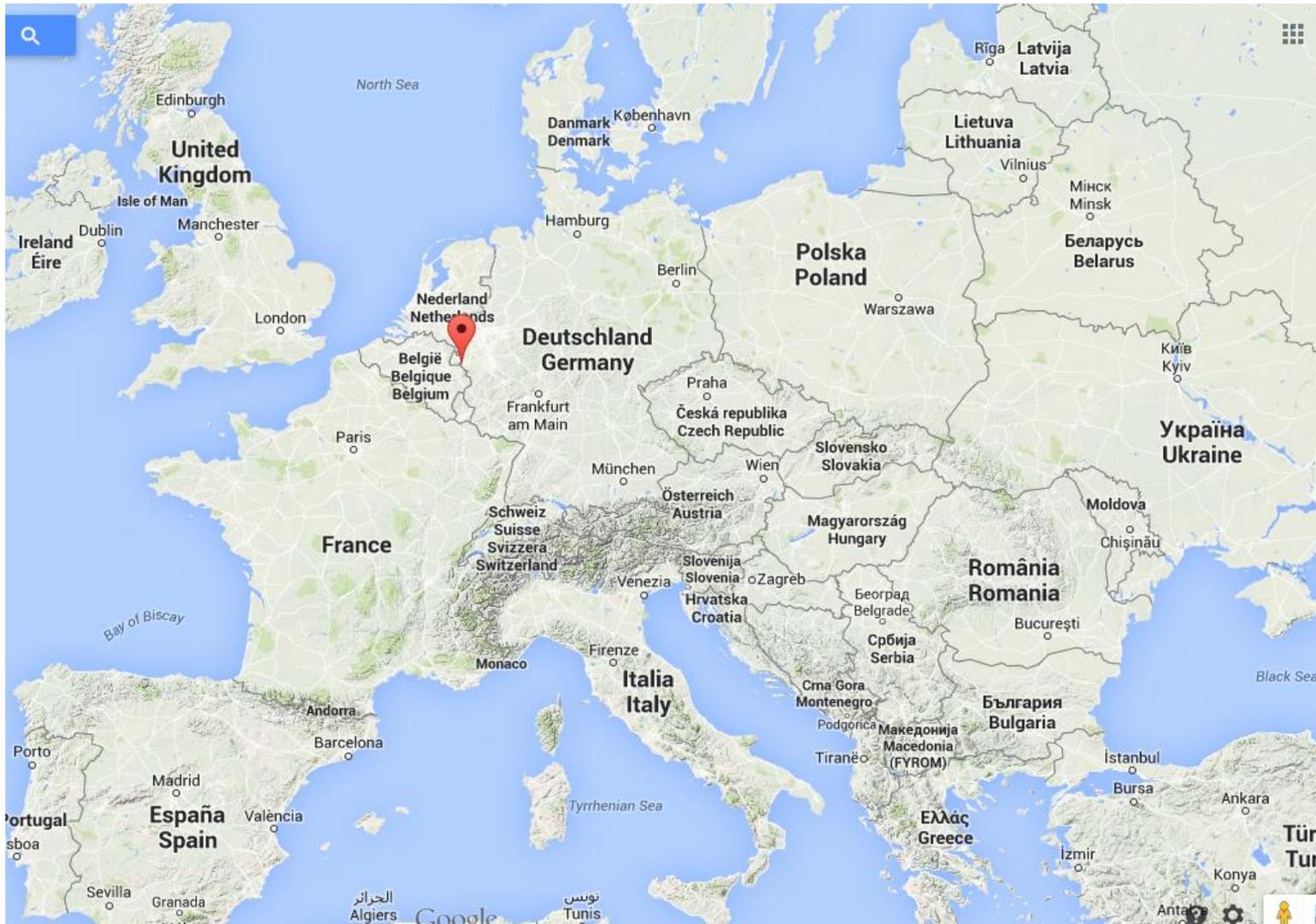




# GIS-Based Automated Model Generation for Urban Energy Systems

Marcus Fuchs, Moritz Lauster, Jens Teichmann, Rita Streblow, Dirk Müller

# Location Aachen and our 2 Reference Districts



# Reference District A

