openstudio_to_modelica

Marco Bonvini (MBonvini@lbl.gov)

Acronyms - full disclosure

OS = OpenStudio

MPC = Model Predictive Control

RC = Resistance Capacitance

BRCM = Building RC Model

ABCD = A,B,C,D matrices representing a linear system

FDD = Fault Detection and Diagnostics

E+ = EnergyPlus

*.idf = Input Data File (E+ model)

HVAC = Heating Ventilation and Air Conditioning

*.gbXML = Green Building eXtended Markup Language

API = Application Programming Interface

VirGIL = Virtual Grid Integration Laboratory - project @ LBNL

Questions

Given an EnergyPlus model and how can I get

- a model that can be used for MPC?

- a simplified dynamic model that can be used for district grid simulation?

- only the chiller model to implement an FDD algorithm?

- the schedules and controllers and directly convert them into an executable control sequence?

EnergyPlus

EnergyPlus has been designed to

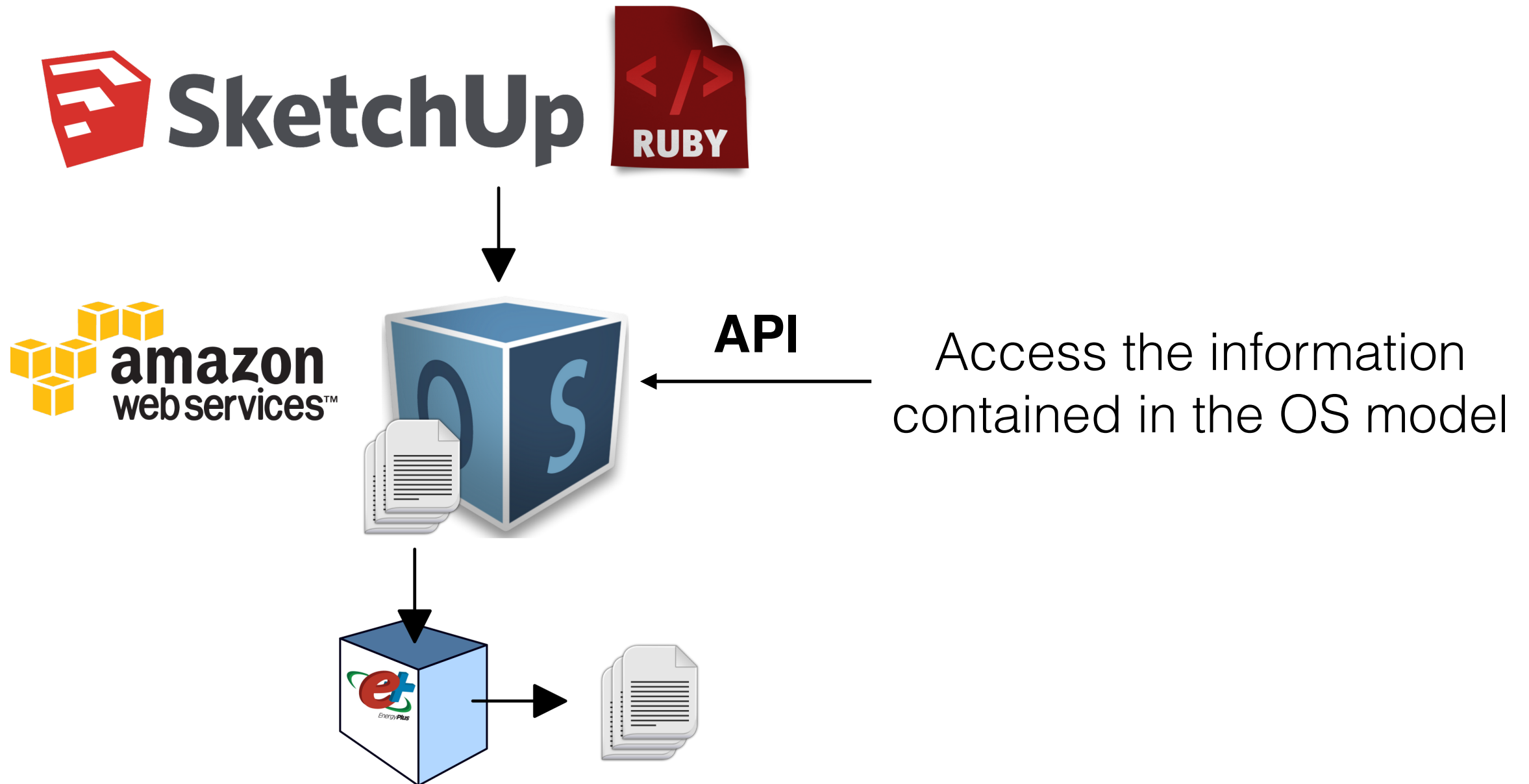- Simulate as fast as possible

- Produce accurate results

It does its job well, and It's not fair to expect more from it

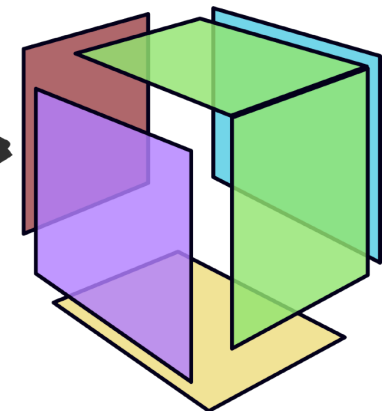# OpenStudio

