DTU / ISTA Collaboration

Digital-twins from energy meter data, enabling continuous-commissioning of heating and ventilation systems

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Heating optimization in studio apartments based on modular construction

Funded by Bjarne Saxhofs Fond

SHORTAGES

Skilled labour

Housing

MODULAR CONSTRUCTION

ScandiByg warehouse

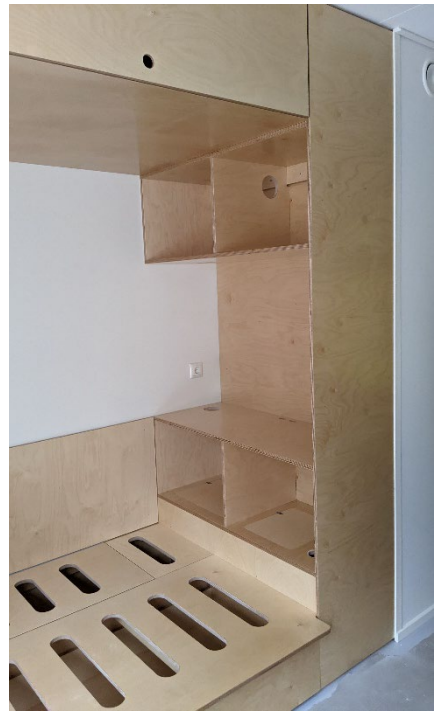
Credit: https://www.building-supply.dk/announcement/view/125712/ny_losning_til_isolering_af_svanemaerkede_boliger

Example: Almenbolig+ from KAB (since 2007)

Credit: https://www.mestertidende.dk/article/view/765586

- Row houses
- Modular construction
- 16 departments (1278 dwellings)
- User-maintained
- Up to 30% cheaper

Boligfonden DTU's student housing

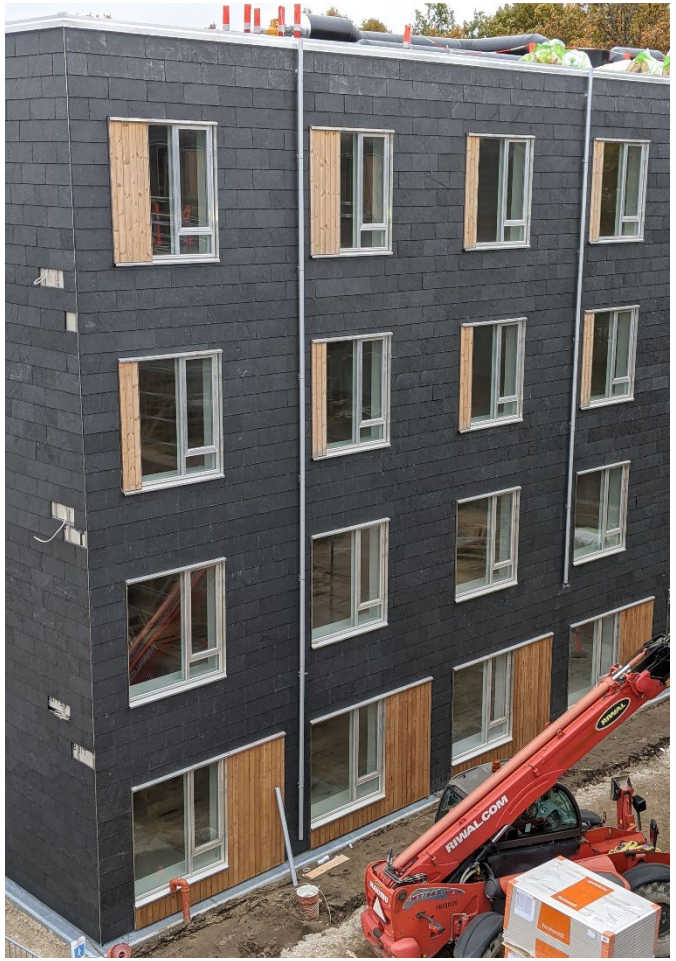


- 491 student apartments
- Built by Scandibyg using modular construction

- BR18 Lavenergiklasse
- DGNB Gold-certified
- Nordic Swan Eco-label

- Projektudviklingsprisen
- Next development is in Ballerup (299 apartments)

Every ~30 minutes



491 similar modules
Only difference is window area

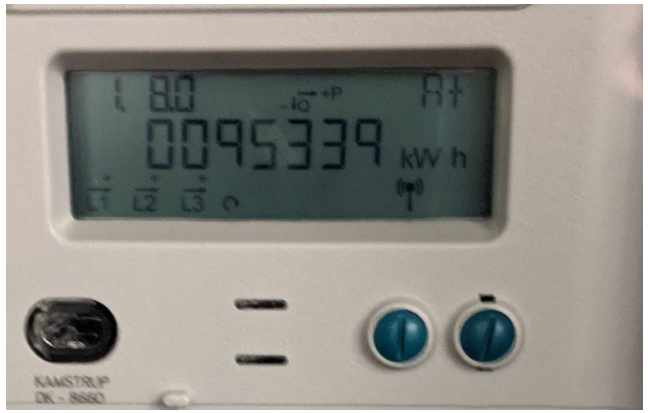
Includes the hallway and mechanical cabinet

Plus all installations and meters

Metering order BEK no. 563

Evaporation meters may no longer be installed - only remotely read meters.