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50 Buildings

Gas boilers and CHP unit

Absorption and compression chillers



# District Heating and Cooling Tunnel in District A



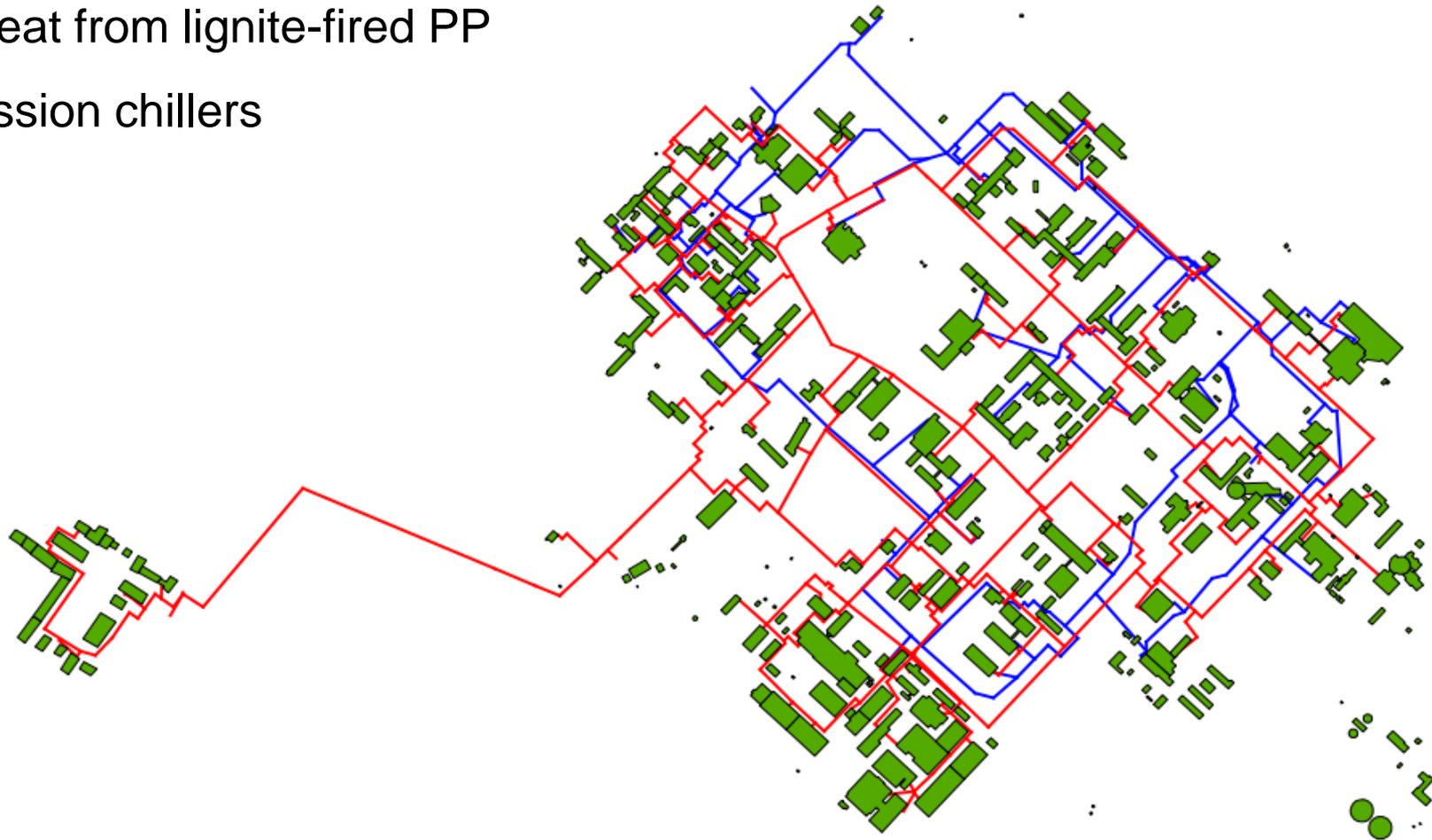
# Reference District B

---

