# Assessment and Optimization of Thermal Energy Storing Potentials in District Heating: Case Study of Nyhavna, Trondheim

Den første
GEOTERMOS-
FESTIVALEN


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# TRAINING

## Thermal energy storing and digitalization in district heating to enable transition to renewable and resource efficient energy systems

### Trondheim, Norway


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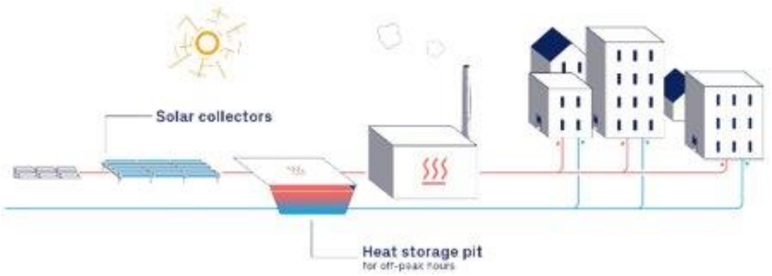
Asplan Viak

Norsk energi

### Härnösand, Sweden




Högskolan Dalarna

Utilifeed

Absolicon Solar Collector AB

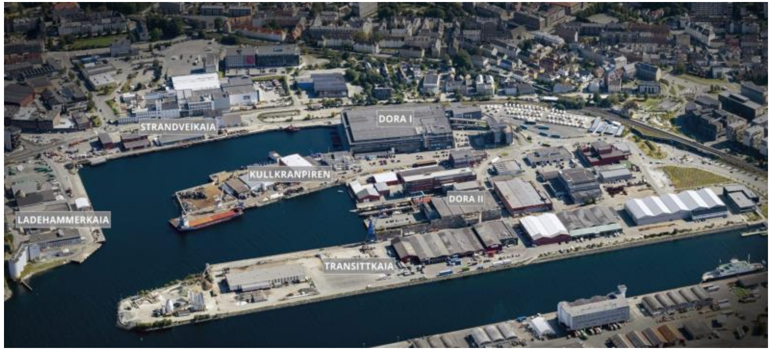
### Kassel, Germany

smart!place SmartrPlace

Fraunhofer Institute for Energy Economics

# Case Description

- Transition from industrial zone to a vibrant city-center district
- Comprises 10 distinct sub-areas
- Total built-up area exceeds 450,000 m²
- 60 % residential and 40 % commercial
- Accommodates 5,200 residents and 4,000 jobs
- Fully self-sufficient in heating and electricity, without adding demand to existing networks





- Photos from nyhavna.no



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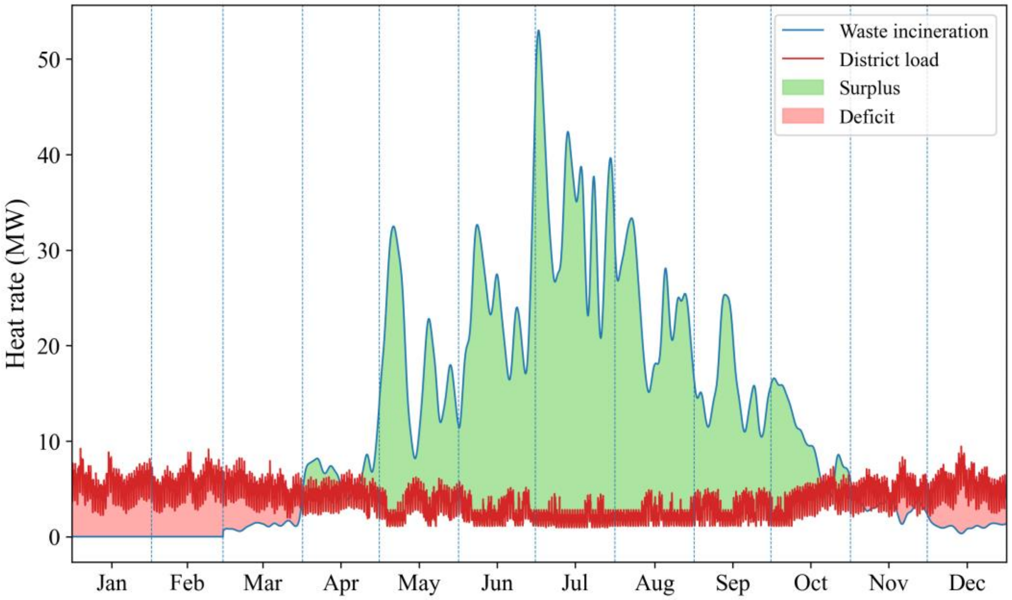
# Heat Demand and Supply

