

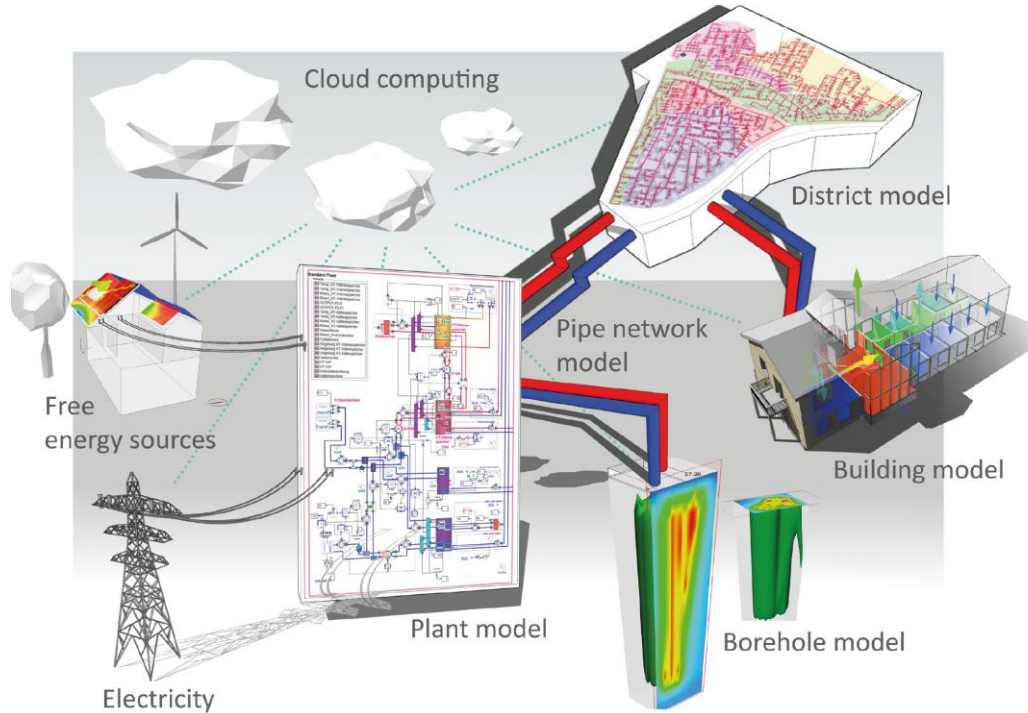
IDA Districts



Why do we want to do this?

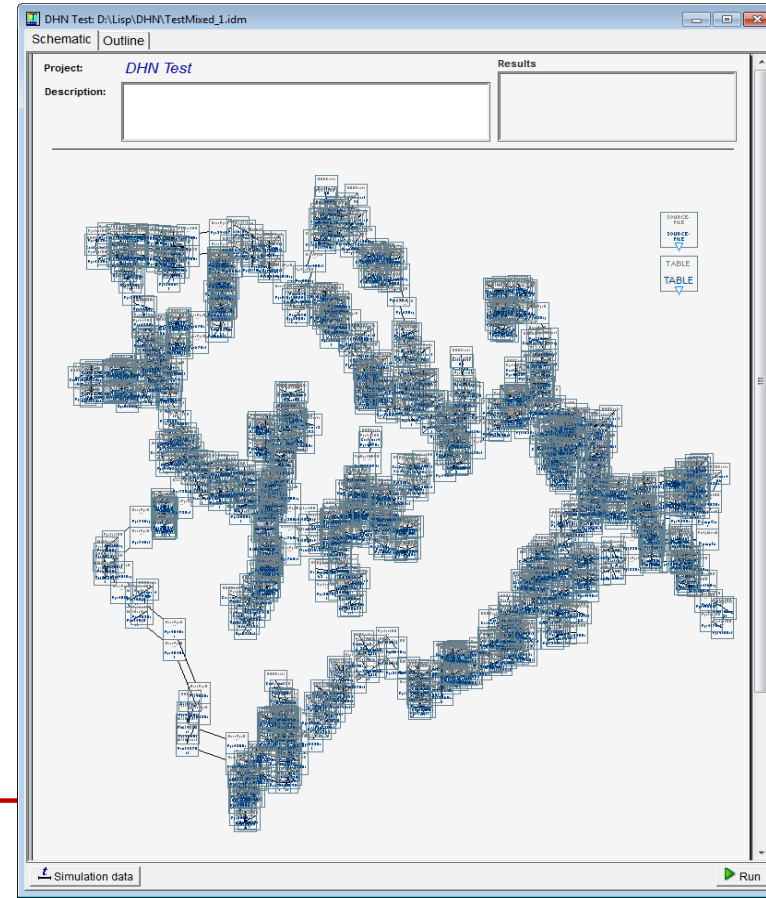
- Our energy systems must be fundamentally re-thought and revised to be *based on* intermittent renewables
- “Prosumer” energy trading and utility demand management strategies
- Current modelling tools are inadequate:
 - Decoupling of production, distribution, and use
 - Quasi-static
 - Linear models for operation optimization
- Which are the most important needed features?
 - Dynamic, fully coupled interaction between non-linear models for energy supply plants, distribution network, storage, and end-users
 - Simulation of large-scale models ($> 10^4$ end-users)

