

SOEP Coupling

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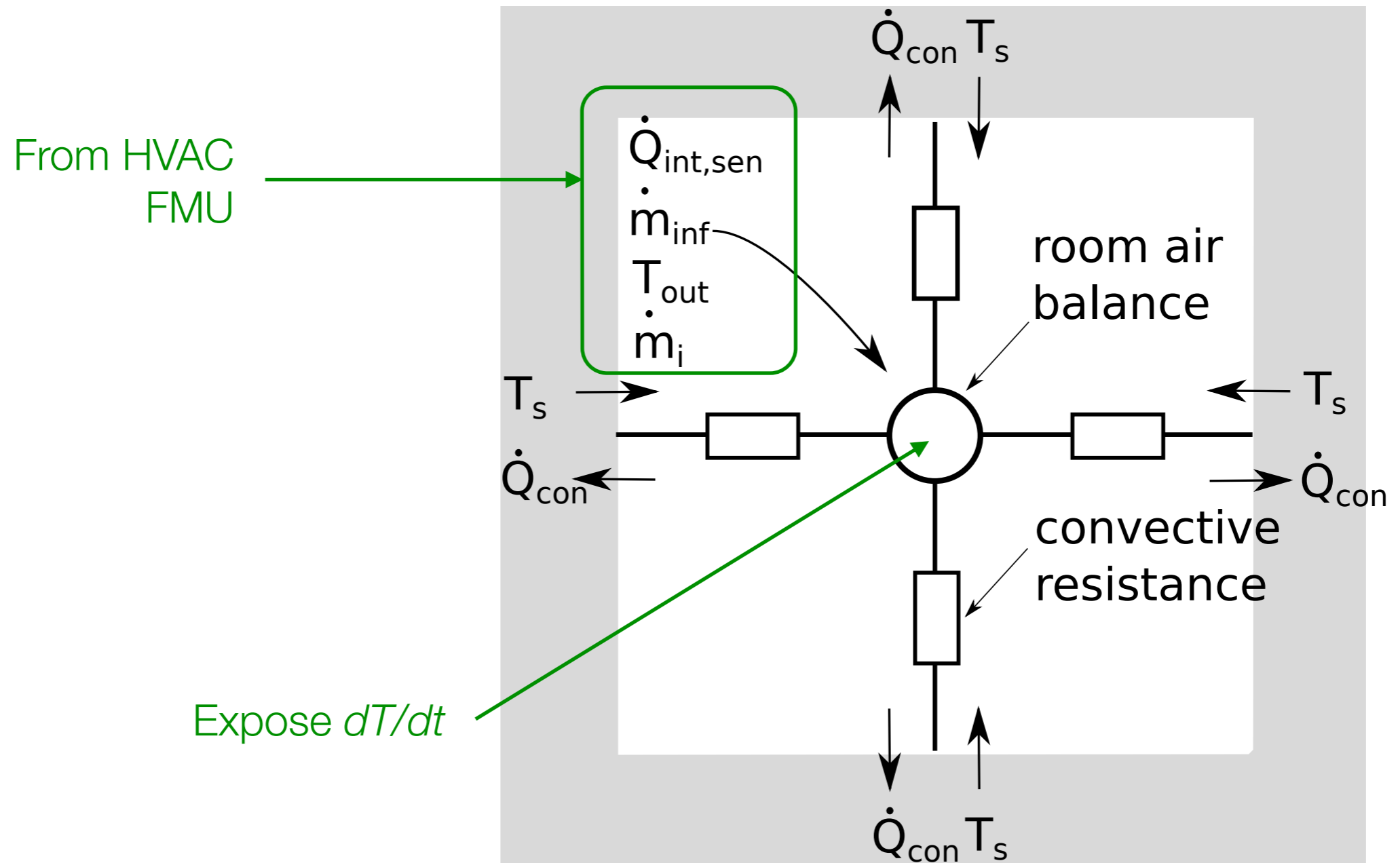
July 24, 2015



Lawrence Berkeley National Laboratory

SOEP integration in zone heat balance

SOEP HVAC will interface to ordinary differential equation of room air



Coupling SOEP with the Zone Heat Balance of EnergyPlus

How to insert SOEP into existing EnergyPlus while allowing large synchronization time steps?