- Estimated 34 GWh annual heating energy demand for space heating and domestic hot water
- 120 GWh annual surplus waste heat from the waste incineration plant
- Potential for seasonal thermal energy storage




- District load provided by Sintef AS using PROFet model

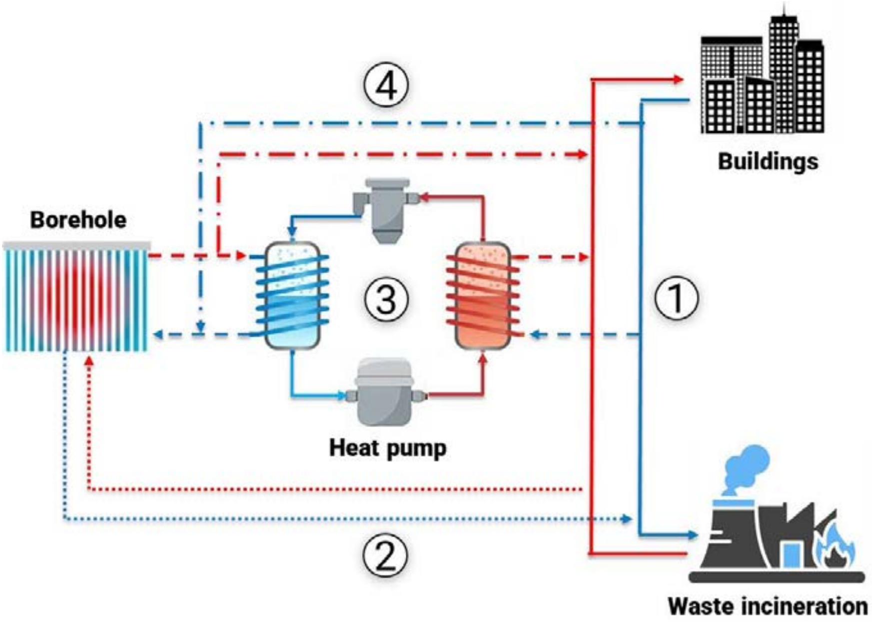
# Local District Heating Network

① Heat demand direct supply by surplus heat

② Borehole charging by surplus heat

③ Borehole discharging by ground-source heat pump

④ Heat demand direct supply by high-temperature borehole discharge



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# Simulation Model

## Model Definition

Boundary temperatures