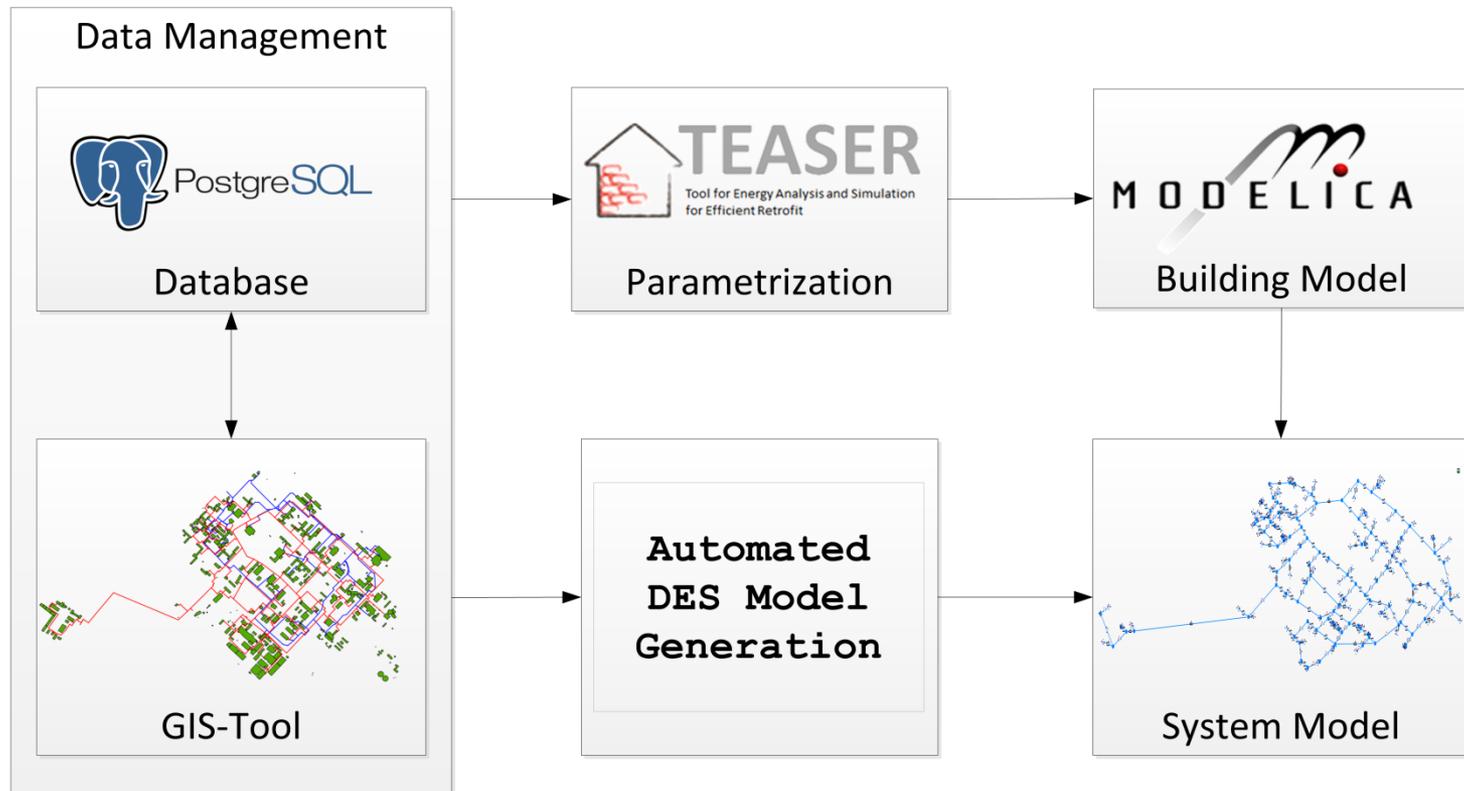
200 Buildings

Waste heat from lignite-fired PP

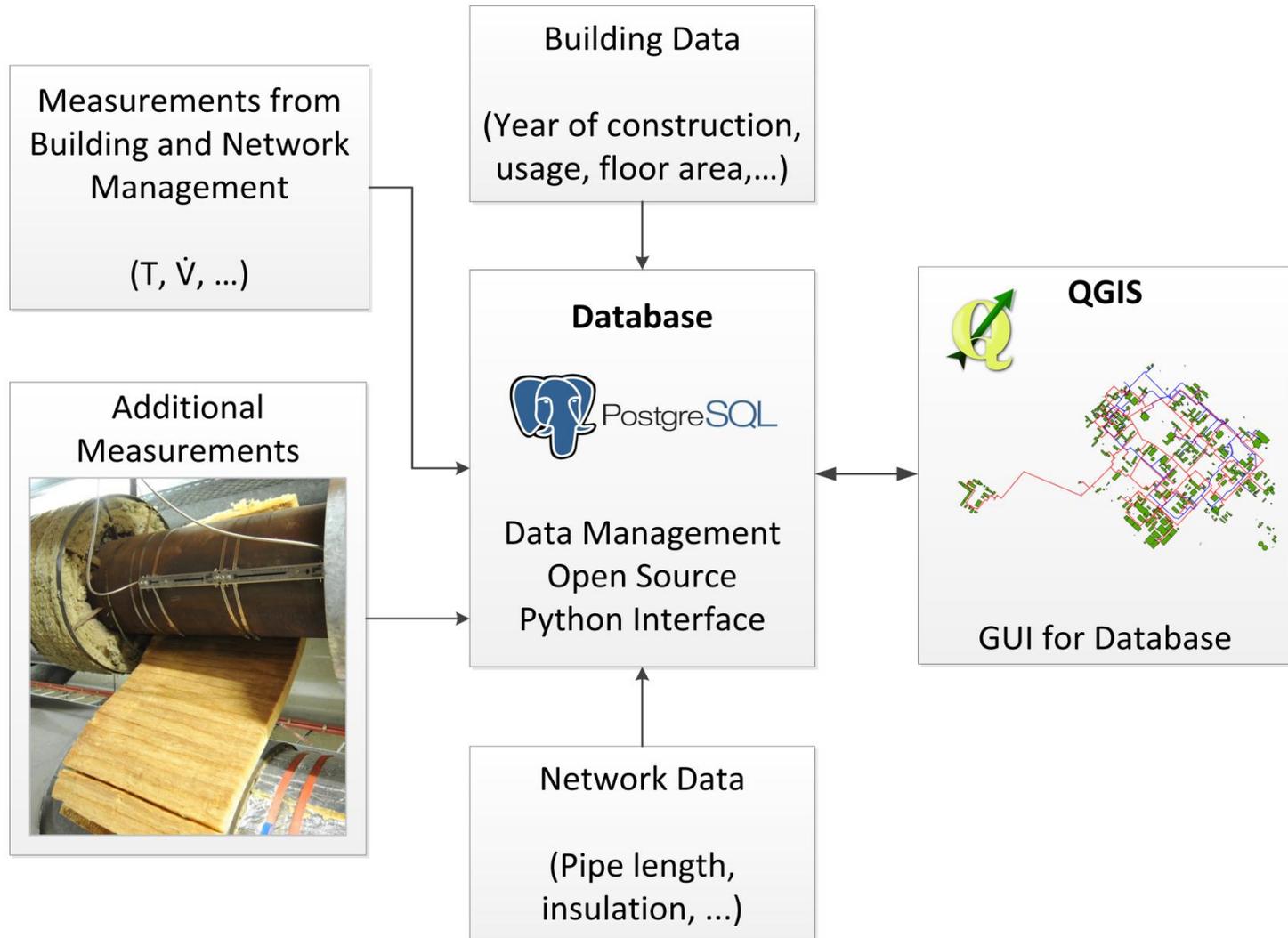
Compression chillers



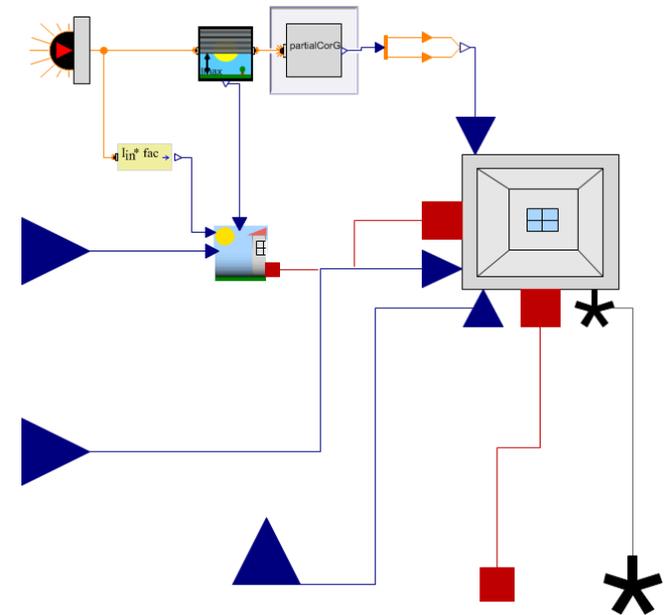
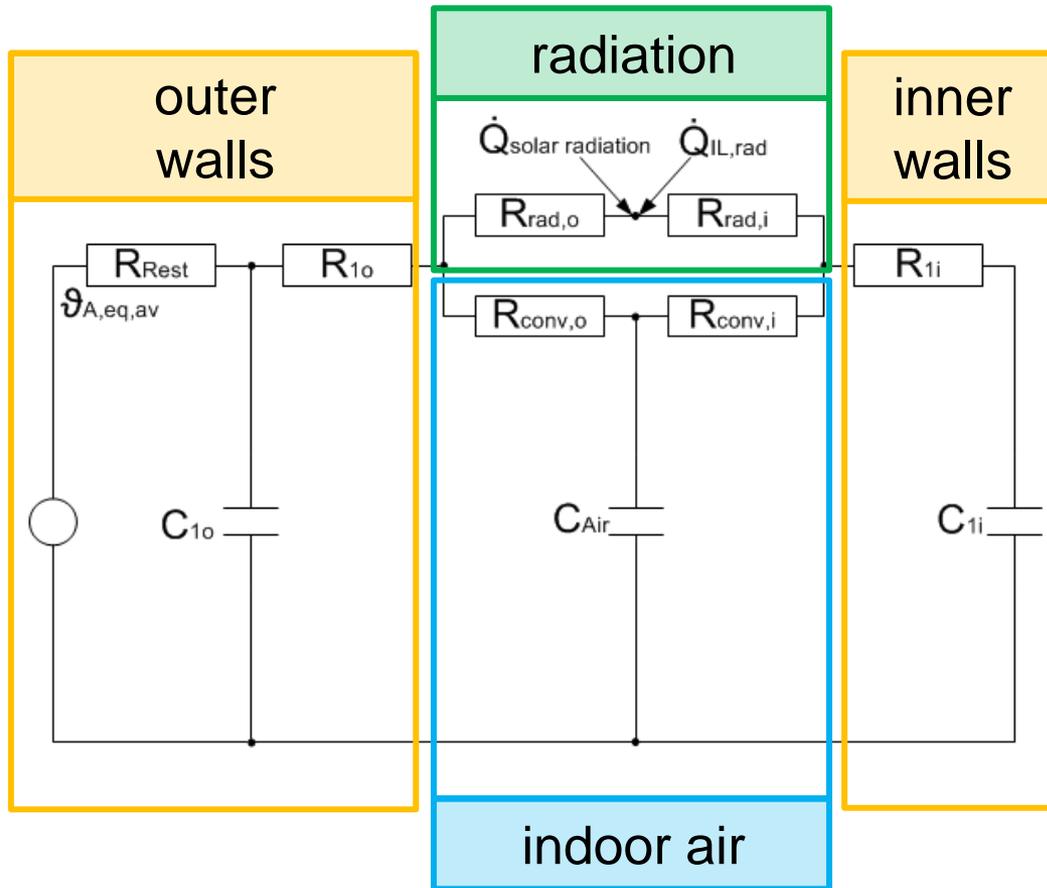
# Process Overview