$$C \frac{dT_z}{dt} = \dot{Q}_{\text{int},\text{sen}} + \sum_{i=1}^{N_{\text{surf}}} \dot{Q}_{\text{con},i} + \sum_{i=1}^{N_{\text{zones}}} \dot{Q}_{z,i} + \dot{Q}_{\text{sys},\text{sen}} + \dot{Q}_{\text{inf}}$$

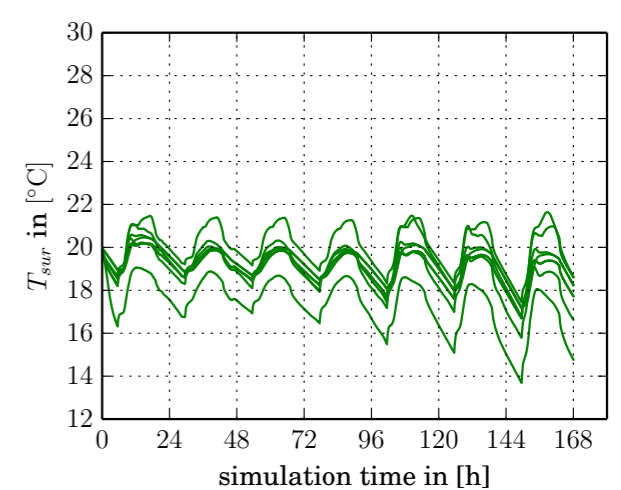
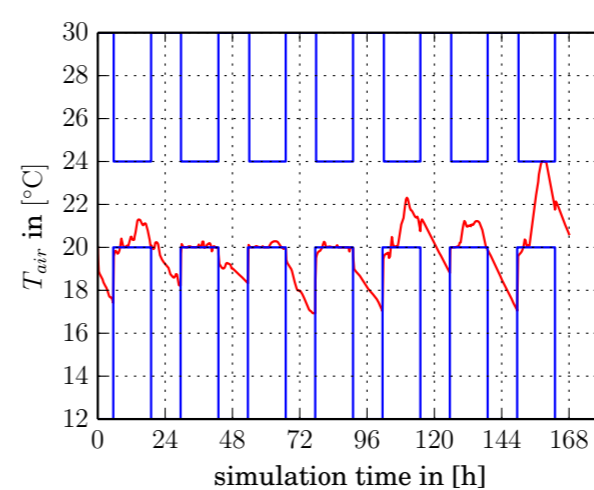