From 1 January 2027, all meters must be remotely read.



Electricity (0.01 kWh)

Space heating (0.1 kWh)

Hot and cold water

Digital twins for secondary services using ISTA data

RELIEVING PAIN POINTS

- Improve commissioning (find faults, set controls)
  - Heating
  - Ventilation
- Limit heat loss from open windows/doors
- Assess inter-apartment heating

491 similar modules – Perfect for digital twins

BASE APARTMENT MODEL

SIMILAR:

- Geometries
- Material properties
- Radiant heaters
- Airtightness

- Ventilation rates
- Heating capacities

} Design values

UPDATE WITH DATA

- Metered electricity use
- Metered heating

UNKNOWNS:

- Indoor temperatures
- Occupancy (emitted heat)
- Window-opening

UPDATE WITH DATA

- Indoor temperatures →  • 154 temperature and relative humidity sensors
- Window opening behaviour →  • 106 window contact sensors
- Occupancy schedules →  • 106 CO_2 sensors → Update ventilation rates

CREATING A DIGITAL TWIN OF THE APARTMENT

Disaggregated heating

- Bathroom floor heating

106 radiator heat cost allocators

- Bedroom radiator

A digital twin of the heating system

32 detailed heat meters
(with flows & temperatures)

19 contact temperature sensors
on the return risers

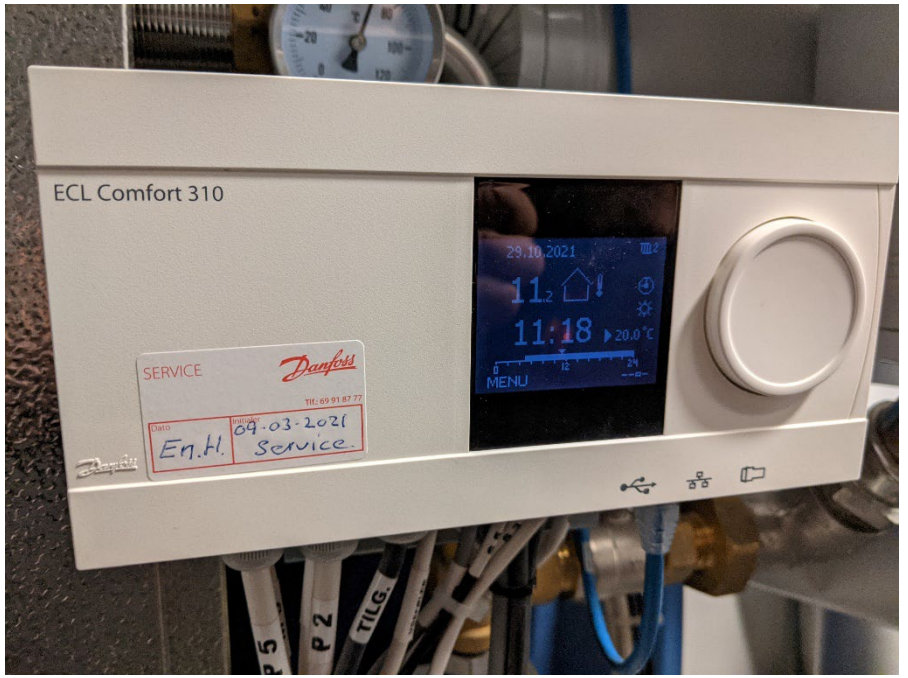
Update heating capacities

Data connections to controllers

Facilitated by Neogrid Technologies

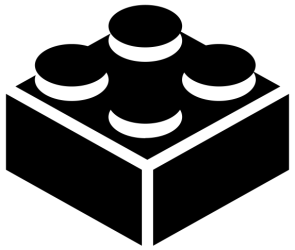
Ventilation

Heating

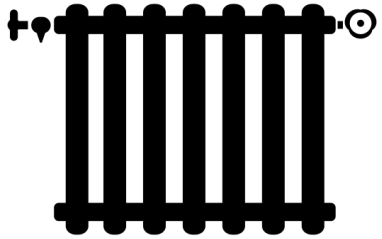


Develop secondary services with minimal establishment cost

DIGITAL TWIN



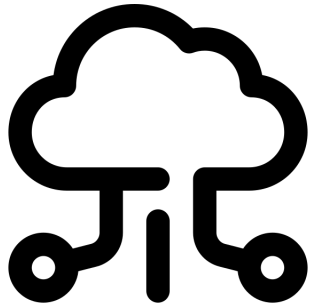
Envelope



Heating

Ventilation

+



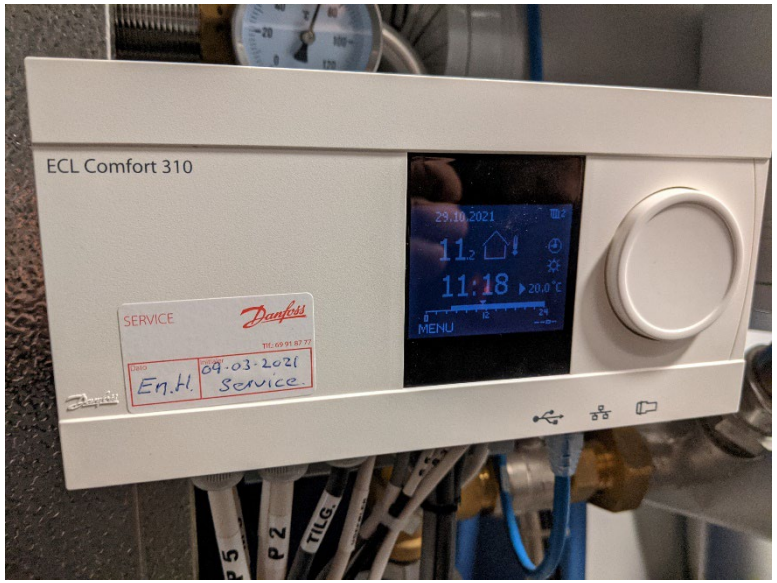
Cloud analytics

EXTRA DATA SOURCES		MODEL-BASED FAULT DETECTION
	• Indoor T & RH sensors	• Envelope – High heat loss – Overheating risk – Mould risk
	• Detailed heat meters	• Faulty heating – Poor hydraulic balancing – Stuck thermostatic valves
	• CO2 sensors	• Ventilation (apartment level) – Improper airflows
	• Connection to ventilation unit	• Ventilation (central level) – Insufficient heat recovery – Excessive supply temperatures

Optimal control

- Verified equations for apartment heat loss and heating
  = **Minimum T_{supply} curve**

- Benefits:
  - Minimum supply and return temperatures while maintaining thermal comfort
  - Constrained heat loss with open windows/doors
  - Accurate estimates of heat transfer between apartments



Official project from Dec 2022 to July 2024

HeatCheck

AI-driven optimal heating of apartment buildings

Grand Solutions project application (Innovation Fund Denmark)