# Data Handling and Management

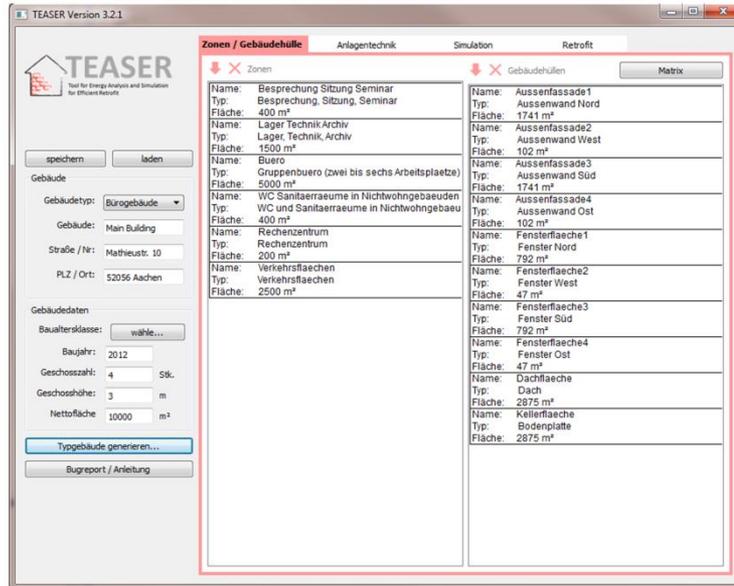


# Building Model According to VDI Guideline 6007



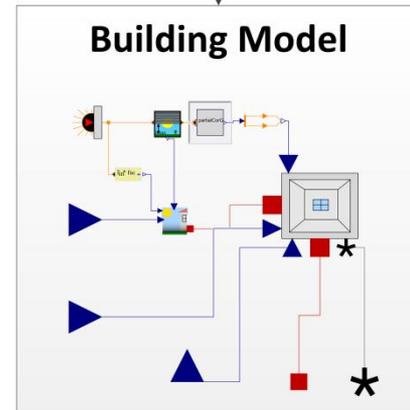
Model and validation available: [www.github.com/RWTH-EBC/AixLib](http://www.github.com/RWTH-EBC/AixLib)

# Tool for Energy Analysis and Simulation for Efficient Retrofit



**Internal Database**

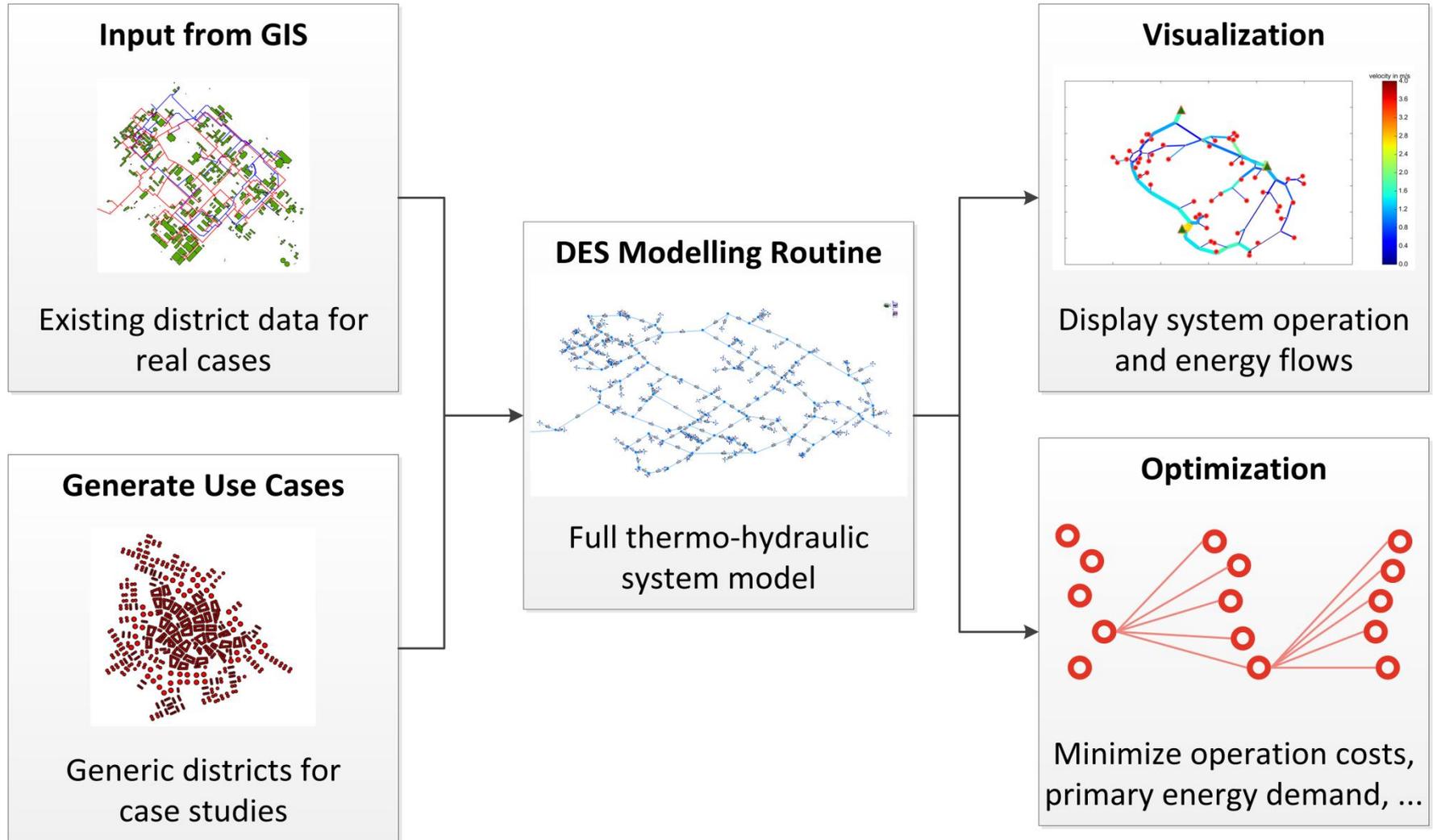
Statistical Data from German Building Stock



- Minimum Data Set:**
- Year of Construction
  - Floor Area
  - Usage Type
  - Building height