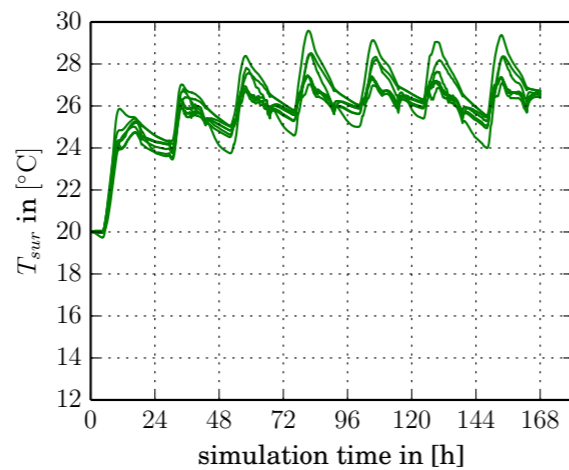
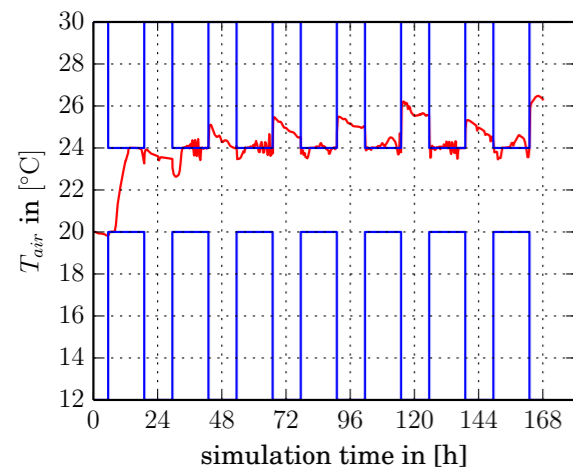
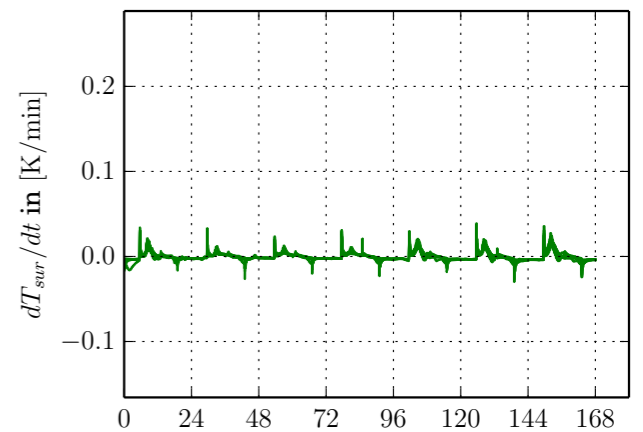
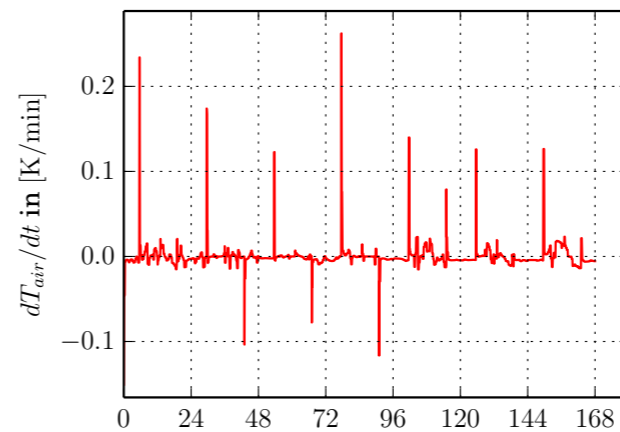
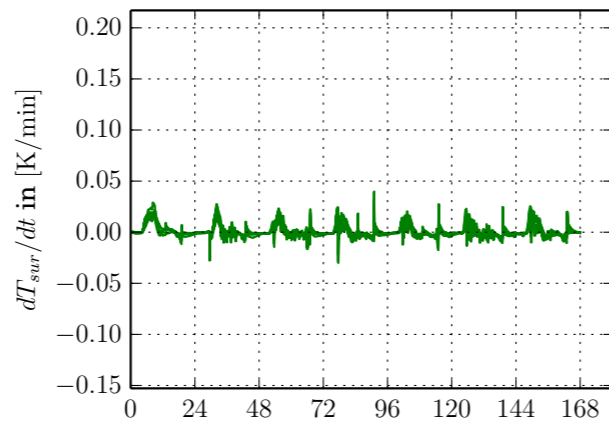
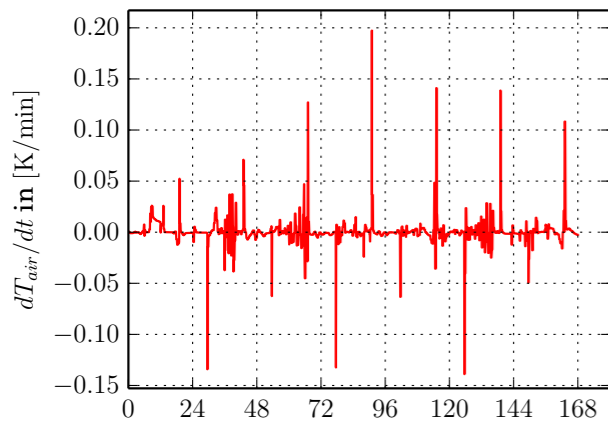
From Brent's refactoring.

