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Simulation based assessment of storage integration & operation in the district heating network of Aarhus

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READY

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4th Generation District Heating Technologies and Systems

THE READY PROJECT

Resource **E**fficient cities implementing **AD**vanced smart cit**Y** solutions

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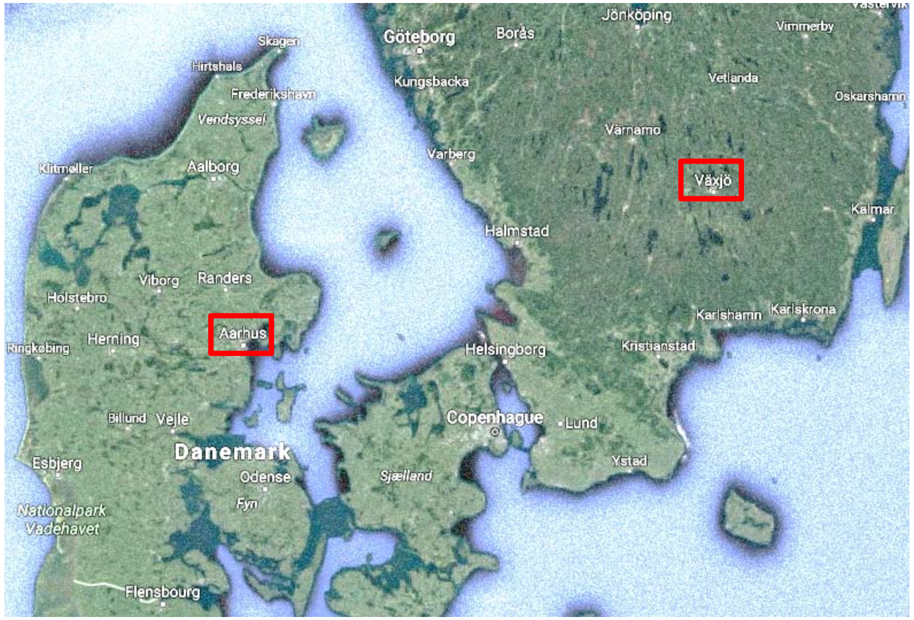
Objectives:

- Demonstrate new solutions for CO_2 neutral districts:
  - Retrofitting
  - New solutions for LTDH
  - Storage solutions for flexible combined energy grids
  - Electricity and water efficiency