Proposed budget: 14.6 million DKK

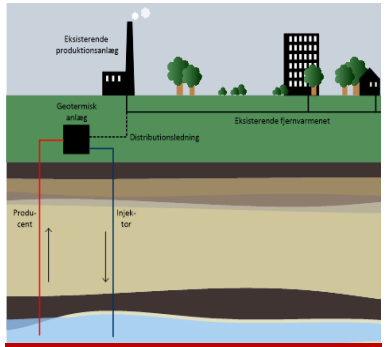
2020


Surplus heat


Waste

2028


Heat pumps



Geothermal energy


Surplus heat

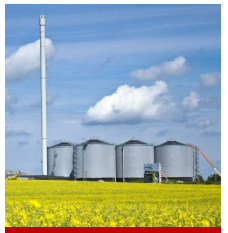

Boiler


Wind

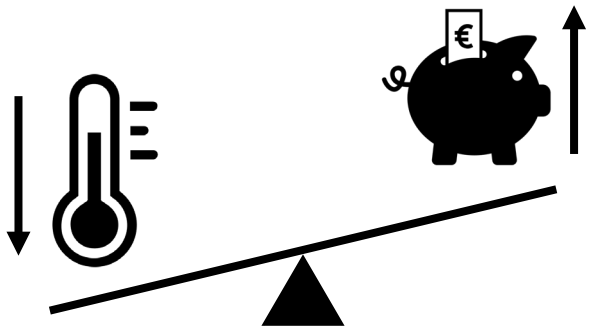

Sun


Waste


Biomass


Biogas


Seasonal heat storrage



€14 billion / year

Source: IEA DHC Annex TS2 Final Report

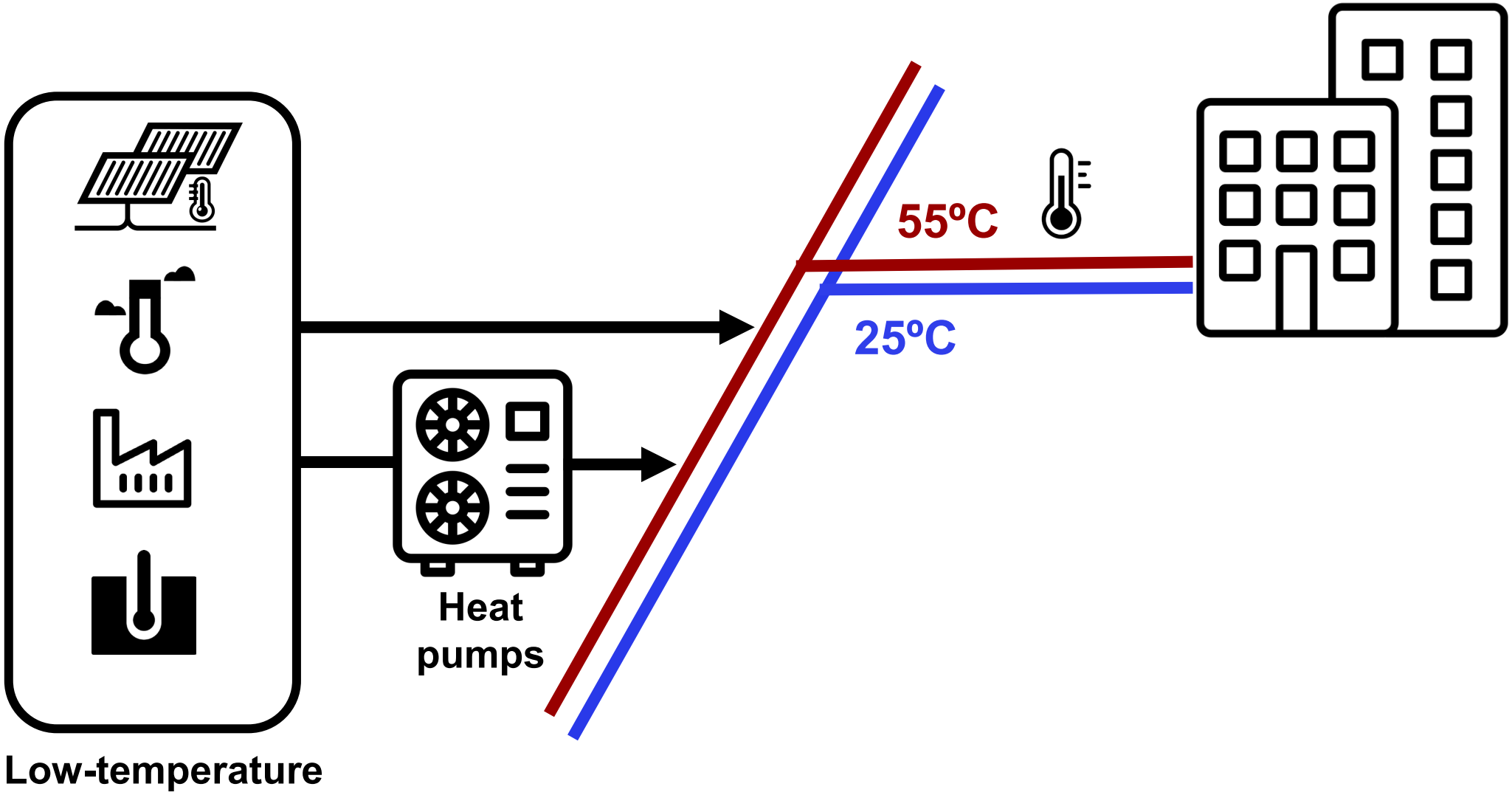
€300-350 million / year

Source: Henrik Lund et al. (2018)