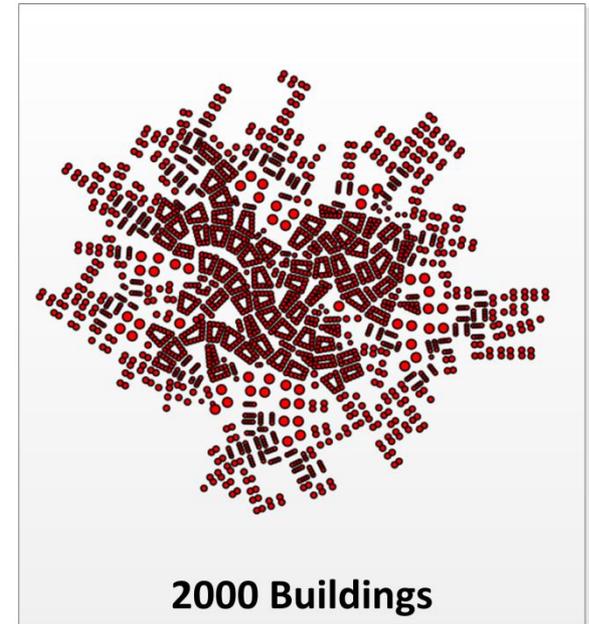
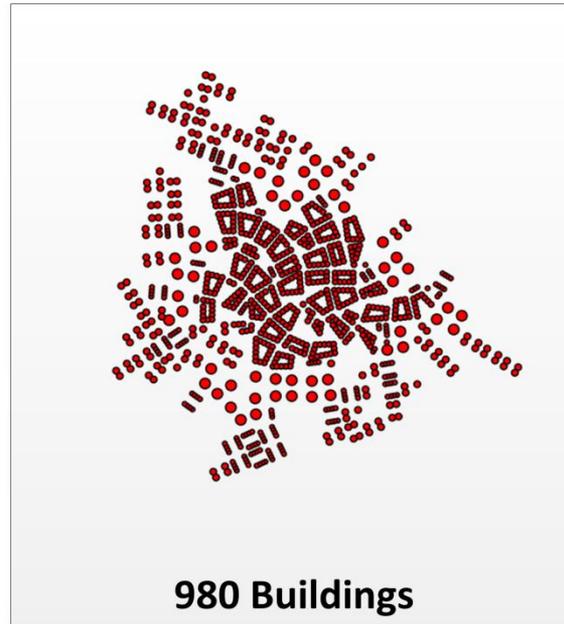
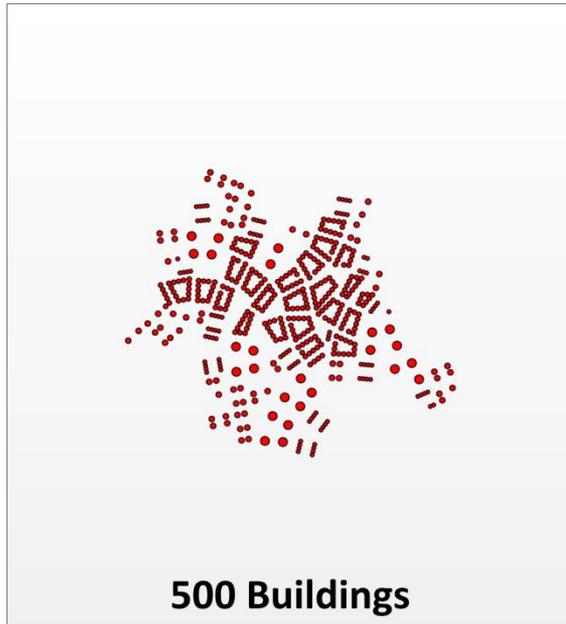
- Optional Data :**
- Wall properties
  - Window properties
  - Zoning
  - ...