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FP7-ENERGY-SMARTCITIES-2012

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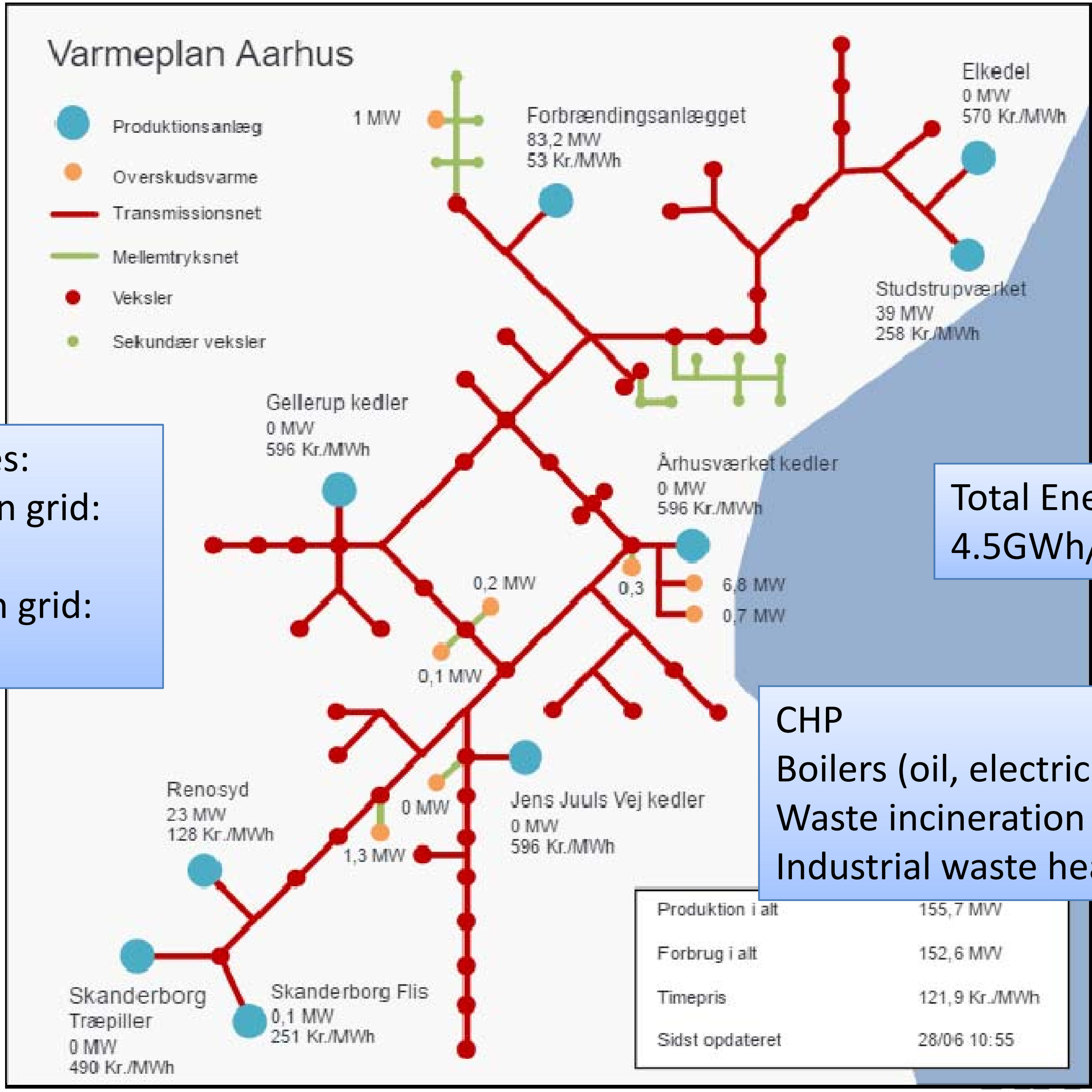

Temperatures:
-Transmission grid:
120-50°C
- Distribution grid:
70-40°C

Total Energy demand
4.5GWh/y

CHP
Boilers (oil, electric and biomass)
Waste incineration
Industrial waste heat

http://transmissionsnet.varmeplanaarhusapps.dk/

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CASE STUDY OF AARHUS

- **Scenario1:** Impact of retrofitting

  Impact of different retrofitting shares (10%-50%-100%) of the building stock before 1972 on the heat load and network return temperature.

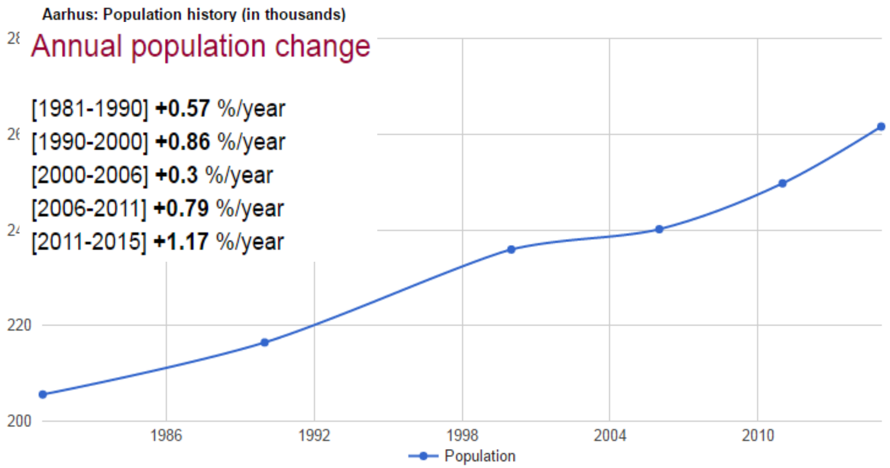
- **Scenario2:** Integration & operation of centralised / decentralised storages.

- **Scenario3:** Integration & operation of alternative heat supply units (seawater HP and waste heat producers).