Vision – Large-scale co-simulation



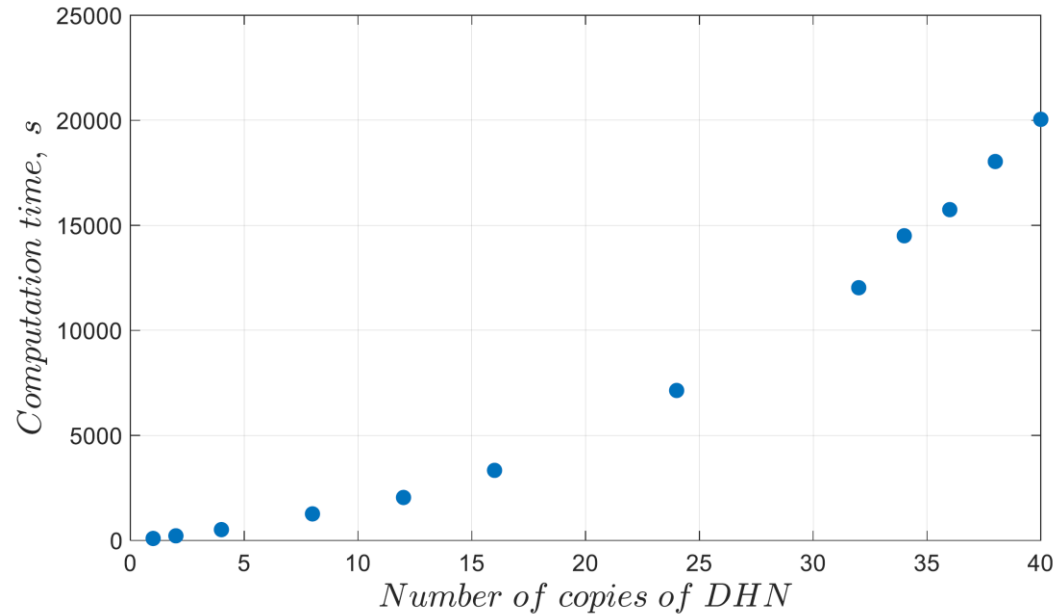
DHN of 205 customers with scalability study

- Study case network:
 - 205 customers
 - 900 pipes
 - 81700 variables
- Simulating this model in IDA ICE for a year took 1245 s
- Simulating an equivalent Modelica model in Dymola **for a day** took 4811 s



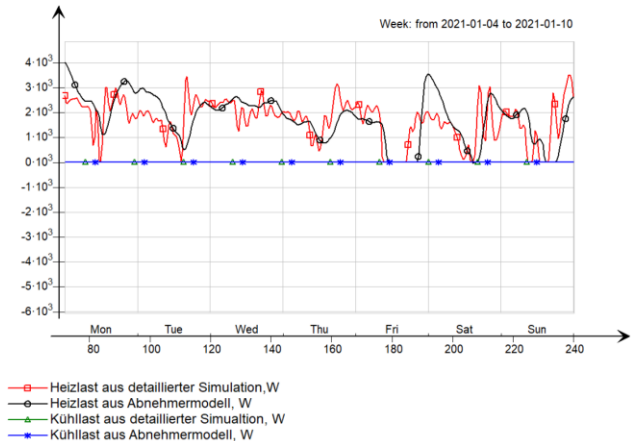
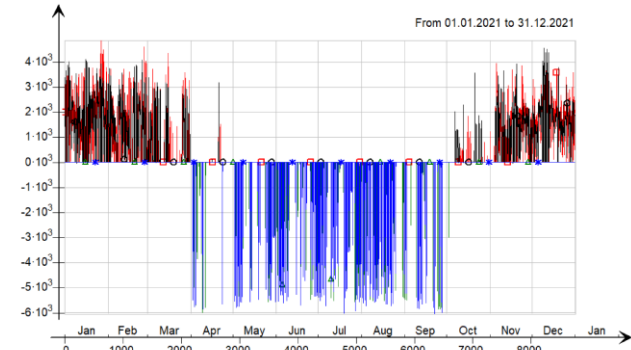
DHN of 205 customers with scalability study