From HVAC FMU.

*For simplicity, we only consider the quantities in green box

Coupling through interior surfaces allows 5 to 10 times larger synchronization time step compared to coupling to air

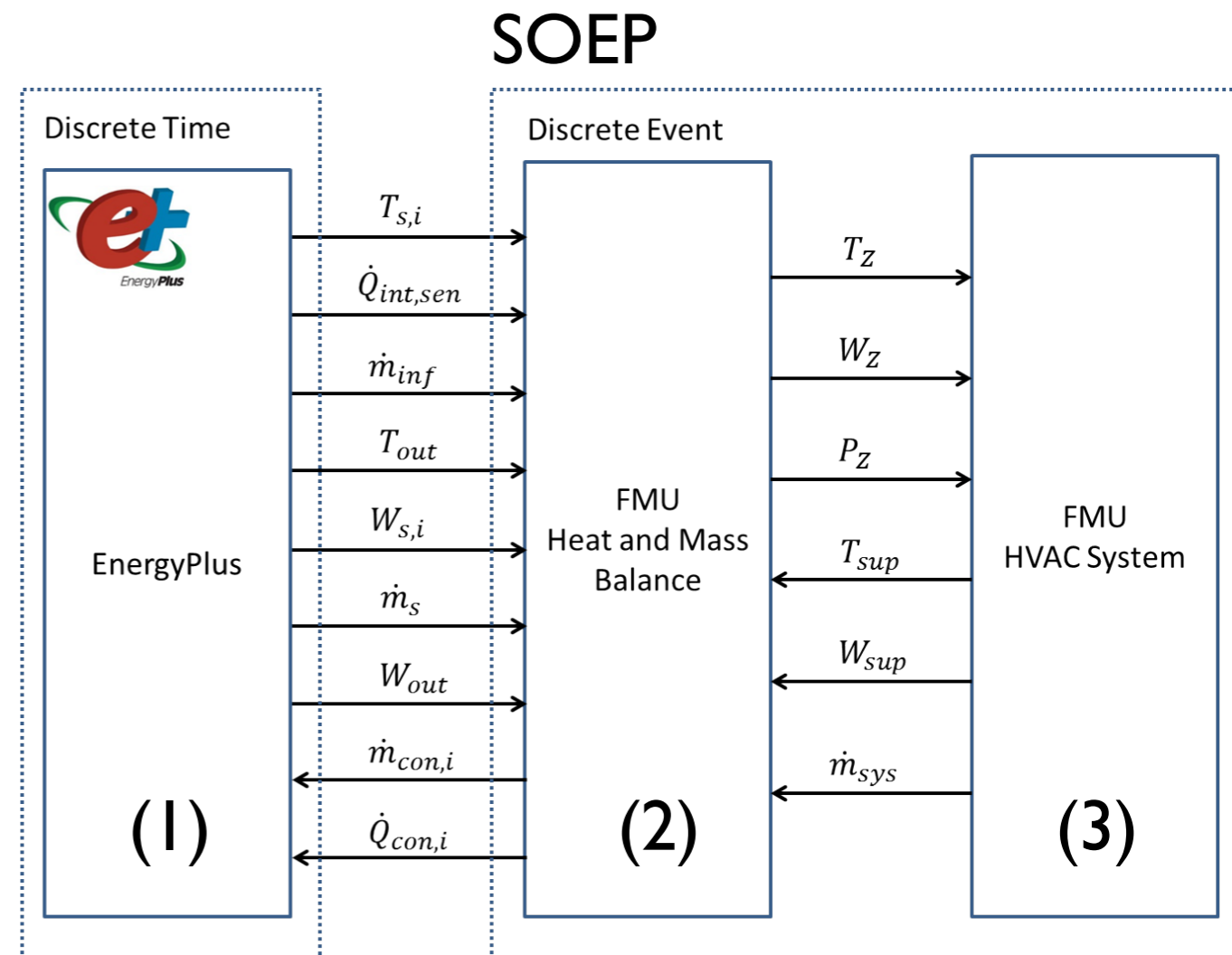
$$C \frac{dT_z}{dt} = \dot{Q}_{\text{int, sen}} + \sum_{i=1}^{N_{\text{surf}}} \dot{Q}_{\text{con, } i} + \sum_{i=1}^{N_{\text{zones}}} \dot{Q}_{z, i} + \dot{Q}_{\text{sys, sen}} + \dot{Q}_{\text{inf}}$$



Coupling SOEP with the Zone Heat Balance of EnergyPlus

$$C \frac{dT_z}{dt} = \dot{Q}_{int, sen} + \sum_{i=1}^{N_{surf}} \dot{Q}_{con, i} + \sum_{i=1}^{N_{zones}} \dot{Q}_{z, i} + \dot{Q}_{sys, sen} + \dot{Q}_{inf}$$

- (1) computes surface temperatures at fixed zone time step
- (2) computes room temperature at variable QSS time steps
- (3) computes HVAC quantities at variable QSS time steps



Summary: Coupling SOEP with the Zone Heat Balance of EnergyPlus

$$C \frac{dT_z}{dt} = \dot{Q}_{\text{int},\text{sen}} + \sum_{i=1}^{N_{\text{surf}}} \dot{Q}_{\text{con},i} + \sum_{i=1}^{N_{\text{zones}}} \dot{Q}_{z,i} + \dot{Q}_{\text{sys},\text{sen}} + \dot{Q}_{\text{inf}}$$

Coupling SOEP through surface temperature rather than zone air temperature for larger synchronization time step.