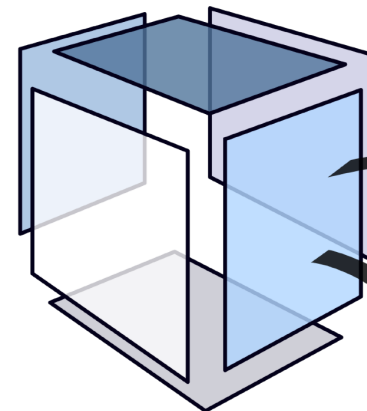# Can we use OS to answer some of the questions?

Leverage OpenStudio

API

Access the information contained in the OS model
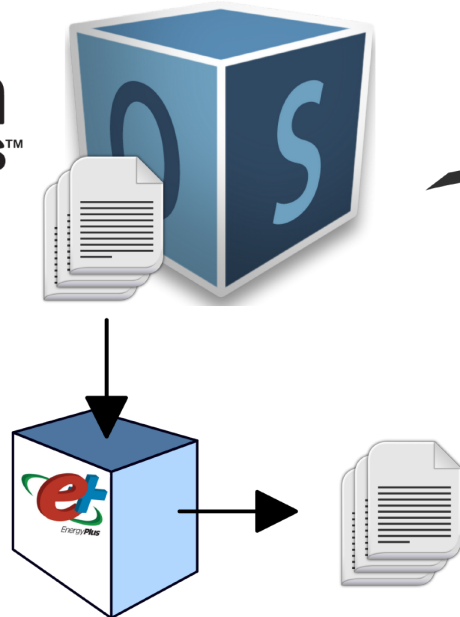
Beyond OpenStudio

Decompose the model into elements
Observe topology and properties
Reconstruct mathematical structure

Isolate and export components

Redefine and aggregate components

Inspiration

Create a simplified building model starting from EnergyPlus model already attempted: Building Resistance Capacitance Model Toolbox

BRCM generates RC building model for MPC from an *.idf (A,B,C,D matrices) + other configuration files

Used for the VirGIL project to generate a simplified dynamic building model for LBNL building 71

BRCM - Pros & Cons

PROS:

- Uses E+ and thus a lot of models and prototypical models are available

- Their approach has been demonstrated

CONS:

- Model focused for MPC, restricted form with few parameters to tune

- Once the ABCD matrices are computed they cannot be changed, makes tuning bit difficult (it could have been solved as an optimization problem)

- It parses directly the *.idf file (will be able to keep up with new if formats?)