- Additional identical networks were connected in parallel to the same pump and heater, with their powers scaled proportionally
- How many copies of the network can be simulated at once?
- In IDA, the (currently) highest possible number of copies that was successfully simulated was 40 (8200 customers)



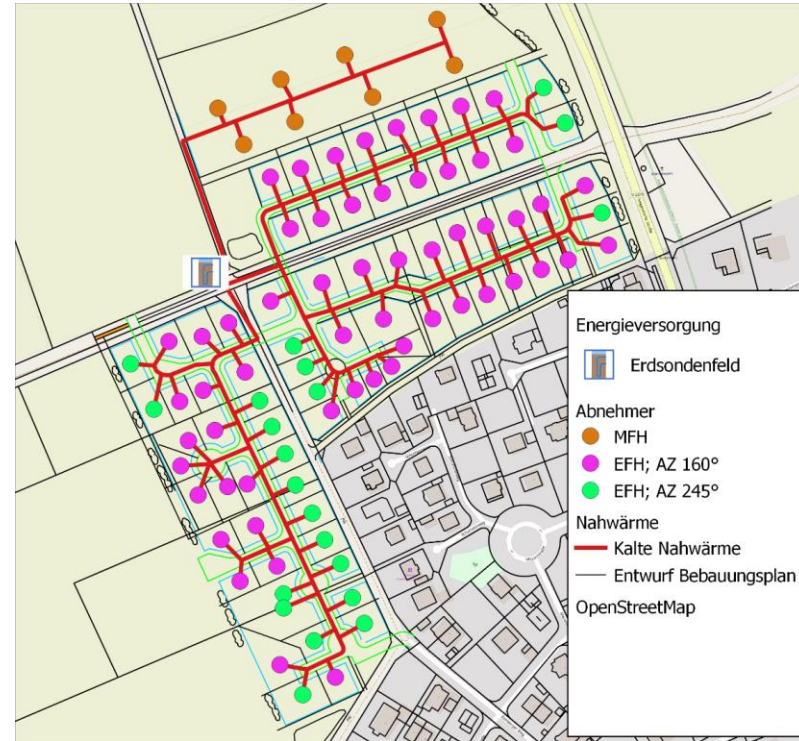
Main features

- Simplified building model:
 - Calibration with load profile (or detailed simulation model)
 - Use of GIS data
 - Stochastic DHW profile
- Interfaces:
 - Import/export from/to shape file
 - CityGML
 - CityJSON
- Data base:
 - Catalog with pipe and plant materials and costs
 - Street topology for pipe laying algorithm