Communication with EnergyPlus (envelope) done at zone time step.

SOEP computes quantities such as zone air temperature, mass flow rates at QSS variable time step.

Implementation of Master Algorithm

Calling sequence

Note:

1. E+ does not allow saving and resetting state variables.
3. E+ needs to stay in memory between warm-up and run-periods, hence E+ needs to call Ptolemy II.

Otherwise, it would be cleaner to have the master algorithm (=Ptolemy II) call all its simulation models.

Calling sequence

OpenStudio

Generate Modelica system model.
Call JModelica compiler.
Generate Ptolemy II input file.
Write modelDescription.xml & zip.
Call EnergyPlus

JModelica

Export FMUs for
model-exchange

EnergyPlus

Automation

Warm-up 1:

Keep states

Run period 1:

Keep results

Warm-up 2:

Keep states

Run period 2:

...

Write results

Simulation

Call Ptolemy II

Call Ptolemy II

Call Ptolemy II

Call Ptolemy II

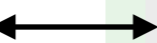
FMU for co-simulation with tool-coupling

FMI-CS
binary

Ptolemy II

Instantiate FMUs.
Simulate

FMU-ME



Calling sequence — if JModelica has QSS solver

OpenStudio

Generate Modelica system model.
Call JModelica compiler.
~~Generate Ptolemy input file.~~
~~Write modelDescription.xml & zip.~~
Call EnergyPlus

For efficiency, would be good to have QSS solver inside JModelica. See [Fernandez and Kofman \(2014\)](#)

EnergyPlus

Automation

Simulation

Warm-up 1:

Call Ptolemy II

Keep states

Run period 1:

Call Ptolemy II

Keep results

Warm-up 2:

Call Ptolemy II

Keep states

Run period 2:

Call Ptolemy II

...

Write results

FMU for co-simulation

JModelica,
exported as FMU for
CS with QSS solver



Calling sequence — variation if E+ supports state reset

OpenStudio

Generate Modelica system model.
Call JModelica compiler.
Call E+ “envelope” FMU export.
Generate Ptolemy input file.

Automation

Warm-up 1:

Call master algo

Store states

Run period 1:

Call master algo

Store results results

Warm-up 2:

Call master algo

Store states states

Run period 2:

Call master algo

...

Write results

JModelica

Export FMUs for model-exchange

E+ FMU export

Export FMUs for model-exchange

FMU for co-simulation with tool-coupling

FMI-CS binary

Ptolemy II,
exported as FMU for
CS

Instantiate FMUs.
Simulate

FMU-ME

Calling sequence — variation if E+ supports state reset & JModelica has QSS

OpenStudio

Generate Modelica system model.

Call E+ “envelope” FMU export.
Generate JModelica input file.

Automation

Warm-up 1:

Call master algo

Store states

Run period 1:

Call master algo

Store results results

Warm-up 2:

Call master algo

Store states states

Run period 2:

Call master algo

...

Write results

JModelica has QSS

Longer term plan if we get QSS into JModelica

E+ FMU export

Export FMUs for
model-exchange

FMU for co-simulation with tool-coupling

FMI-CS
binary

JModelica,
exported as FMU for
CS with QSS solver

Next steps

1. Split off the piece(s) of EnergyPlus that interface with SOEP
 1. Refactor room air heat balance for export as FMU-ME
 2. Expose “E+ envelope” API to room heat balance ODE
2. Implement
 1. Ptolemy II export as FMU-CS (tool-coupling).
 2. have “E+ envelope” call the FMU-CS.
3. Begin writing an OpenStudio translator for the HVAC and controls part of SOEP.
 1. Populate OpenStudio “HVAC & controls library”
4. Begin putting together the SOEP package in terms of Ptolemy II and JModelica.
5. Transitioning some component/systems from EnergyPlus to SOEP.