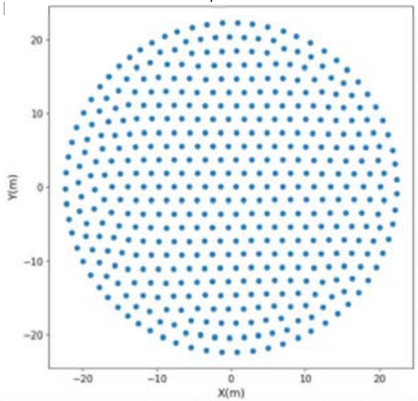
Material properties

Fluid&Flow

Operation plan

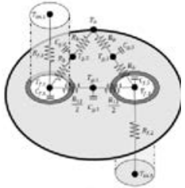
Demand& Supply

System components




## Model Calibration

**pygfunction**



g-function

TRT data

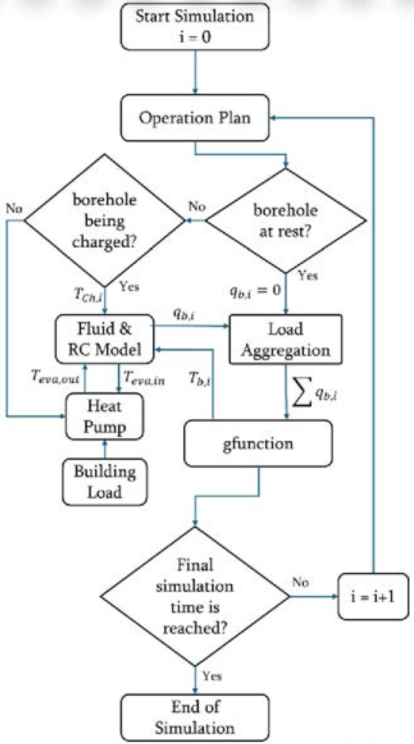
Parameter estimation

$k_g$

$R_b$

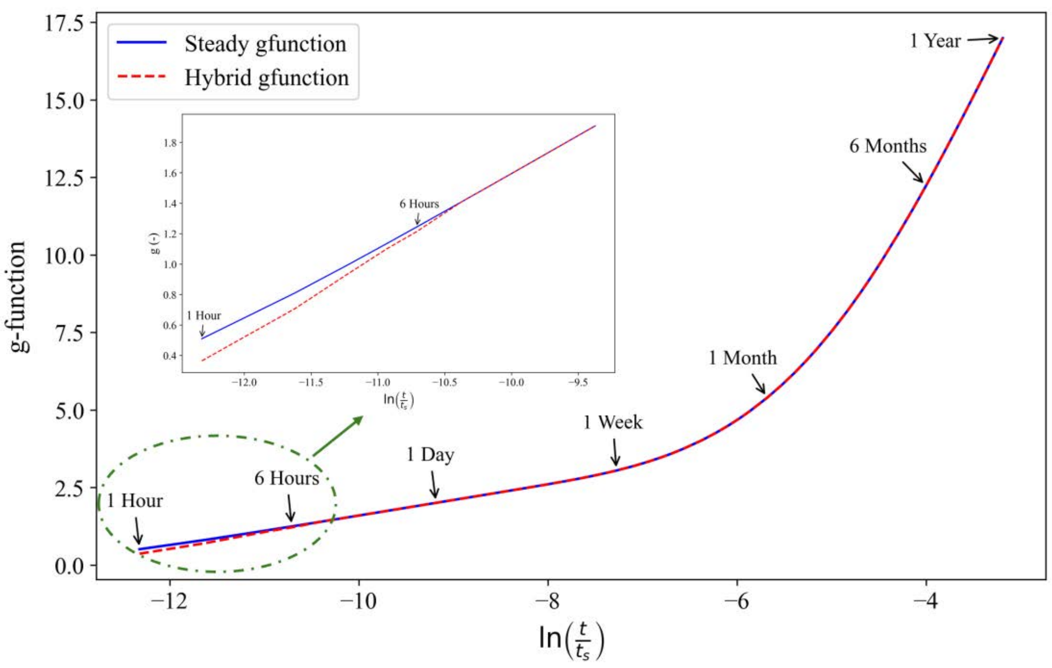
$k_s$

## Simulation



# g-function Generation

- Steady gfunction computed with pygfunction library
- Transient gfunction generated using a TRC network
- Hybrid gfunction assembled by merging transient and steady solutions at breaking time
- Resolves long-term seasonal trends and short-term load dynamics



