



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

TASK3: Application and Dissemination

WP 3.1 District Energy DESTEST

Dirk Saelens

Paris expert meeting – Status presentation – 20181001

## WP 3.1 Application and DESTEST for district energy models

- Track 1: Demonstration of case studies → Free papers
- Track 2: Development of DESTEST (=main activity)

## TRACK 2: Development of DESTEST

Aim is to:

1. Develop typical or representative DES configurations
  - that can be used for testing different DES models (intermodel comparison, validation?)
  - that can be used for testing different DES implementations and approaches (f.i. central vs decentral storage)
2. Develop a test framework for testing individual DES models (f.i. substations, pipes, heatpumps ...)

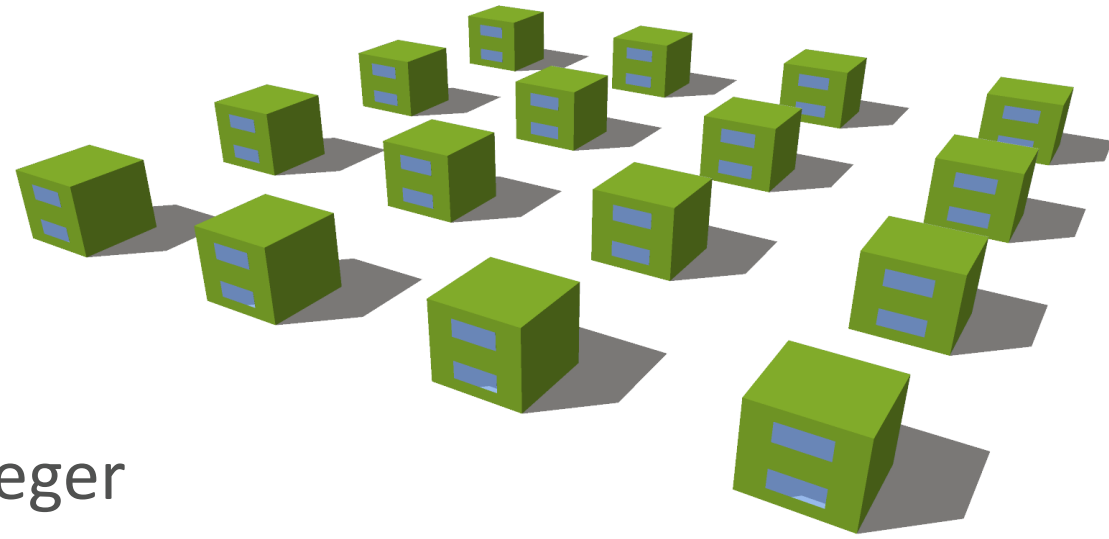
# Activities and Participants

- Activities
  - 4 coordination meetings
  - different subgroup meetings

# Activities and Participants

| Participants          | Affiliation                    |
|-----------------------|--------------------------------|
| Krzysztof Arendt      | University of Southern Denmark |
| Felix Bünning         | EMPA                           |
| Ina De Jaeger         | KU Leuven                      |
| Konstantin Filonenco  | University of Southern Denmark |
| Enora Garreau         | CSTB                           |
| Alessandro Maccarini  | Aalborg University             |
| Michael Mans          | RWTH Aachen                    |
| Peter Remmen          | RWTH Aachen                    |
| Dirk Saelens          | KU Leuven                      |
| Artem Sortnikov       | Hochschule Luzern              |
| Christoph Stettler    | Hochschule Luzern              |
| Bram Van der Heijde   | KU Leuven                      |
| Annelies Vandermeulen | KU Leuven                      |
| Ilaria Vigna          | Politecnico di Milano          |