Generation

Distribution

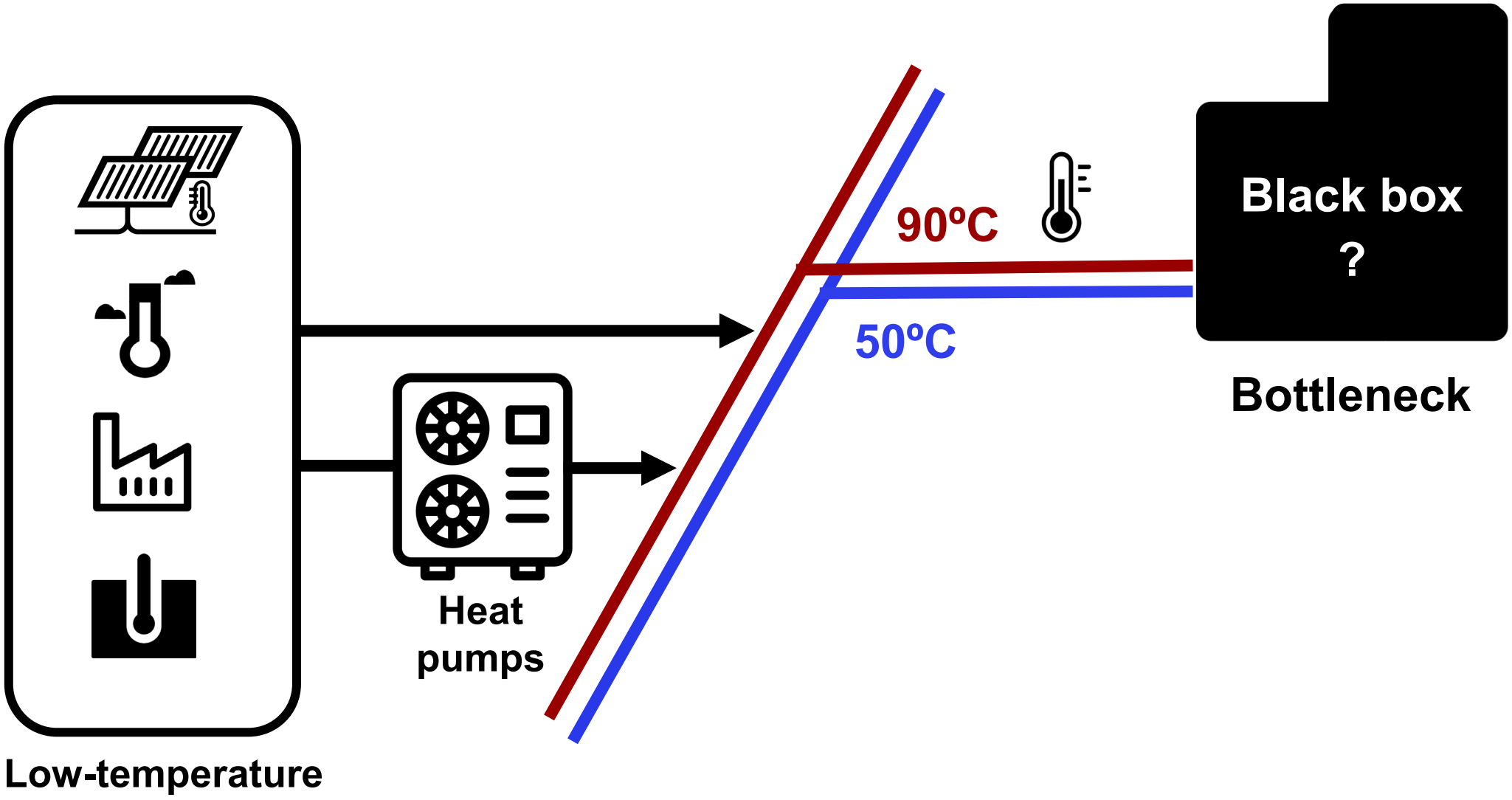
Buildings



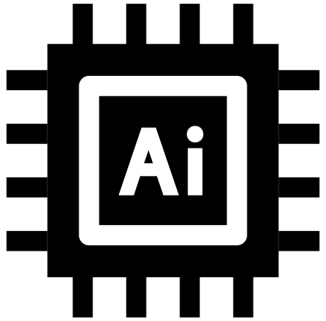
Generation

Distribution

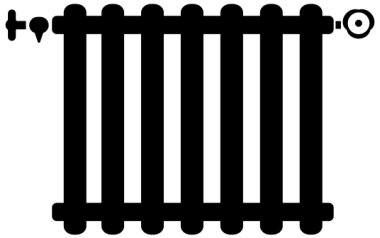
Buildings



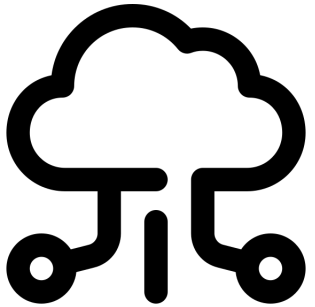
HeatCheck: AI-driven optimal heating of apartment buildings