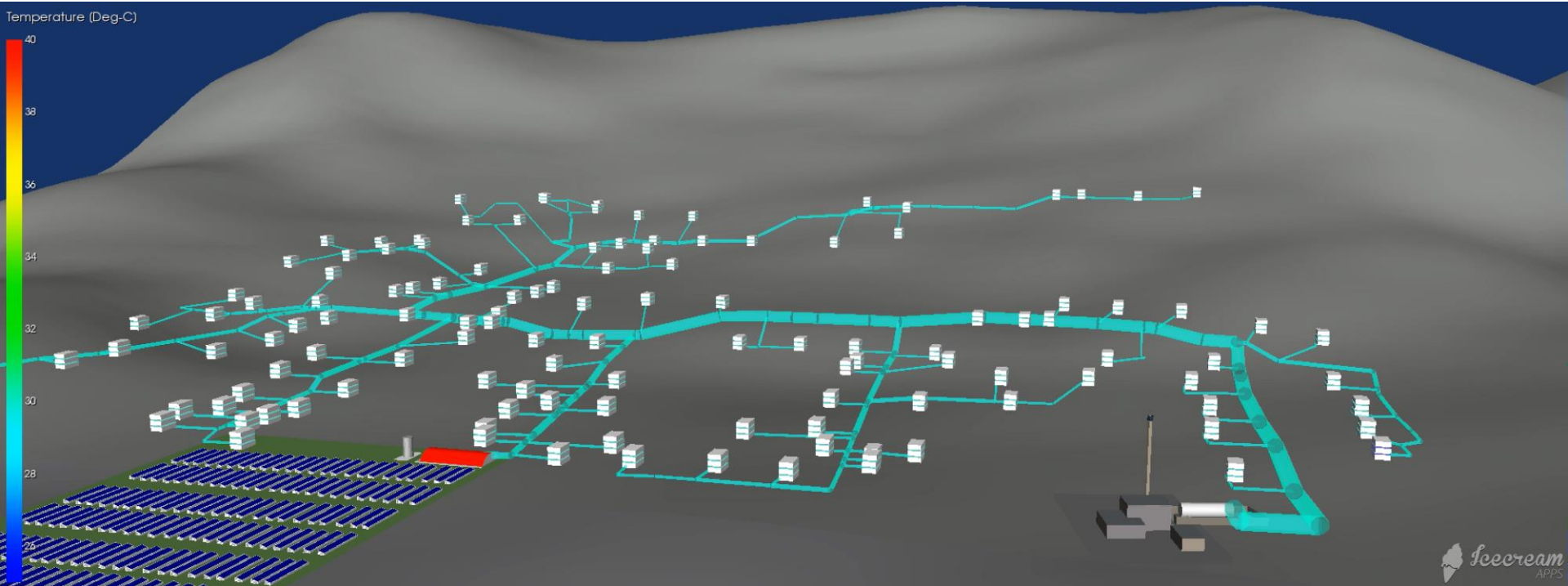


Main features

- Visualization:
 - 2D Modelling and Visualization in QGIS
 - 3D visualization:
 - Georeferenced
 - Terrain model with elevation height
 - Aerial photograph from Open Street Map, etc.
 - Use of “layers” and “groups”
 - Level of detail functionality
 - Result representation:
 - Heatmaps
 - Building specific energy demand
 - Path reports
 - Animations (*Temperature, pressure, velocity, ...*)



Main features



Main features

- Optimization:
 - Design optimization
 - Operation optimization
- Simulation:
 - Whole year
 - Some days (transient events)

Use cases

- Design and optimization:
 - Network topology:
 - Automatic pipe laying algorithm
 - Import existing network topologies
 - Edit existing network topologies
 - Automatic pipe sizing
 - Automatic substation sizing (sizing of valves, pumps, heat exchangers, heat pumps) (substation can also be an interface between two districts)
 - Automatic sizing of pumps and closing valves of the network
 - Plant sizing
 - Storage sizing

Use cases

- Operation:
 - Normal operation:
 - Control strategies evaluation:
 - how much can the supply temperature can be decreased (or increased for cooling)?
 - Investigating demand side management strategies
 - Evaluating model predictive control strategies
 - Evaluation of insufficient heat supply:
 - Pressure driven mass flow calculation with valves in the substations:
 - Recognizing where does the heat insufficiency occur
 - Recognizing measures that can be taken against it
 - Testing different operation strategies

Use cases

- Operation:
 - Evaluation of failure scenarios:
 - Model assisted fault detection in network or substations
 - How long does it take for the buildings to cool down?
 - What happens if a heating plant has a malfunction?
 - Restart procedure
 - Dynamic digital twin:
 - Model is state-adjusted in real time to match measured signals