## TRACK 2: Development of DESTEST

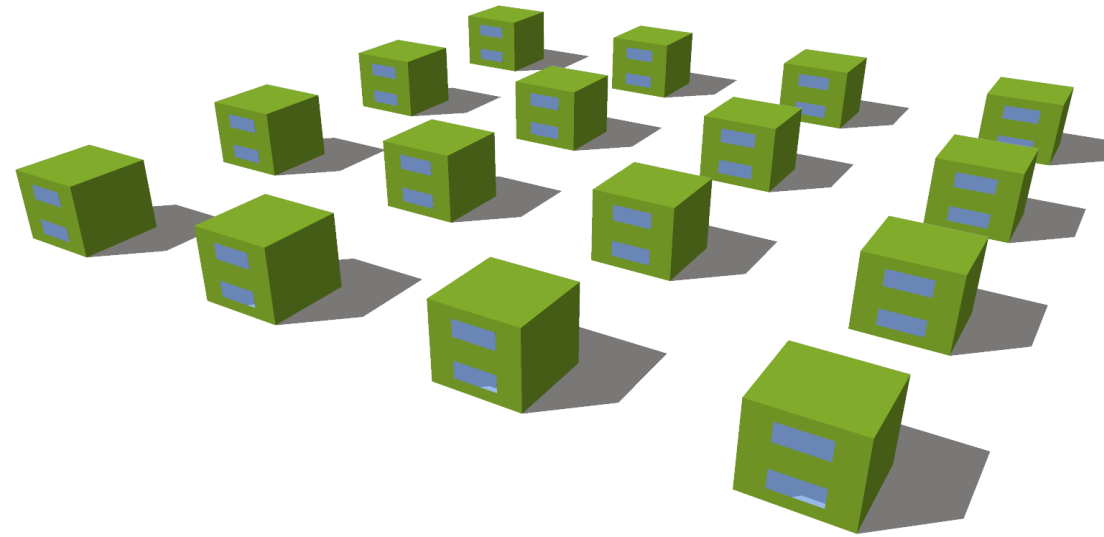


- Two tracks are working in parallel
  - Focus on **building** models: Ina De Jaeger
  - Focus on **energy system** models: Felix Bunning
- Start with description of (very) simple neighborhood of buildings
- Use this information to design thermal network(s)

# BUILDINGS: Start simple

- 16 identical single-family dwellings of 1980
- Thermal properties based on TABULA project for Belgium
- Two-zone model (day zone and night zone)
- Standard occupant (ISO 13790)
- Only heat demand for space heating
- Documented in TEASER.xml format

→ Simulated with IDEAS and Buildings library



|                              |                                     |
|------------------------------|-------------------------------------|
| Save current file            | version="1.0"                       |
| project:Project              |                                     |
| version                      | 0.5                                 |
| xmlns:project                | http://teaser.project               |
| xmlns:usecond                | http://teaser.boundary              |
| project:Residential          |                                     |
| project:name                 | SimpleDistrict_1                    |
| project:street_name          |                                     |
| project:city                 |                                     |
| project:type_of_building     | SingleFamilyDwelling                |
| project:year_of_construction | 1980                                |
| project:year_of_retrofit     | None                                |
| project:number_of_floors     | 2                                   |
| project:height_of_floors     | 3.5                                 |
| project:net_leased_area      | 128.0                               |
| project:ThermalZone          |                                     |
| project:name                 | DayZone                             |
| project:area                 | 64.0                                |
| project:volume               | 224.0                               |
| project:infiltration_rate    | 0.4                                 |
| project:typical_length       | 3.0                                 |
| project:typical_width        | 6.0                                 |
| project:UseCondition         |                                     |
| project:OuterWall            |                                     |
| project:name                 | OuterWall_1_1                       |
| project:year_of_construction | 1980                                |
| project:construction_type    | heavy                               |
| project:area                 | 22.4                                |
| project:tilt                 | 90.0                                |
| project:orientation          | 90.0                                |
| project:inner_convection     | 2.7                                 |
| project:inner_radiation      | 5.0                                 |
| project:outer_convection     | 20.0                                |
| project:outer_radiation      | 5.0                                 |
| project:Layer                |                                     |
| project:id                   | 1                                   |
| project:thickness            | 0.1                                 |
| project:Material             |                                     |
| project:name                 | HeavyMasonryForExteriorApplications |
| project:density              | 1850.0                              |
| project:thermal_conduc       | 1.1                                 |