Digital twin



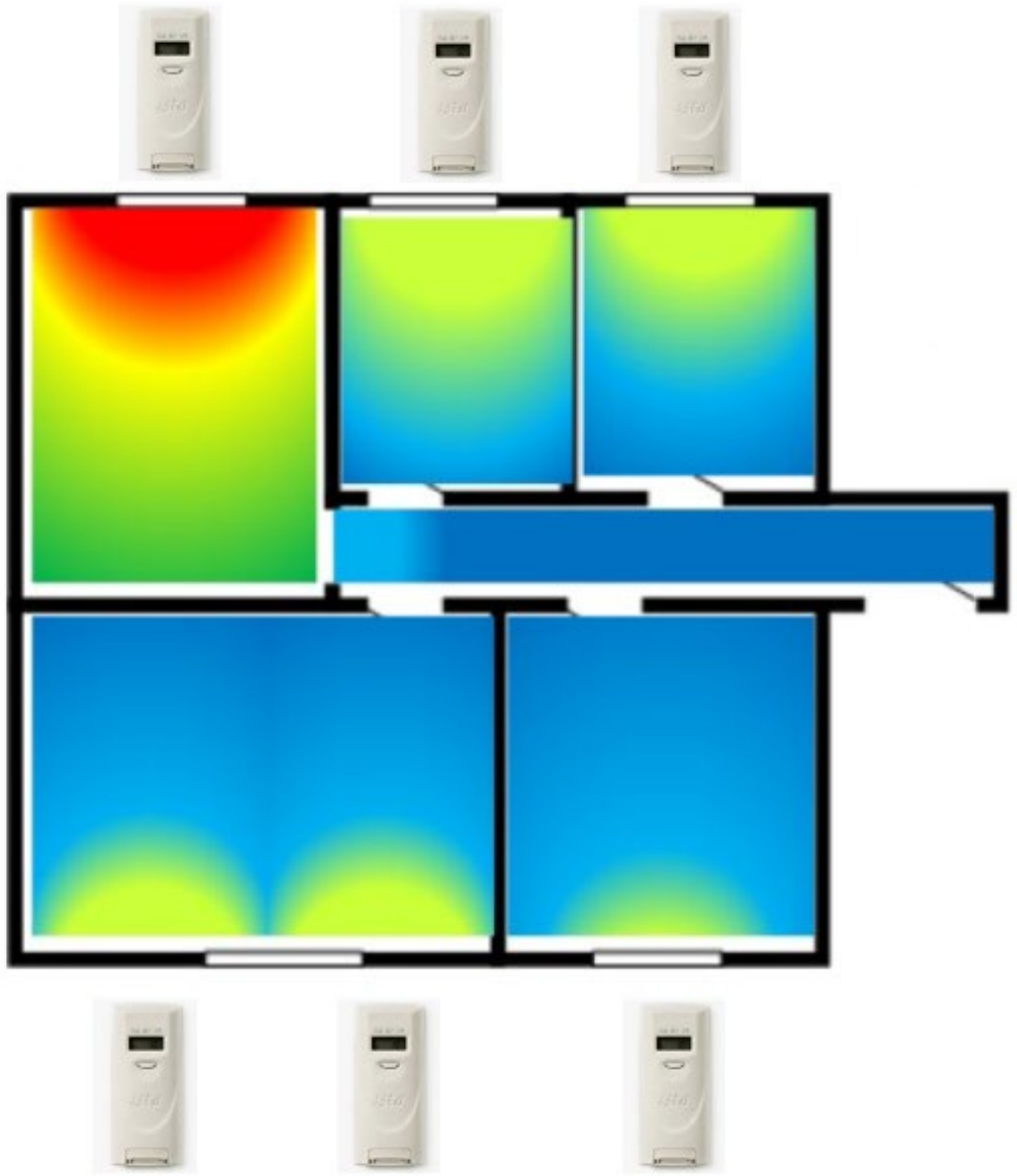
Residential heating



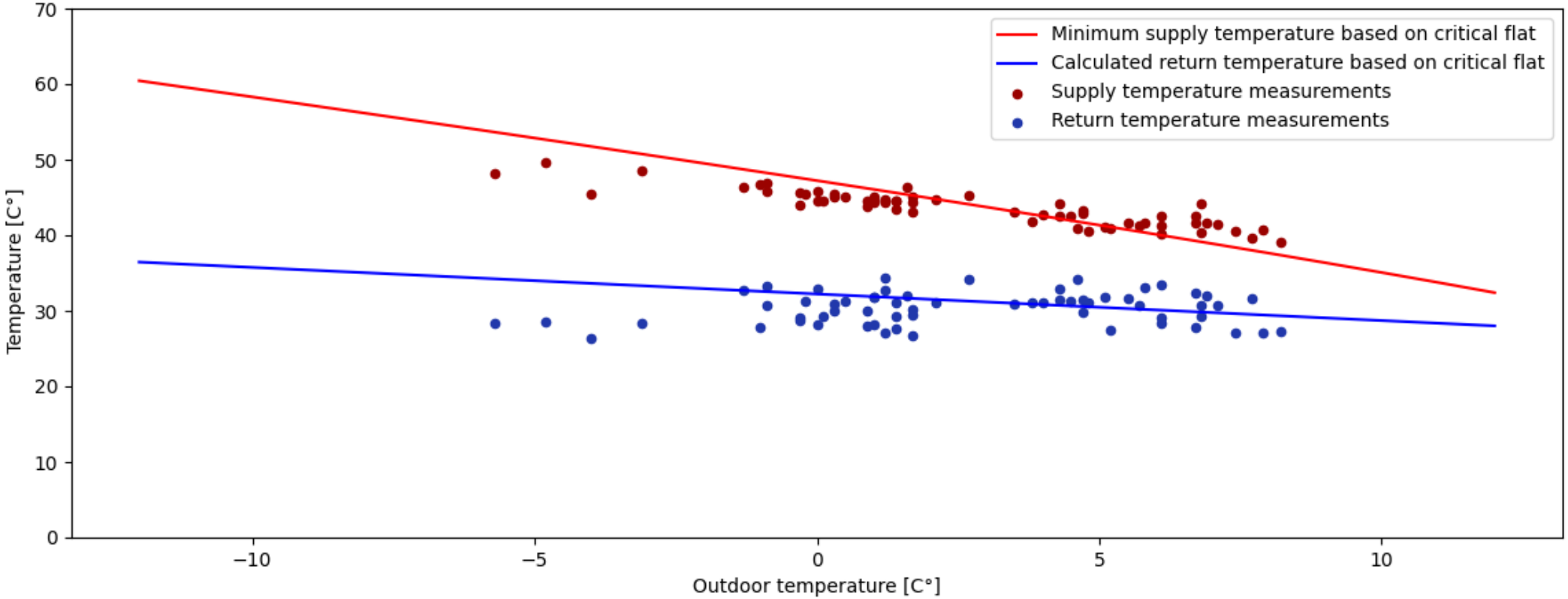
Toolchain

ista	5800 employees	60 million radio connected devices	13 million apartments wordwide
techem	3900 employees	42 million radio connected devices	12.2 million apartments wordwide

From billing to innovative services



Proof of concept (PoC)