# Approach for Automated Model Generation

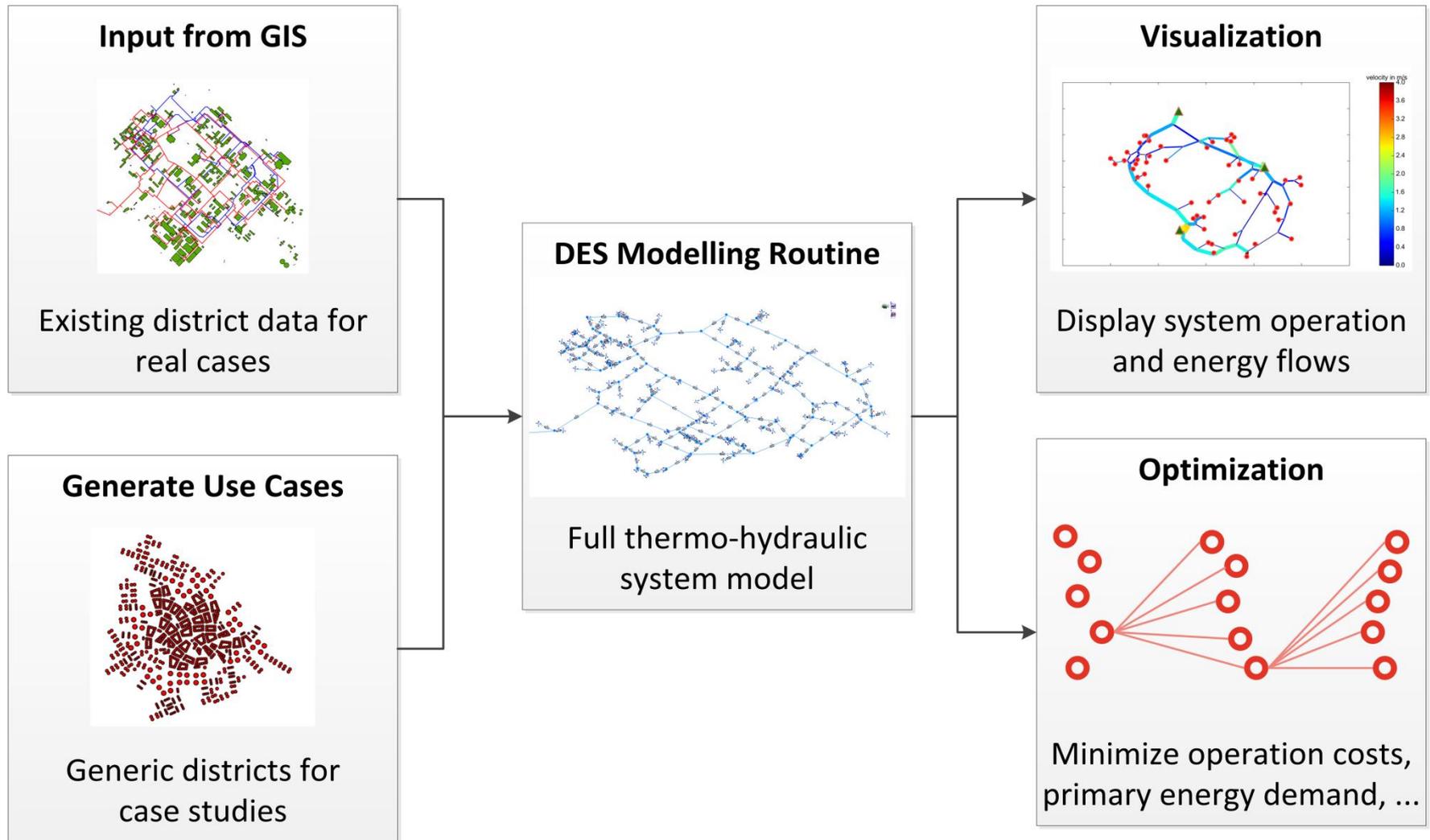


# Generic Districts for Case Studies and Performance Tests

Random placement of buildings according to district archetypes

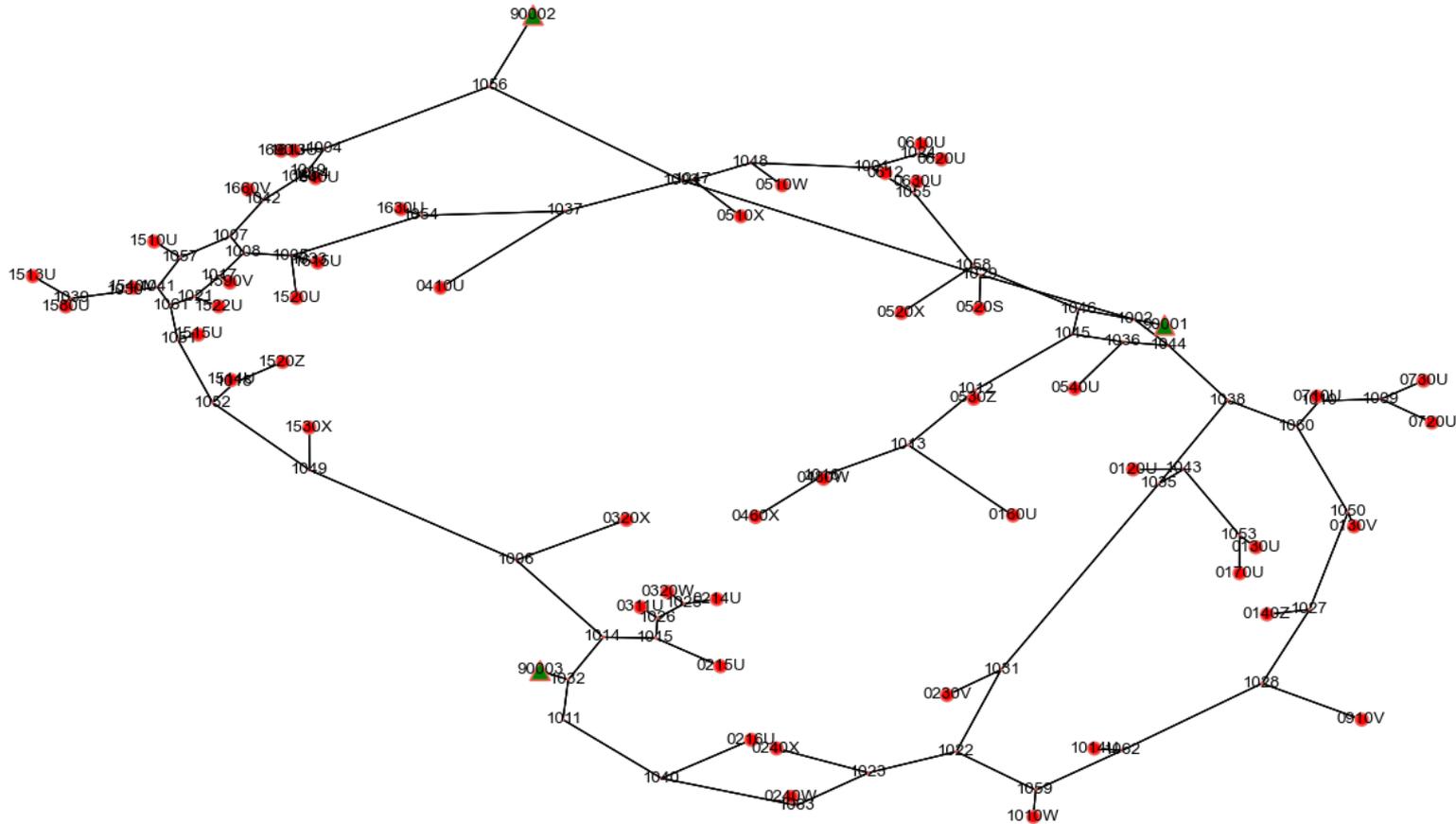


# Approach for Automated Model Generation



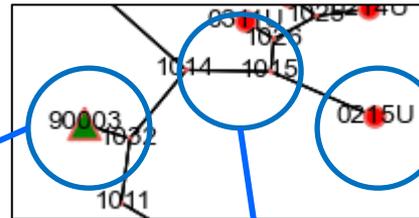
# Automated Model Generation from Python Graphs

Transferring data from GIS and database to graph structure using *networkX*



# Nodes and Edges as Data Containers

Attaching data and objects as attributes to nodes and edges of the graph



```
Graph.node[90003]:
```

```
x = ...  
y = ...  
Q_flow_max = ...  
type =
```

**Supply**

...

get\_temp()

calc\_costs()

write\_mo()

```
Graph.edge[1014][1015]:
```

```
diameter = ...
```

```
type =
```

**Pipe**

...

get\_temp()

get\_losses()

write\_mo()

```
Graph.node[0215U]:
```

```
x = ...
```

```
y = ...
```

```
T_supply = [...]
```

```
type =
```

**Building**

...

get\_temp()