- Based on Matlab (people outside of the academic world? What if you'd like to use the ABCD matrices with your own solver?)
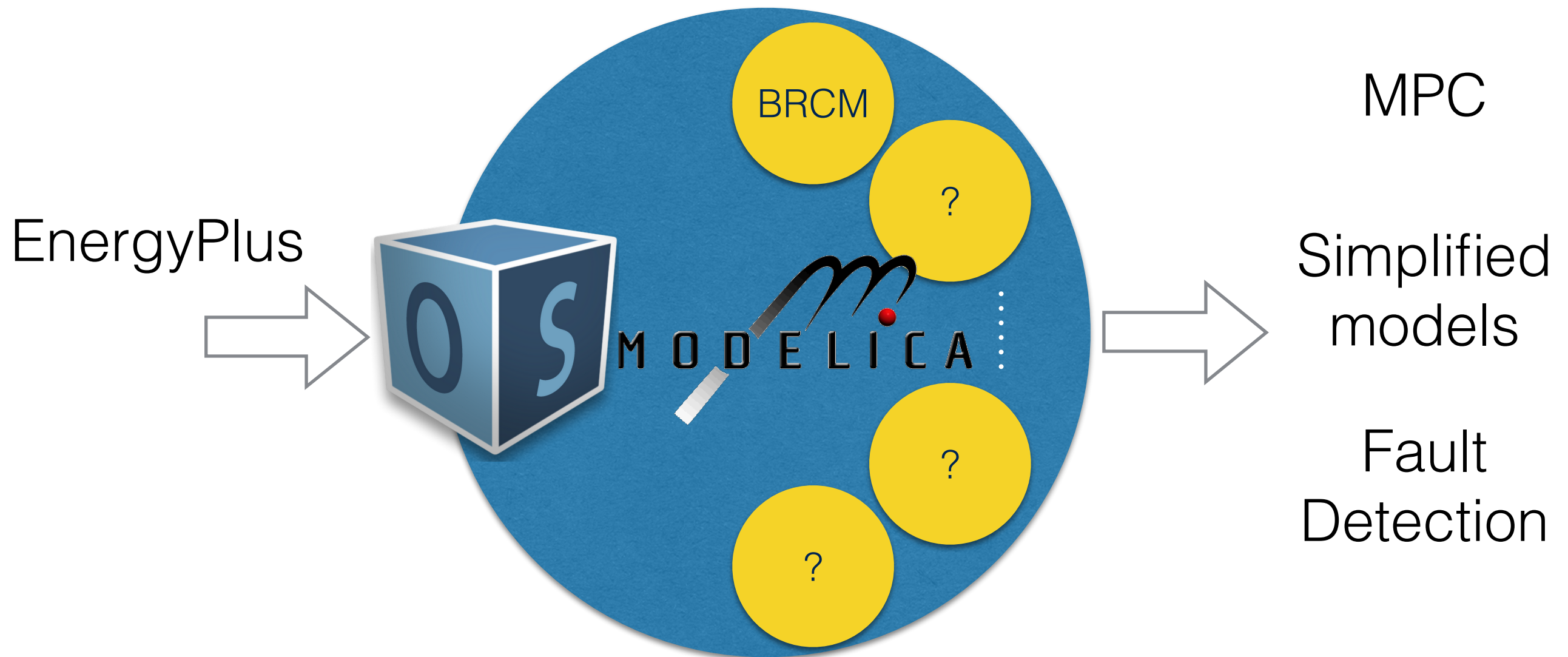
Idea

Why not trying to include the approach used by the BRCM toolbox in a bigger picture?

EnergyPlus

BRCM

?