HeatCheck's scalable value chain

Data sources

Heat cost allocators

techem

ista

District heating meters

Aalborg Forsyning

Fjernvarme Horsens

HOFOR

data

Data Infrastructure

CENTER DENMARK

Intelligence

DTU

TEKNOLOGISK INSTITUT

data

B2B

HOFOR

Fjernvarme Horsens

Aalborg Forsyning

ista

techem

Beneficiaries

KAB

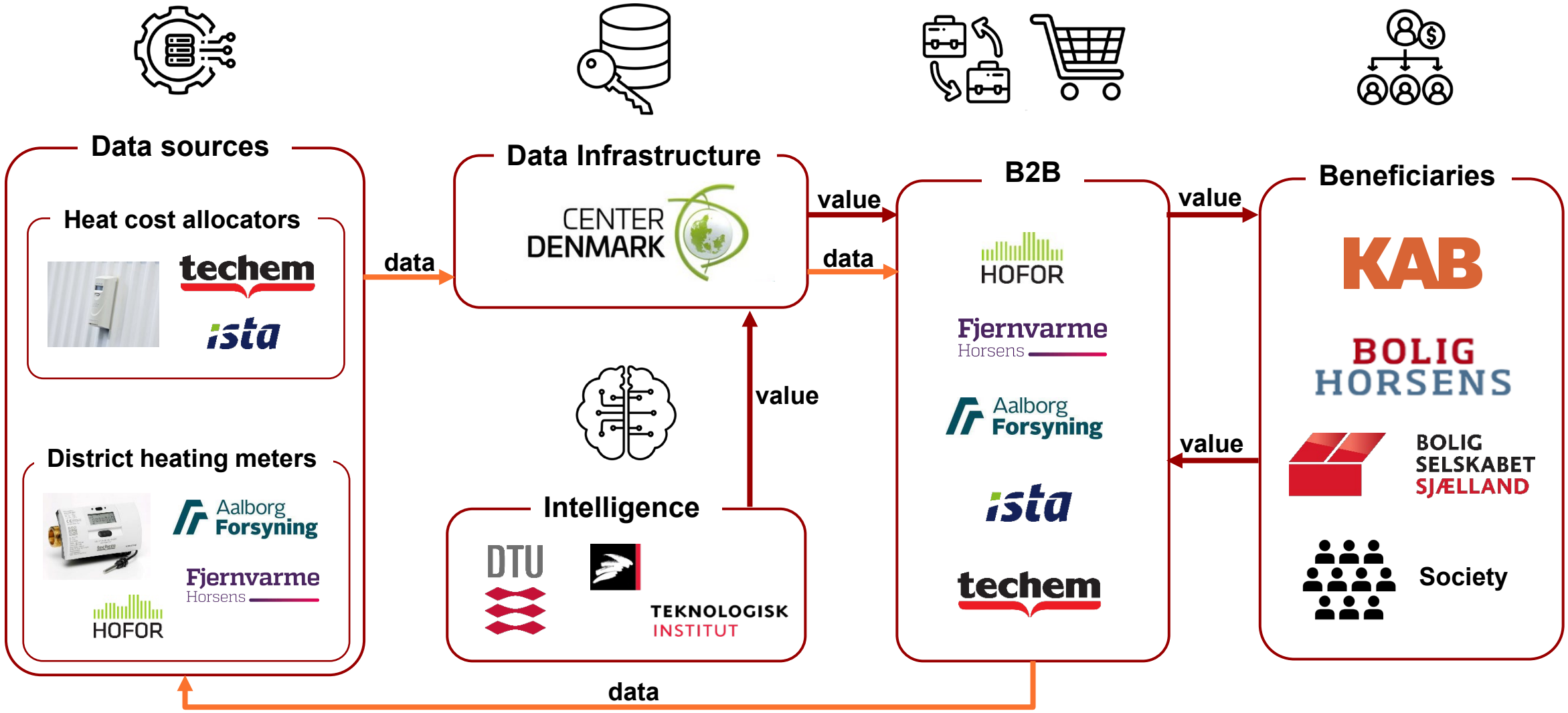
BOLIG HORSENS

BOLIG SELSKABET SJÆLLAND

Society

data

HeatCheck's scalable value chain



Stakeholder impact

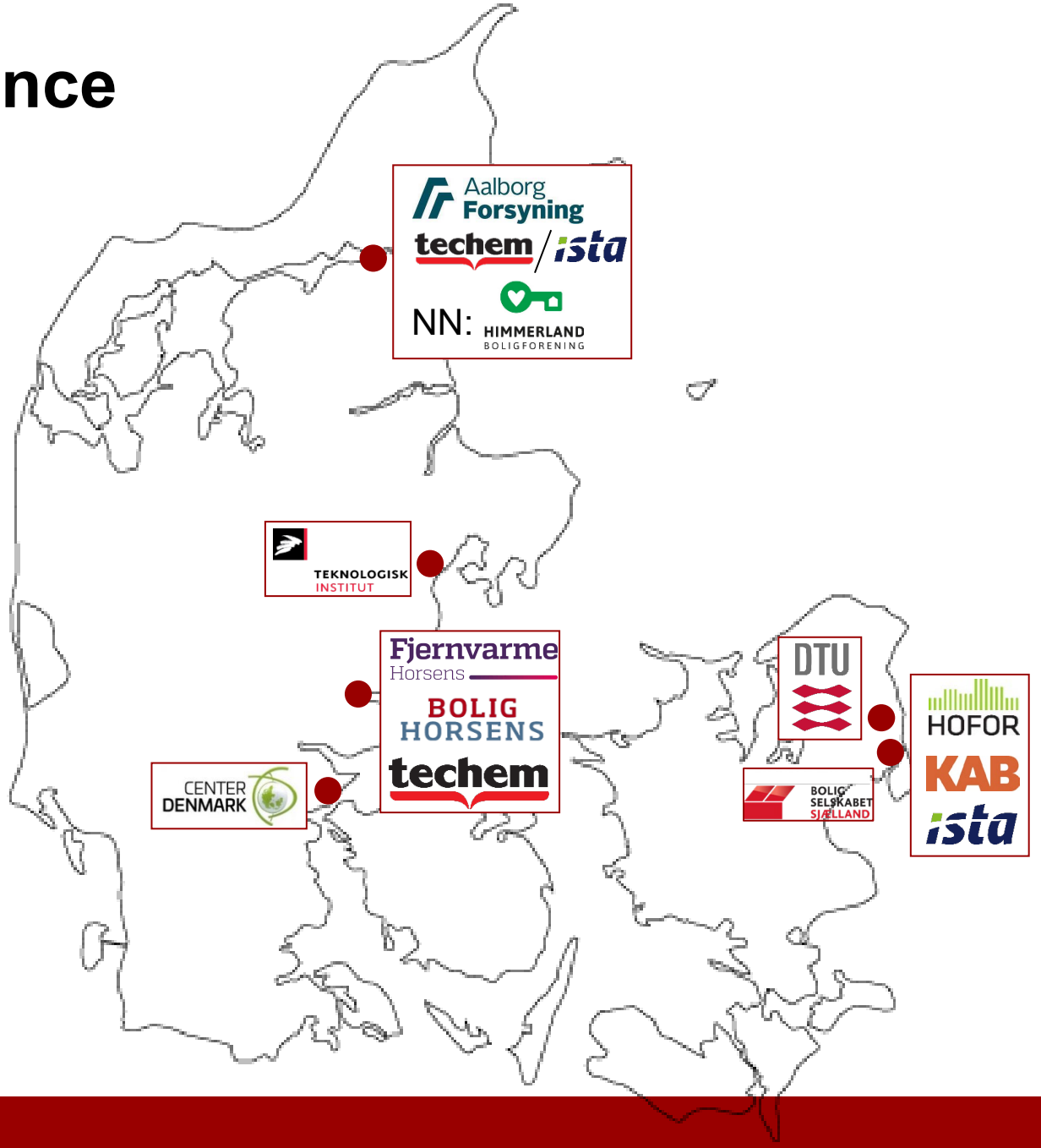
District heating operators

- 10-20% energy savings (with HPs)
- Total savings in DK: €300-350 million/year
- Focused installer/technician visits - forensic team

House associations

- Reduction of penalties
- 10-20% cost savings from lower heating bill
- HeatCheck facilitates and extends forensic efforts
- Optimal control of heating substations

R&D Excellence



Execution

1st heating season | 2nd heating season | 3rd heating season | 4th heating season

WP#	Leader	2023	2024	2025	2026
1	DTU	Project management			
2	DTU	Mapping & Benchmarking			
3	CENTER DENMARK	Data infrastructure ↦ Platform dev.		↦ Toolchain dev.	
4	DTU		AI-driven heating control ↦ Optimisation		↦ Automation