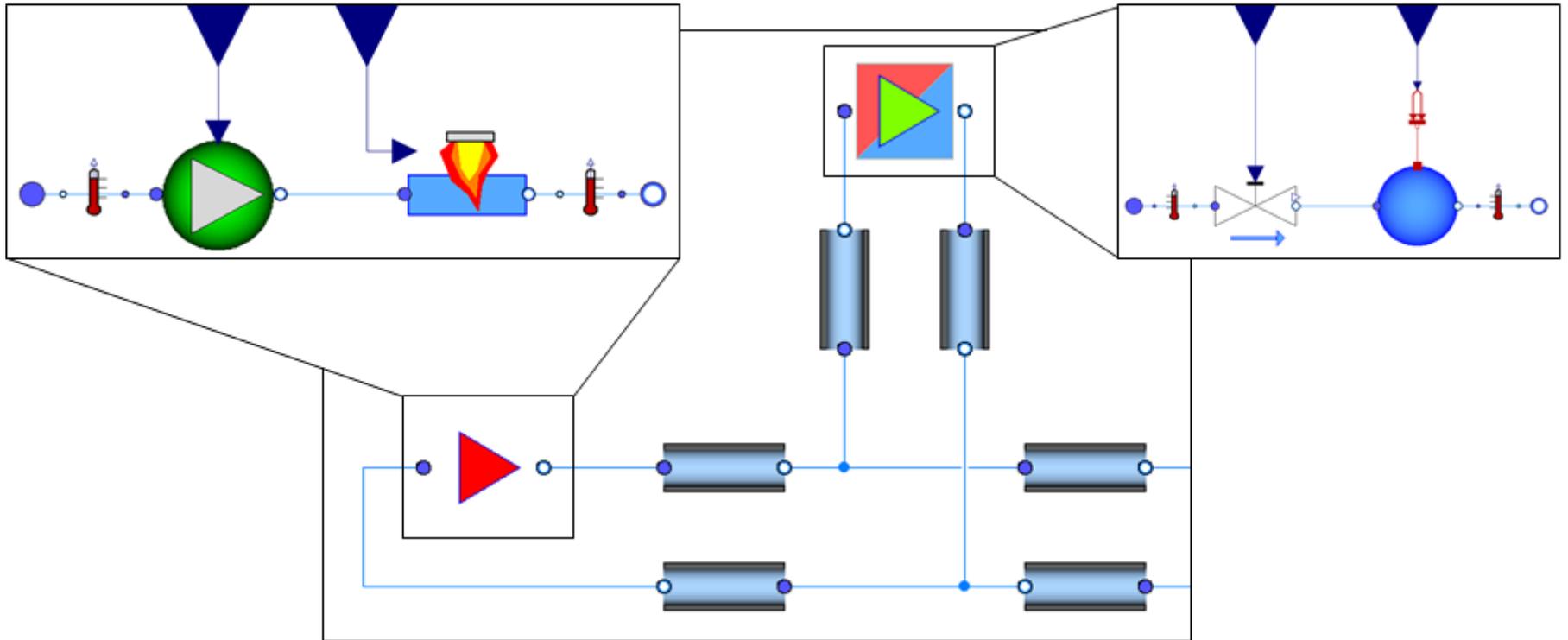
calc\_costs()

write\_mo()

# Simplified Graphical Model Representation

## Advantages of modeling in Modelica

- Acausality: Enables modeling of reverse flows
- Object-orientation: Use of model libraries and modifiers on model instances