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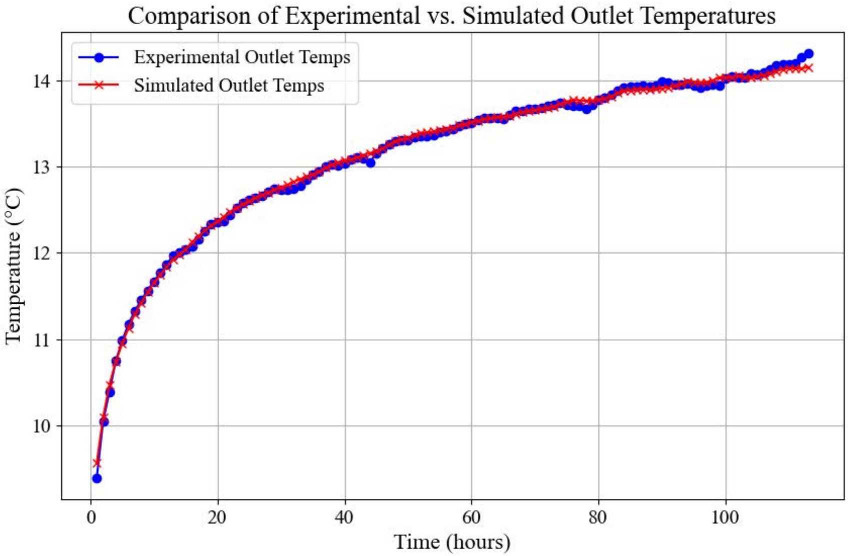
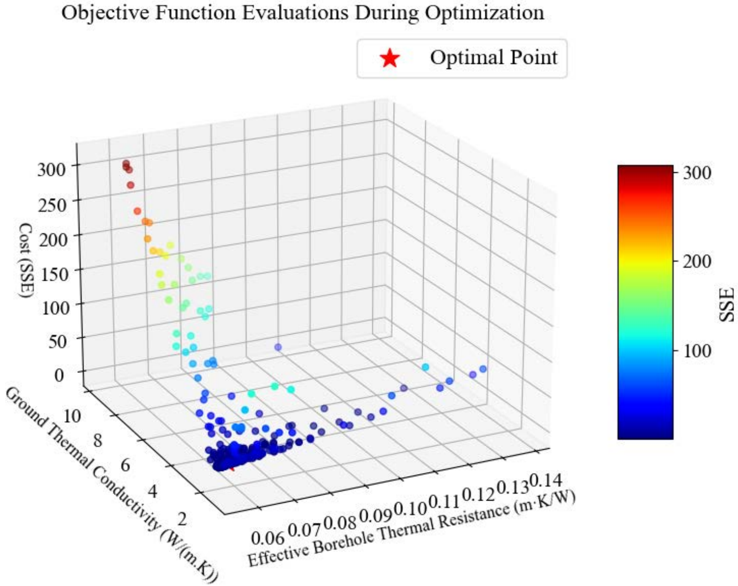
# Model Calibration

- Minimizing sum of squared errors to fit simulation and experimental outlet temperatures




- Borehole thermal resistance based on equivalent grout conductivity: $R_b = 0.073\ K/W$





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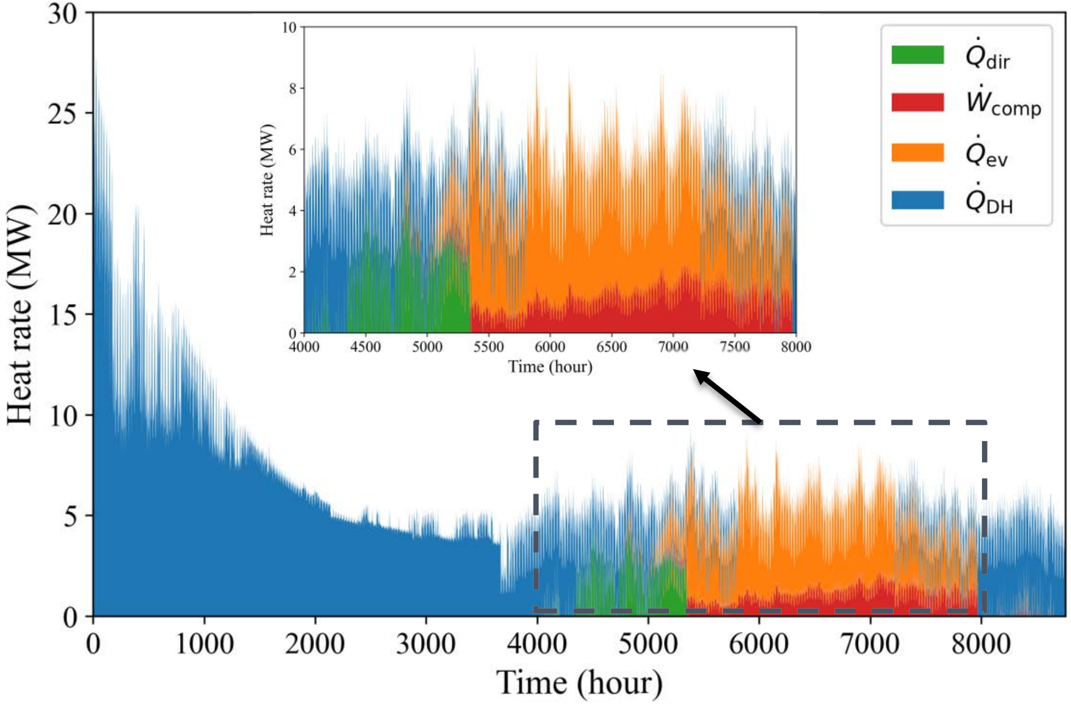
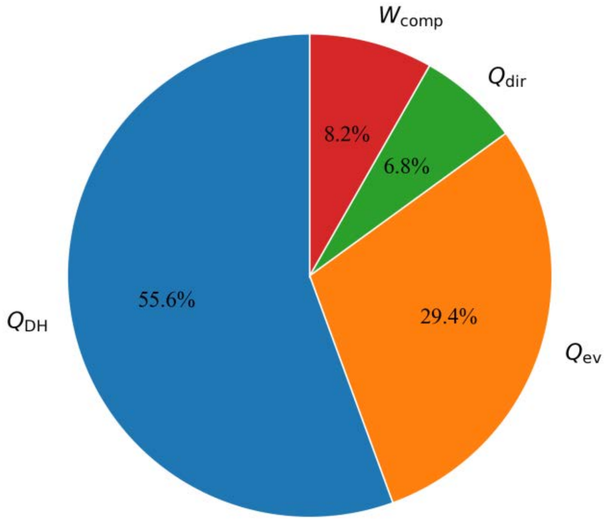
# Results