# Results

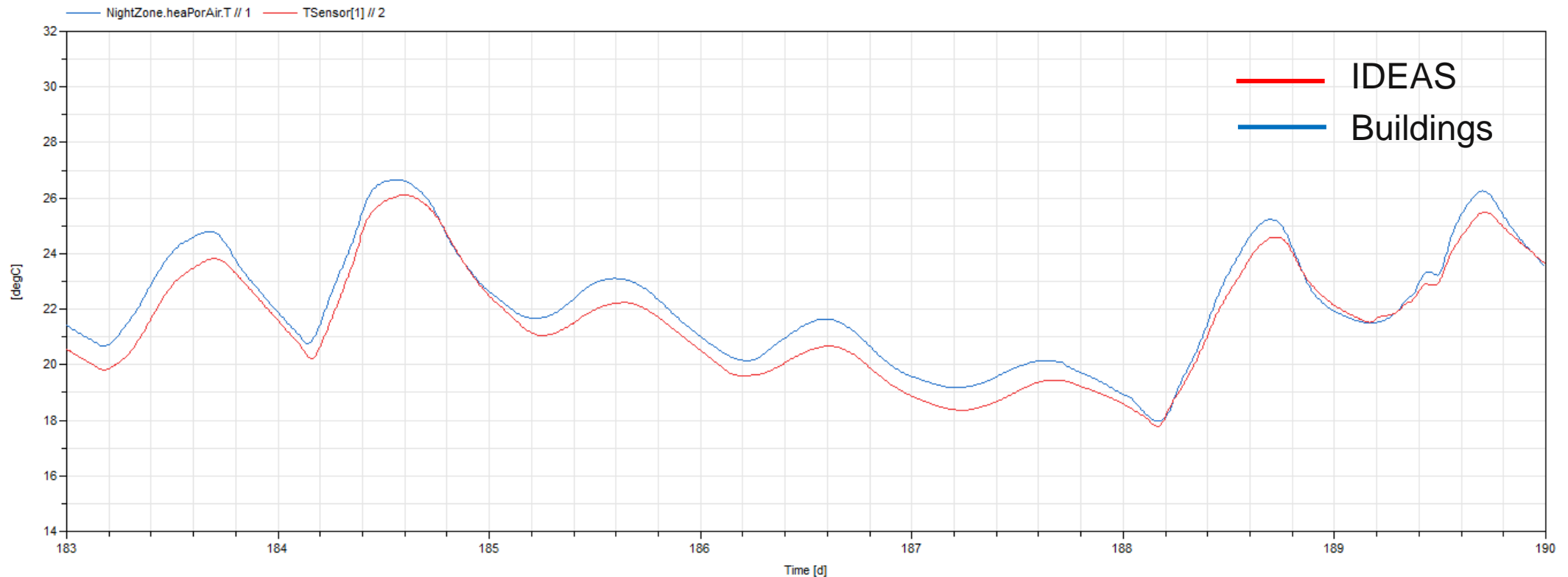
Example from IDEAS library: Yearly energy demand for space heating: 20.17 MWh





# Results

- Comparison between IDEAS and Buildings library showed some discrepancies.
- Analysis of cause is ongoing