5	TEKNOLOGISK INSTITUT		Users, value & markets ↦ Validation		↦ Strategy
6	DTU			Dissemination & communication	

Thank you.

Questions?

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Mitigation of risk

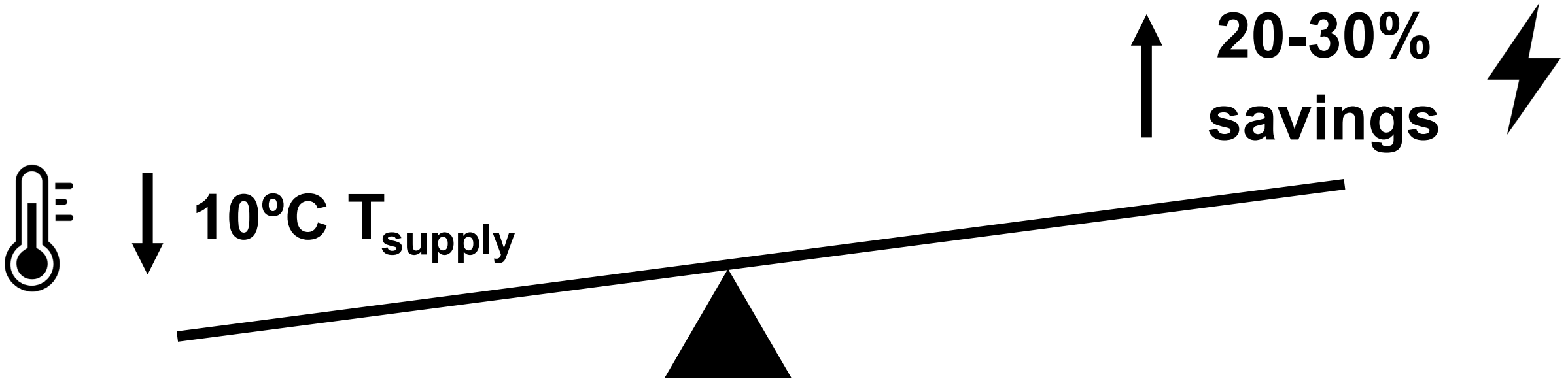
- Open-source toolchain
- Works on historic and new data. 10y of data is already available in many places.
- Minimally invasive data collection.

- GDPR
  - Heating data already used for billing purposes and agreements with customers in place already
  - Companies only provide anonymized data to third-party (DTU, DTI and CDK)
  - CenterDenmark has the infrastructure and experience to ensure data security

HeatCheck Summary

- HeatCheck will **optimize and service heating systems in apartment buildings**
- HeatCheck will **develop a toolchain together with companies to provide them with new business opportunities**
- HeatCheck will **lower the operating temperatures in the DH network** and **minimize the risk of investments** that any small or big DH operator needs to go through in the coming years
- For HeatCheck **the time is now,** considering the expected expansion of DH across all Europe and the directive on transparent billing

Heat pumps



Rørmosen – Reduction of supply and return-temp.