MPC

Simplified models

Fault Detection
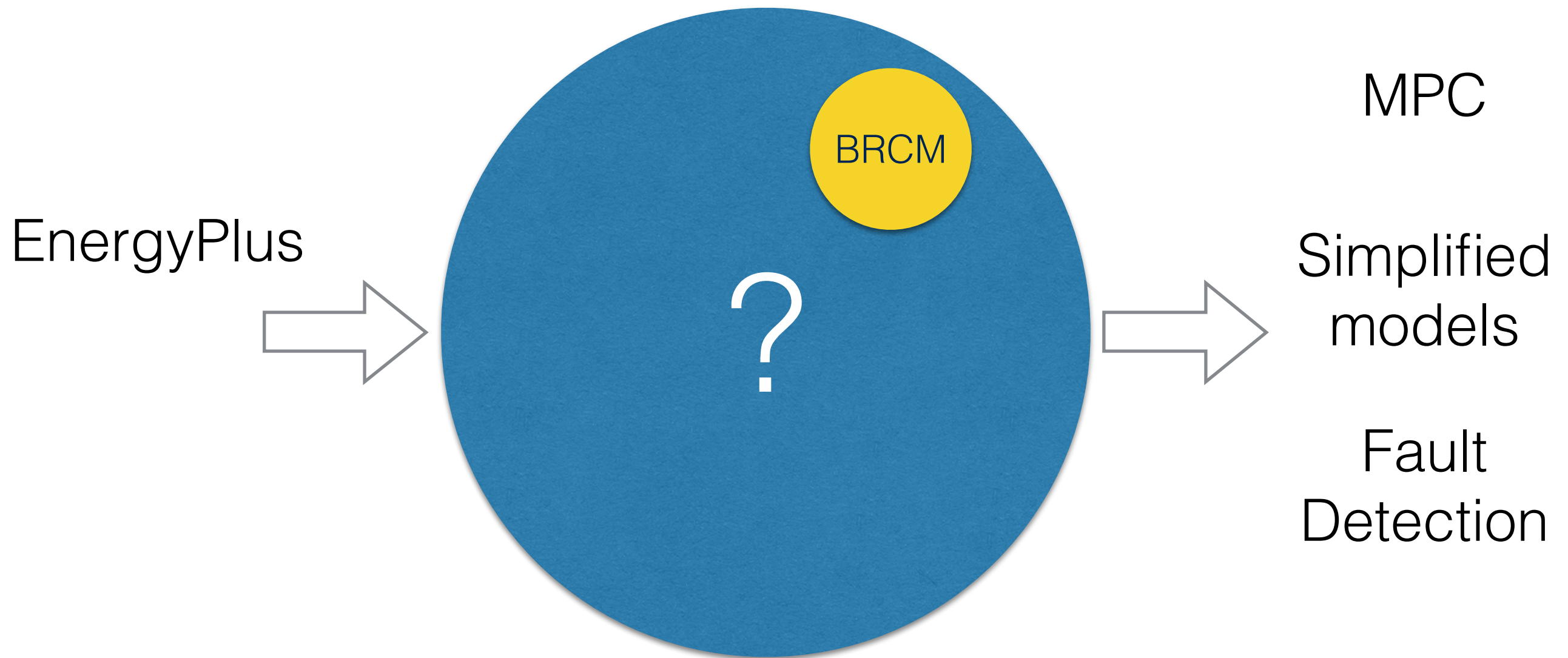
Idea

Why not trying to include the approach used by the BRCM toolbox in a bigger picture?