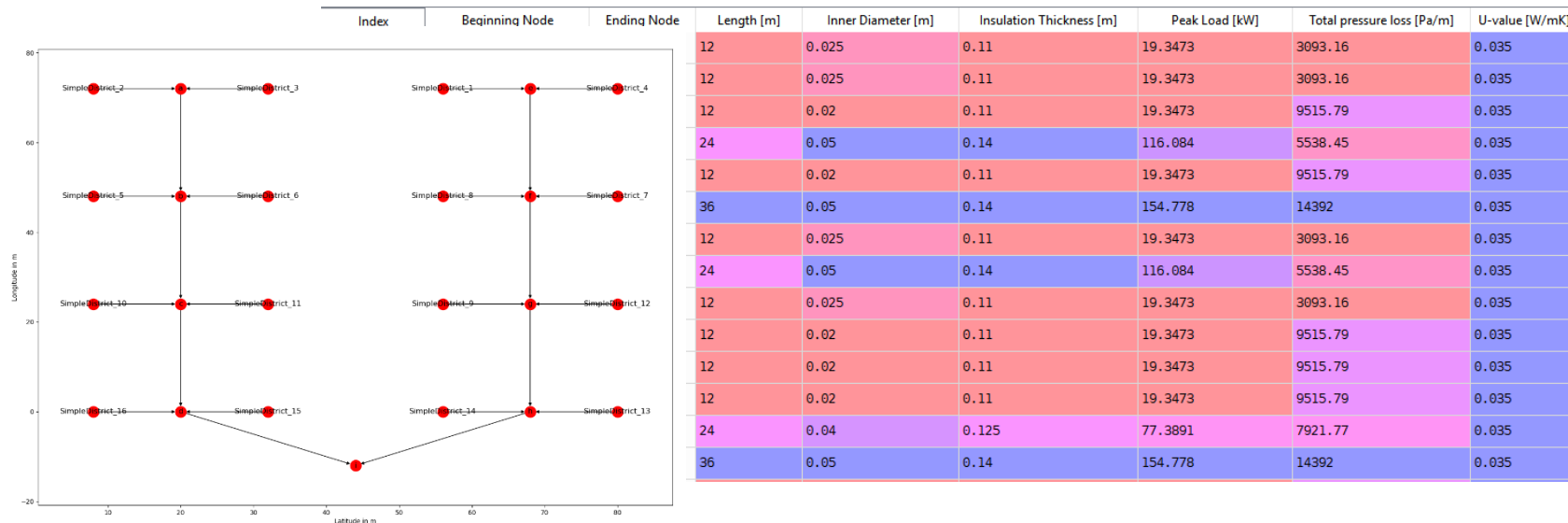
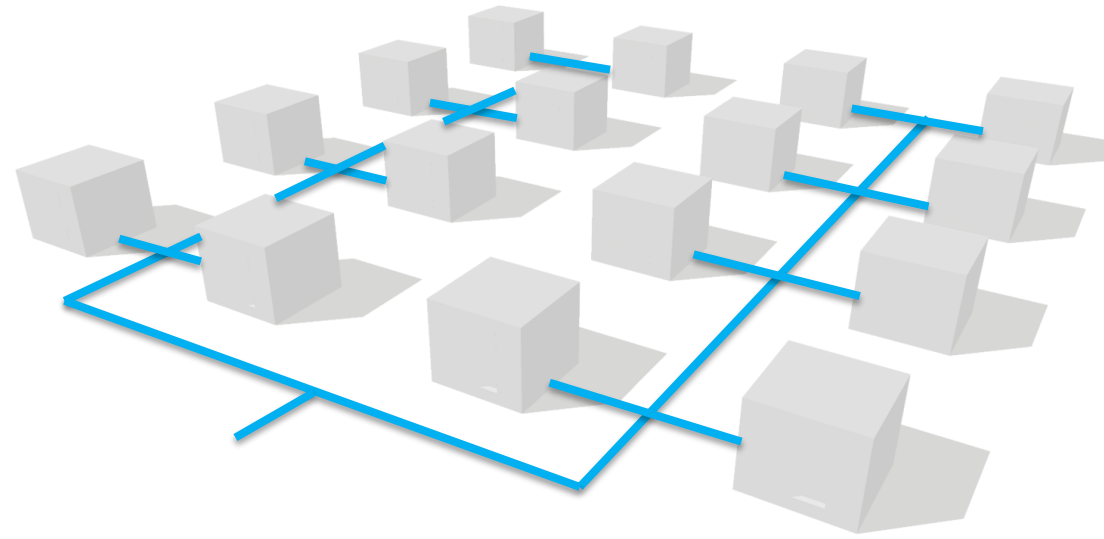