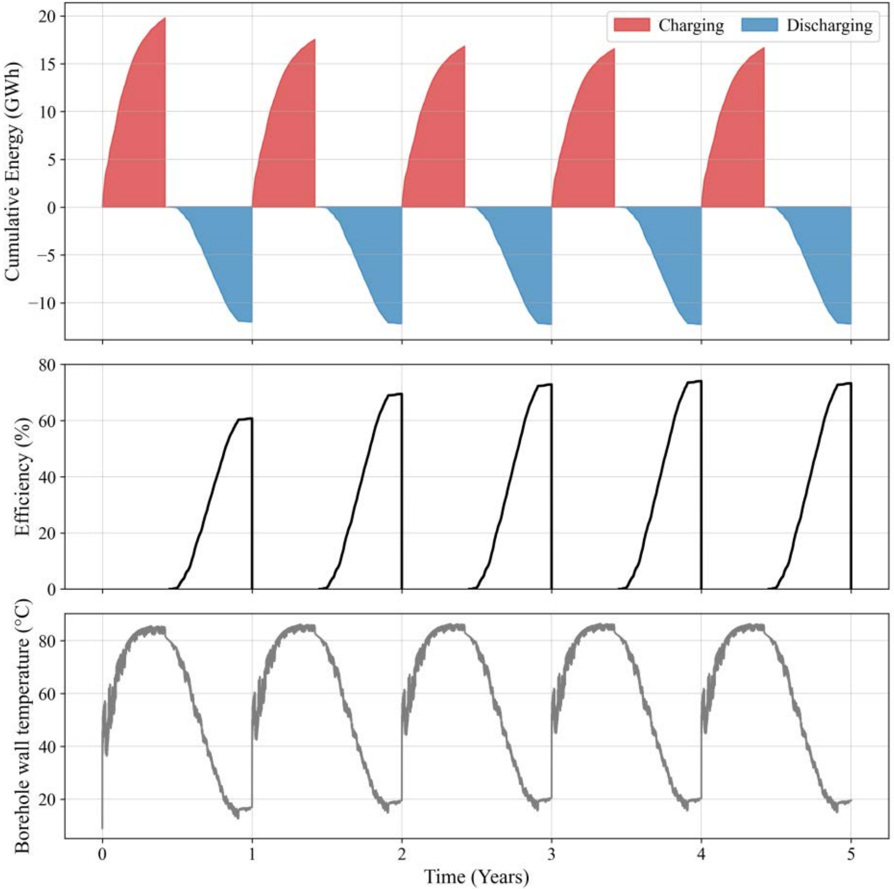
Heat rate (MW)
Time (hour)
$\dot{Q}_{dir}$
$\dot{W}_{comp}$
$\dot{Q}_{ev}$
$\dot{Q}_{DH}$
Heat rate (MW)
Time (hour)