OpenStudio

- Import of EnergyPlus *.idf, *.gbXML, and OS model

- Directly generate a model with SketchUp

PROS

- API and ability to create scripts that analyze the building model

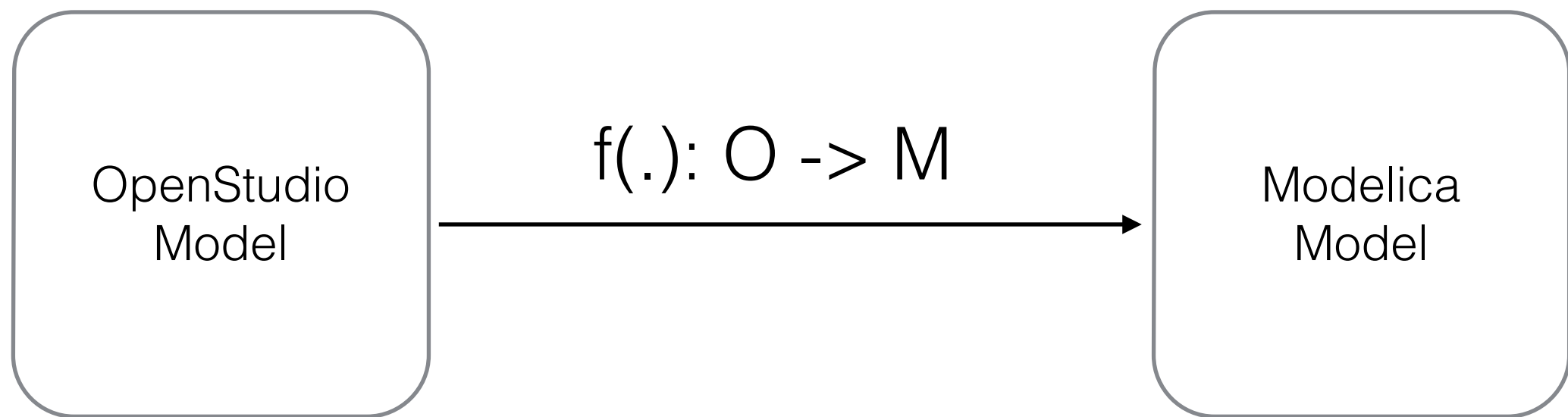- Well documented and supported - leverages the EnergyPlus ecosystem

CONS

- Carries some limitations of the EnergyPlus model (more later…)

- Does not convert HVAC network part of the EnergyPlus models (components like schedules, etc.)

- Scripting in Ruby (Ruby itself is fine, but it limits the ability to interface with packages for simulation and numerical analysis available in Python)
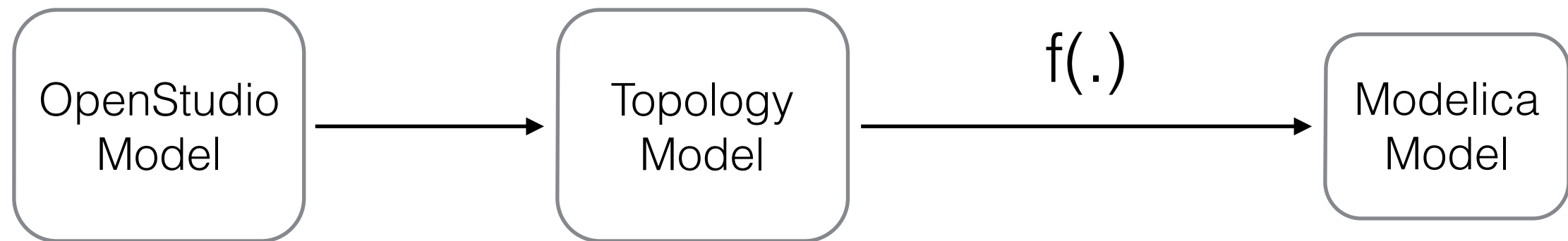
Limitations (so far)

- Semantic of links between surfaces and zones

    Each zone (aka space) has an array of surfaces associated to it. A wall will have two surfaces, defined as adjacent. Not assured that the surfaces are equal.
    > Surface object with two sides?

- Access material properties while iterating over the models without going to the "root" building model

- Naming conventions are a mess: 1 Inch Stucco, Room Floor:Side (E), etc.

openstudio_to_modelica

- Ruby package to convert an OpenStudio model into an equivalent* Modelica model.

- *Equivalency depends on the use of the model (simulation, MPC, etc.)

- Focused on the envelope (so far)

- Transformation as a function f(.) from domain **O** of OpenStudio models to the co-domain of Modelica models **M**