## Next steps

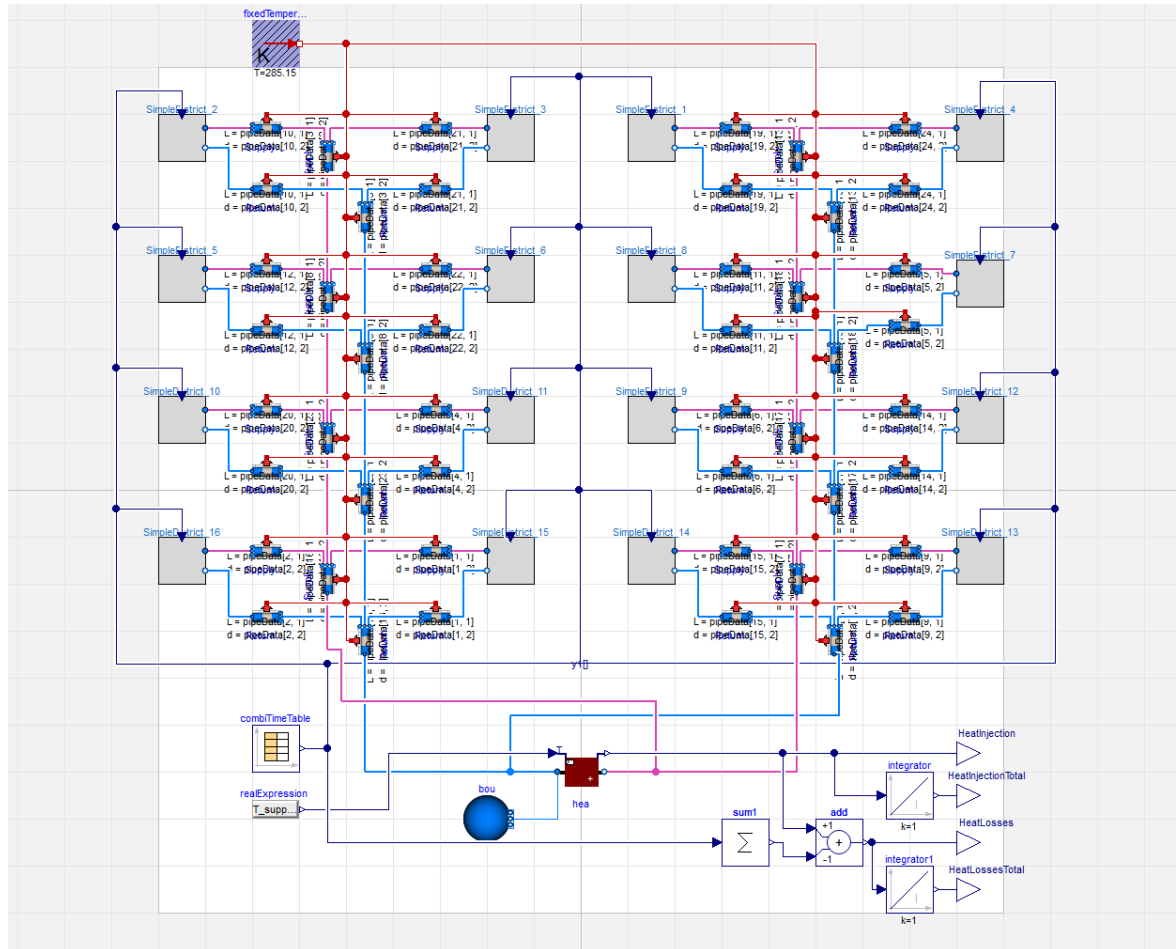
- Replace nodes with other loads
  - Automated model generation with TEASER
    - Other types of single-family dwellings
    - Apartment block
    - Office building
  - Further comparison of different calculation cores
  - Usage of different building standards and countries
  - Effect of Solar Radiation
- Change network layout + increase number of buildings

# NETWORKS: From building load to district heating system

- Building loads stored on github
- Derive network from loads:
  - Fix topology
  - Python: Automatically generate pipe dimensions, write to csv file