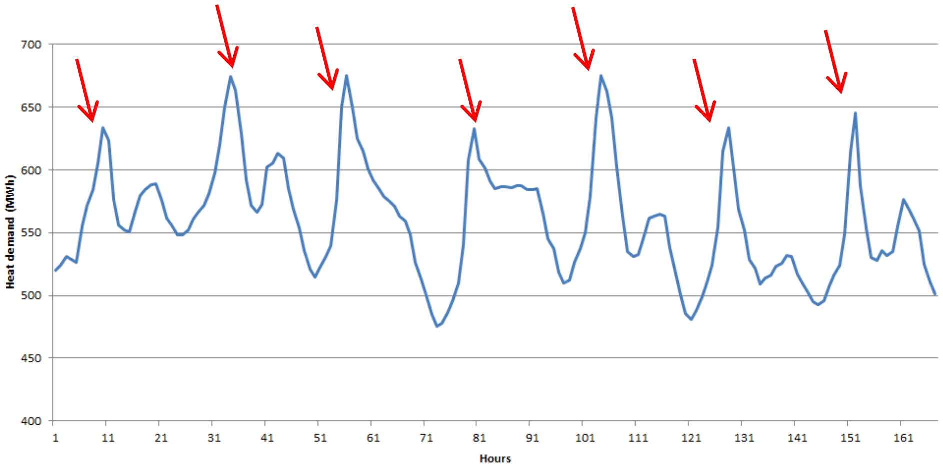
CASE STUDY OF AARHUS - CHALLENGES

- City densification

  +4.7% by 2030



- Morning peaks



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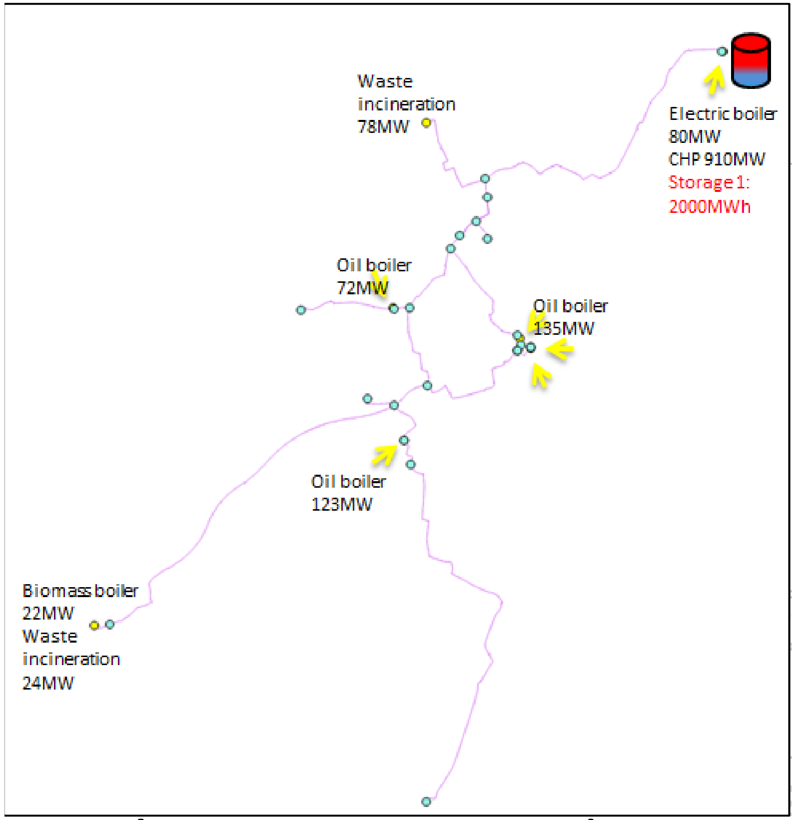
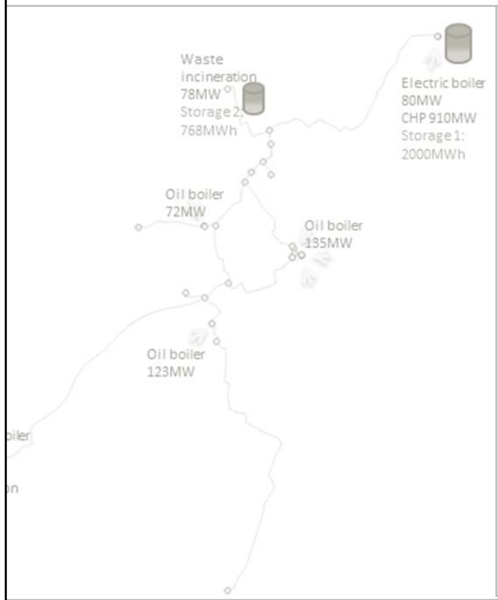
SCENARIOS DESCRIPTION