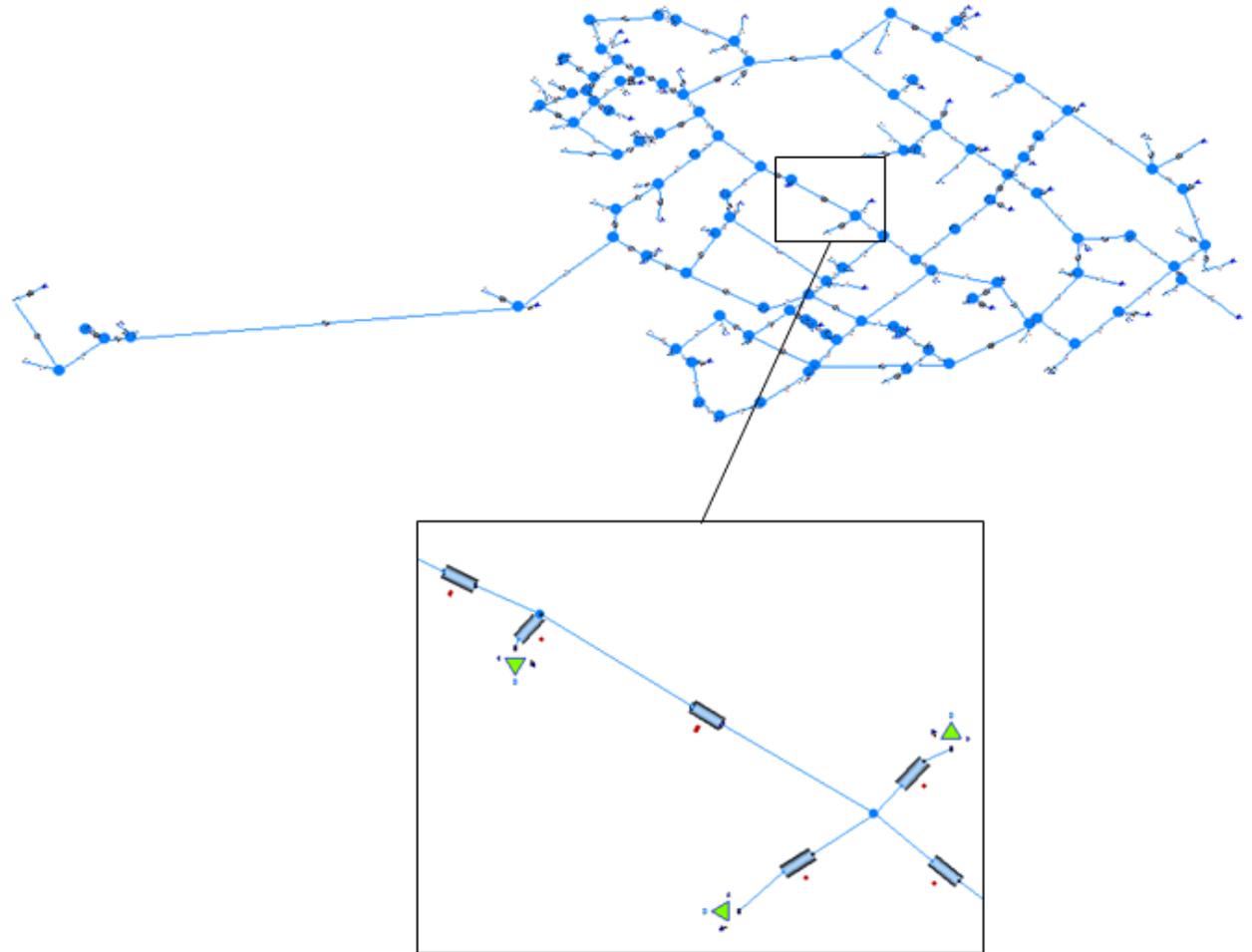


# System Model for Heating Network of District B

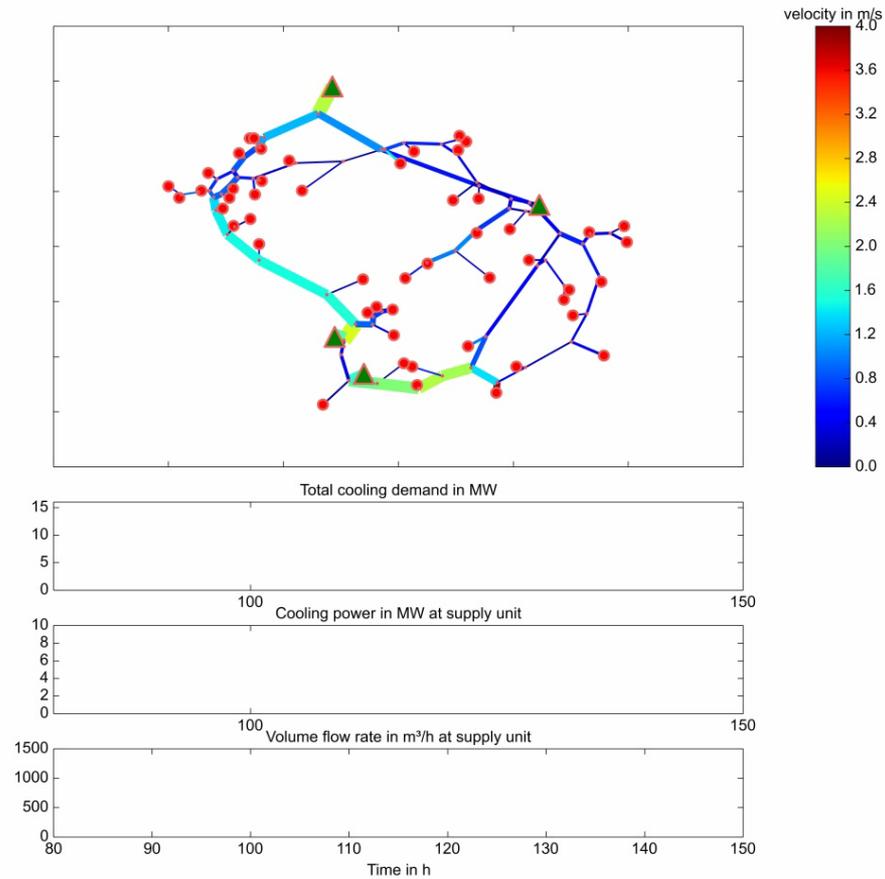
1 Heat supply

118 Substations

238 Pipe elements



# Visualization: Flow Velocities in Cooling Network



# Some Use Cases for the Developed Software-Tools

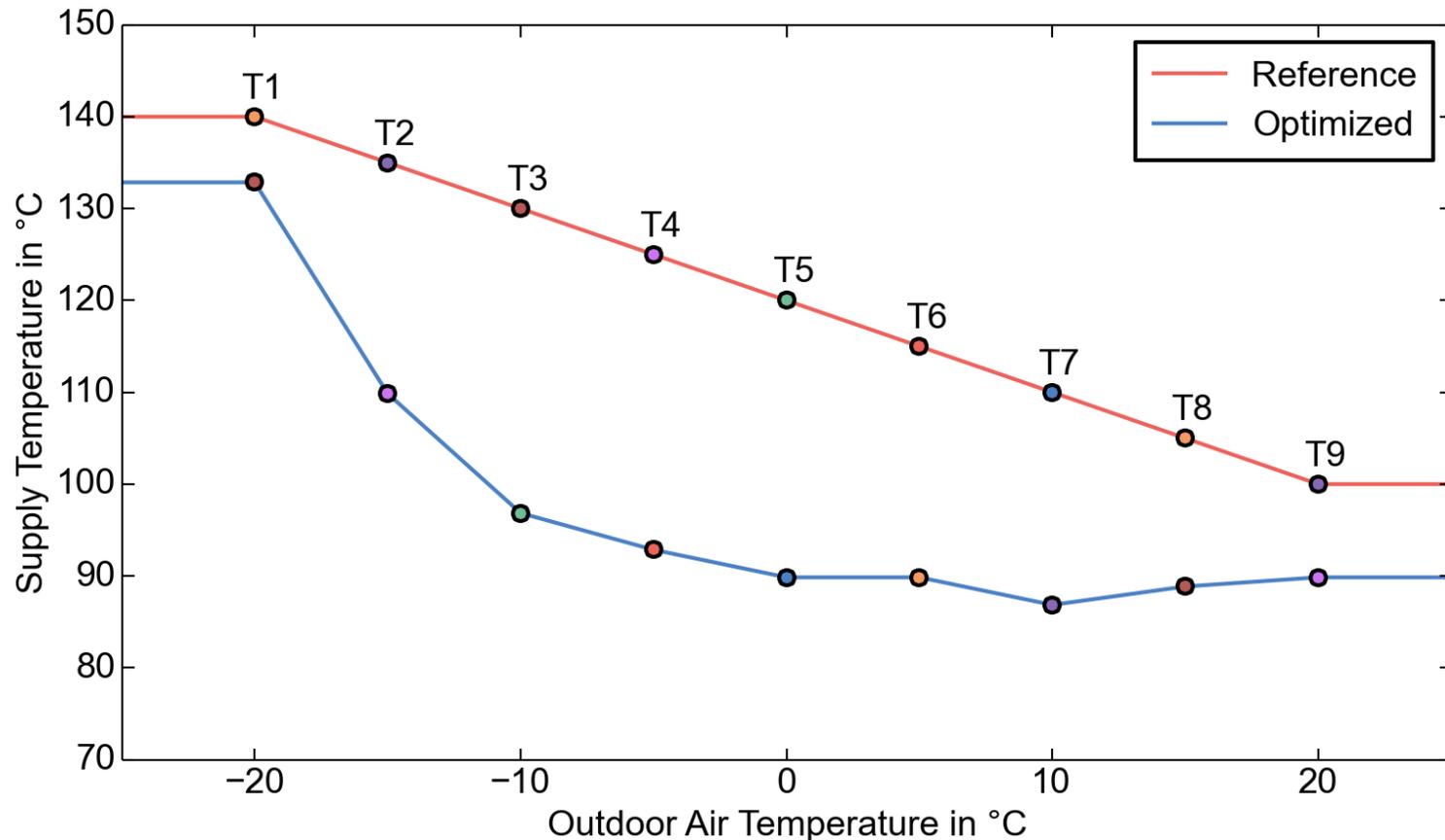
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- Simulate existing energy systems to better understand dynamic energy flows and operation patterns
- Optimize control parameters and test new control concepts on digital prototypes
- Plan operation of new systems and extensions of existing districts
- Evaluate effects of storage capacities on system operation
- Evaluate district energy systems versus building level generation equipment
- Estimate effects of large-scale building retrofits on district's energy consumption
- Investigation of effects from integration of decentralized generation equipment into existing district energy systems
- ...

# First Steps into Optimization

Demonstration of heating curve optimization with Hill Climb Algorithm

Result after 11 generations with a population of 12 individuals:



# Conclusion and Outlook

---

Tools to go from GIS to integrated system model as fast as possible

Open Source Releases (fork us on [www.github.com/RWTH-EBC](https://www.github.com/RWTH-EBC)):

- Building Model and validation already in AixLib
- City District Generator
- TEASER
- Automated Model Generation

Future Work:

- Validate integrated system model
- Use model for optimization
- Extend scope to electrical networks and scale to urban

# GIS-Based Automated Model Generation for Urban Energy Systems

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