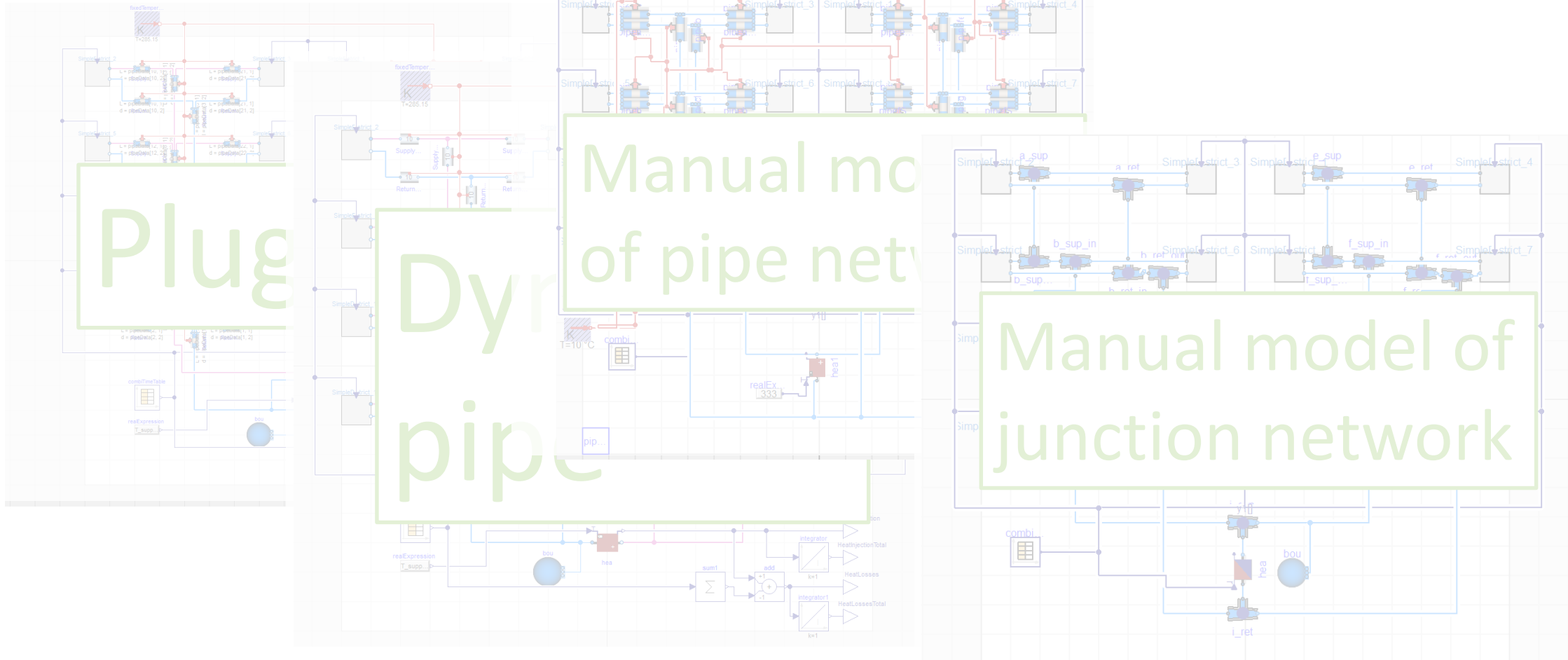


# Modelica model generation



- Modelica: automatic parametrization from csv file
- → automated process from building energy loads to simulation-ready Modelica model

# Comparison of different pipe models



# First simulation results

- Fixed boundary conditions, e.g.  $T_{ground} = 12^{\circ}\text{C}$
- Results heavily depend on solver tolerance

| Model – tolerance     | Heat injected (in J) |
|-----------------------|----------------------|
| Plug flow – 1e-004    | 1.166e+12            |
| Plug flow – 1e-006    | 1.215e+12            |
| Plug flow – 1e-008    | 0.924e+12            |
| Dynamic pipe – 1e-004 | 1.037e+12            |
| Dynamic pipe – 1e-006 | 1.123e+12            |
| Dynamic pipe – 1e-008 | 1.195e+12            |

- → Deviation from mean: up to 17%

# Publications

- 2 papers submitted for BS2019
  - The influence of input data uncertainty on the district energy demand, Ina De Jaeger et al
  - Towards a DESTEST: a District Energy Simulation Test Developed in IBPSA Project 1, Dirk Saelens et al

# Plan for breakout sessions

|               |  |
|---------------|--|
| <b>BS 1-1</b> | <b>Free papers</b>   |
|               | Centralized MPC of district heating and cooling networks modeled in Modelica: TERMUNET project ((Krzysztof Arendt, Konstantin Filonenko, Christian T. Veje)) |
|               | Progress of PhD work Ina   |
|               | Progress of PhD work Bram  |
|               | Discussion   |
| <b>BS 1-2</b> | <b>Discussion on results of building modeling group</b>  |
|               | Presentation of first results (Ina)  |
|               | Discussion   |
| <b>BS 2-1</b> | <b>Discussion on results of thermal network modeling group</b>   |
|               | Presentation of first results (Felix)  |
|               | Discussion   |
| <b>BS 2-2</b> | <b>Definition of further steps and discussion on research plan</b>   |
|               | Definition of next common exercise   |
|               | Definition and finalization of research plan   |
| <b>BS 2-3</b> | <b>Joint session with ST1 or ST2</b>   |
| <b>BS 2-4</b> | <b>Wrap-up, discussion and commitments</b>   |