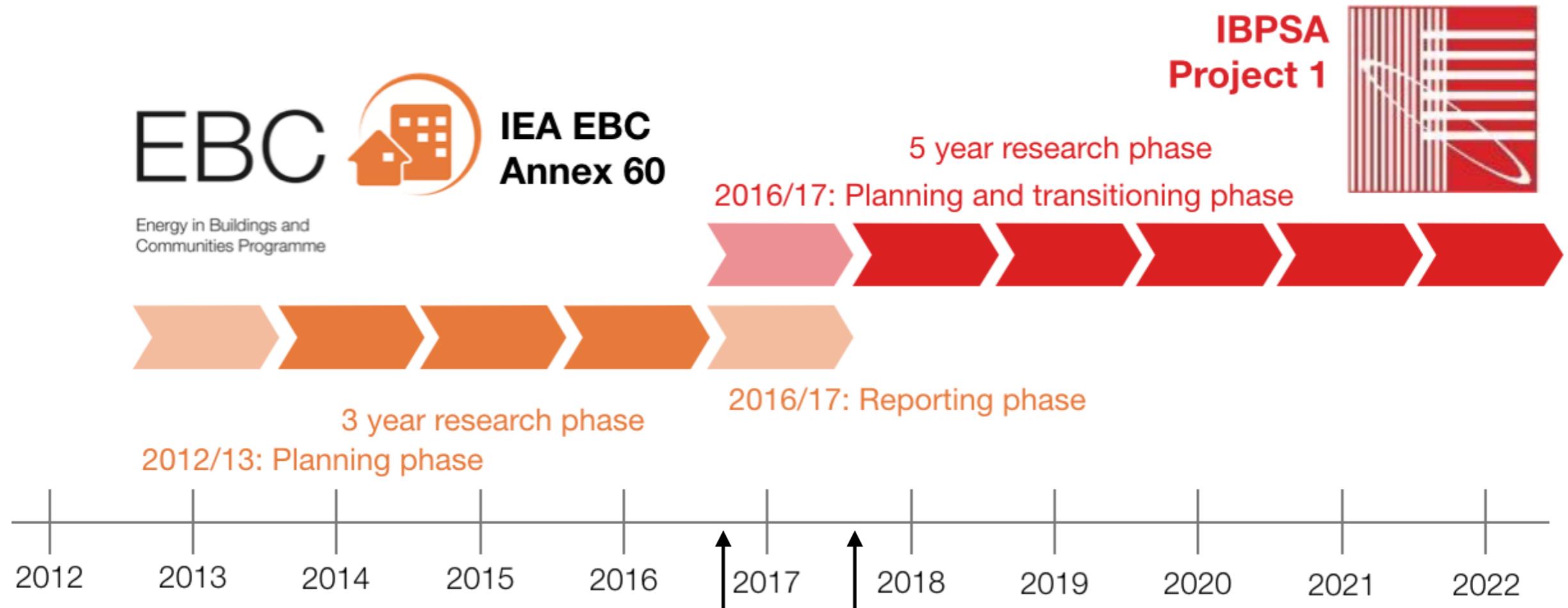
3 year DOE/CEC funded project.

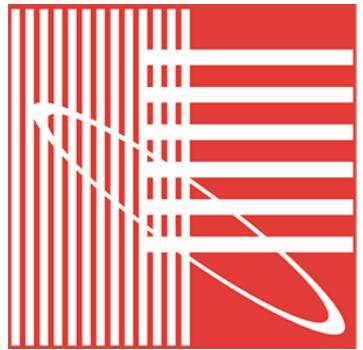
Start in fall 2016.



Next steps

Next steps





IBPSA Project 1

Visit <https://ibpsa.github.io/project1/> for

- work plan
- project registration
- Corsica training registration

Questions?