OpenStudio Model → f(.): O -> M → Modelica Model

openstudio_to_modelica

```
┌─────────────┐       ┌─────────────┐    f(.)    ┌─────────────┐
│ OpenStudio  │──────▶│  Topology   │──────────▶ │  Modelica   │
│   Model     │       │   Model     │            │   Model     │
└─────────────┘       └─────────────┘            └─────────────┘
```
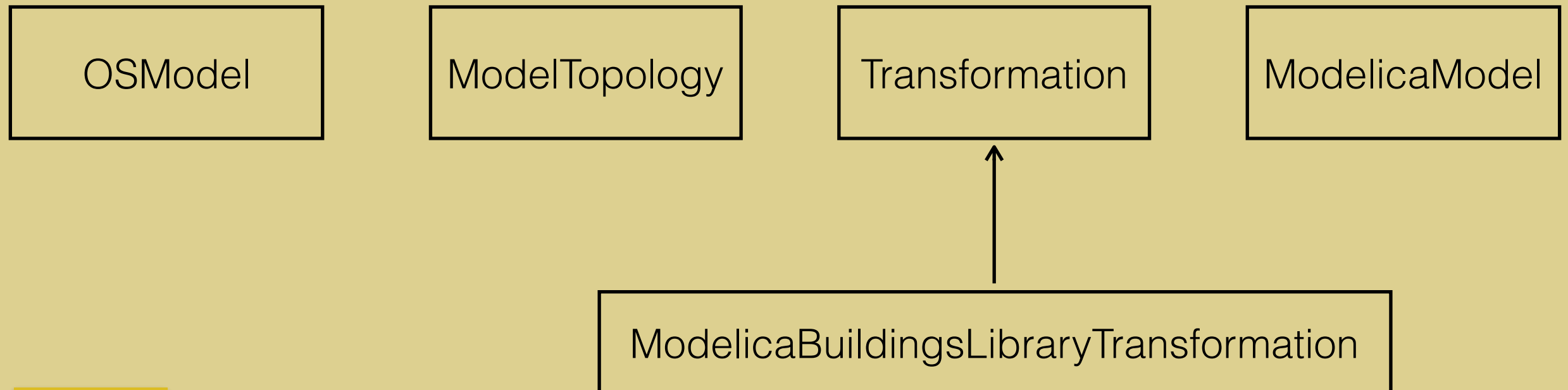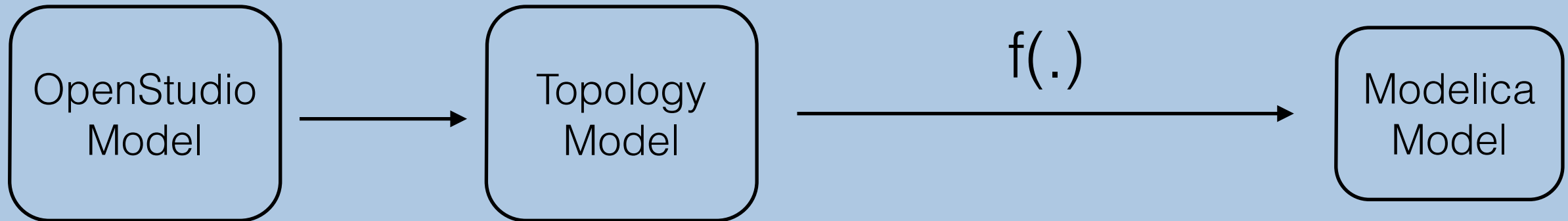
Process the OS model and identify its topology: what are the rooms, walls and how they are connected (graph)

Given the topology information convert to the desired Modelica model: BuildingsLibrary, LinearSystems ABCD, Simplified RC, etc.

openstudio_to_modelica

openstudio_to_modelica

```ruby
# Load the openstudio_to_modelica package
require 'openstudio'
require 'openstudio_to_modelica'

# Initializes an object model from an EnergyPlus file
eplus_model_path = "path/to/your/file.idf"
mm = ModelicaModel.new(eplus_model_path)

# Identify the topology of the model
mm.identify_topology()

# Instantiate a transformation object that performs the conversion.
# In this case it is specific for the Modelica Buildings library
tr = ModelicaBuildingsLibraryTransformation.new()

# Generate the Modelica model with the transformation tr
modelica_model_dir_path = "path/to/directory/where/saving/the/model"
mm.generate_modelica_model(
        tr,
        "TestBuilding",
        "Building model generated for test purposes",
        modelica_model_dir_path)
```

Demo

Conclusions

- Good API and documentation is priceless

- Trying to go beyond the simulation itself and improve the overall "EnergyPlus experience"

- Trying to look ahead and support development of tools that improve the operation of real buildings