$W_{comp}$
$Q_{dir}$
$Q_{ev}$
$Q_{DH}$
8.2%
6.8%
29.4%
55.6%

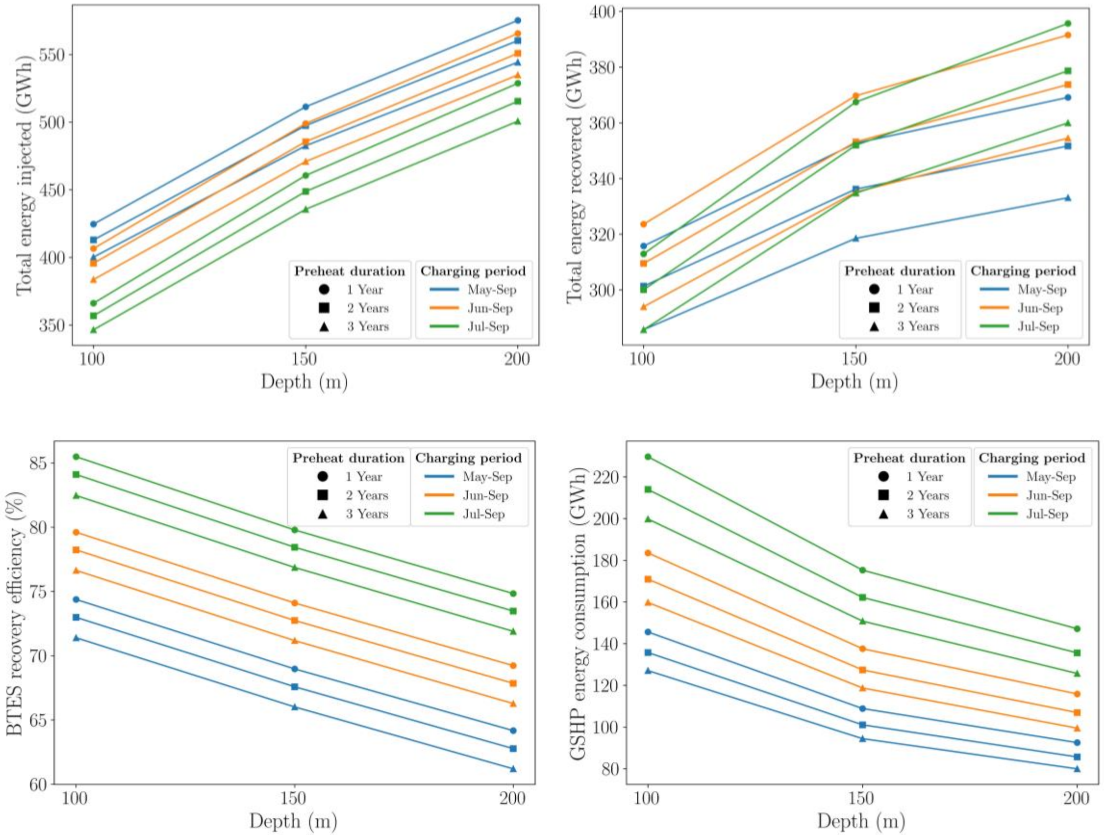
# Results

- Total injected energy per year:
  - 1st year: 19.8 GWh
  - 5th year: 16.6 GWh
- Total recovered energy per year:
  - 1st year: 12 GWh
  - 5th year: 12.2 GWh
- Recovery efficiency on annual level:
  - 1st year: 61%
  - 5th year: 73.1%
- Minimum borehole wall temperature 12.6°C



# Results

- 20-year simulation links borehole size with operating strategy, revealing long-term trade-offs
- Longer borehole stores more heat, but the gain diminishes with depth.
- Energy recovery lags injection in deeper wells, driving storage efficiency down.
- Design trade-off: shallow wells maximize efficiency, while deeper wells cut heat-pump power demand.
- Extended pre-heat/charge windows further lower GSHP work, but at the cost of additional efficiency loss.





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# Contributions and Next Steps

- Impacts so Far
  - Multiscale simulation framework, accounting for long-term effects and hourly fluctuations
  - Reduced computational cost while preserving accuracy
  - Calibrated to site-specific data, replicating the case study
  - Fully coupled thermal integration among system components
  - Flexible model supporting exploration of design and operation schedules

- Path Ahead
  - Parametric sensitivity analysis to rank the most influential design and operating variables
  - Quantification of system-boundary uncertainties and their impact on key performance indicators
  - Design and control optimization exploring various objectives
  - Techno-economic assessment of the entire heating network
  - Development of a transferable, case-specific design

# Thank You for Your Attention!

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