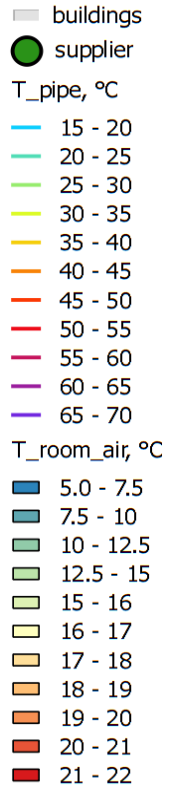
Study cases

Failure scenario



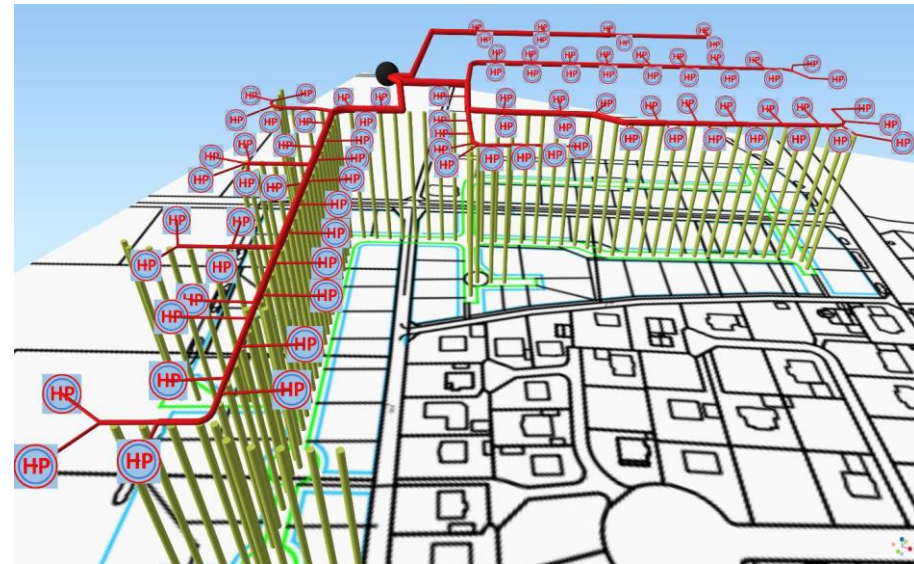
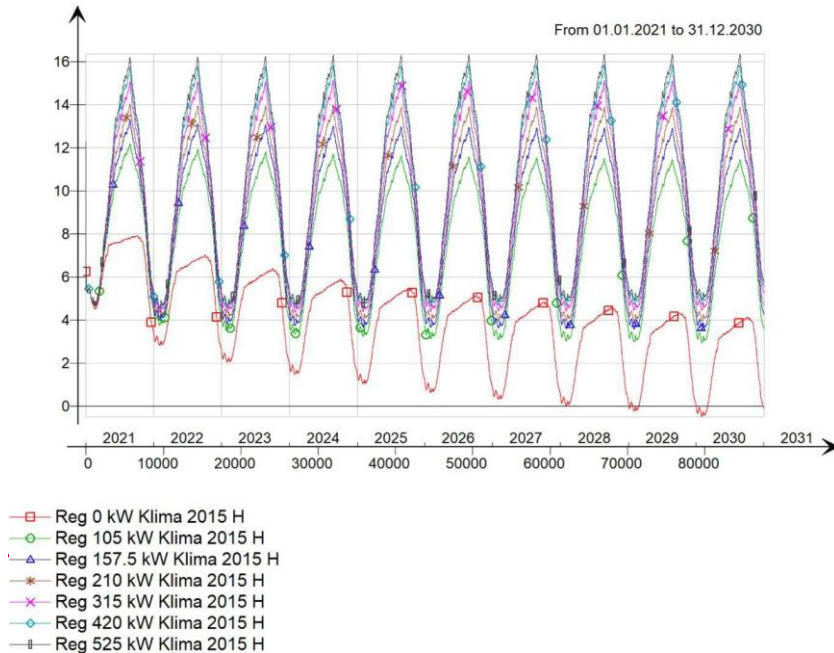
30 kWh/m²a
Building

60 kWh/m²a
Building



Cold district heating network

Design study for an 87-building district with a low temperature district heating and cooling (DHC) network connected to a 108 hole ground heat exchanger. Temperatures, pressures, mass flows, and control were modelled throughout the boreholes, piping network, and buildings. PV power production on buildings was studied.



Fields of application

- Accompany the transformation process of district energy systems
- Analysing and visualization the status quo of demand and supply
- Evaluation of climate scenarios (climate change)
- Evaluation of demand change scenarios (refurbishment and densification)
- Evaluation of supply change scenarios (heating and cooling systems)
- Designing new district heating network (DHN) topologies
- Automated pipe sizing of DHN
- Evaluation of demand side management strategies
- Evaluation of failure scenarios of heat generation plants