Sc2a (REFERENCE SCENARIO):

Storage 1: Price strategy



Storage 1: Price strategy

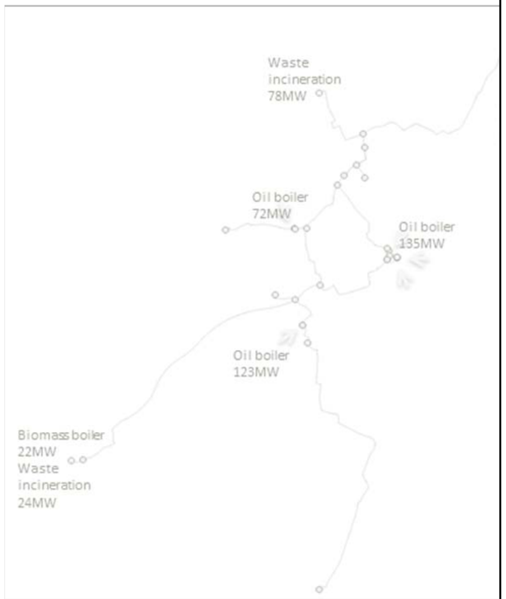
Storage 2: Peak strategy

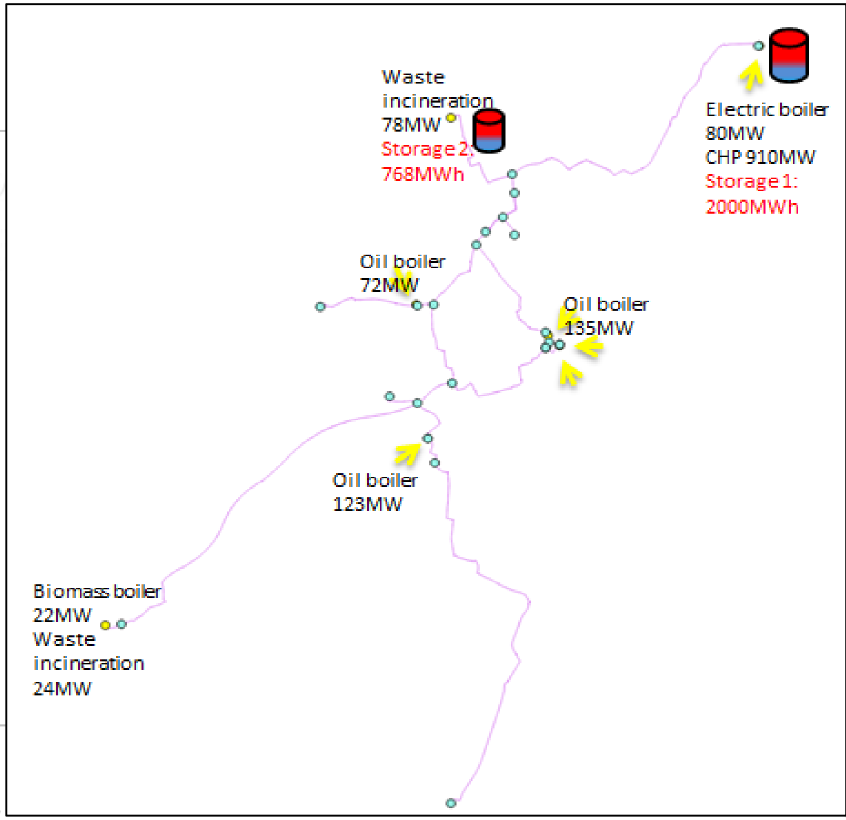
Sc2c: Price/Peak strategy

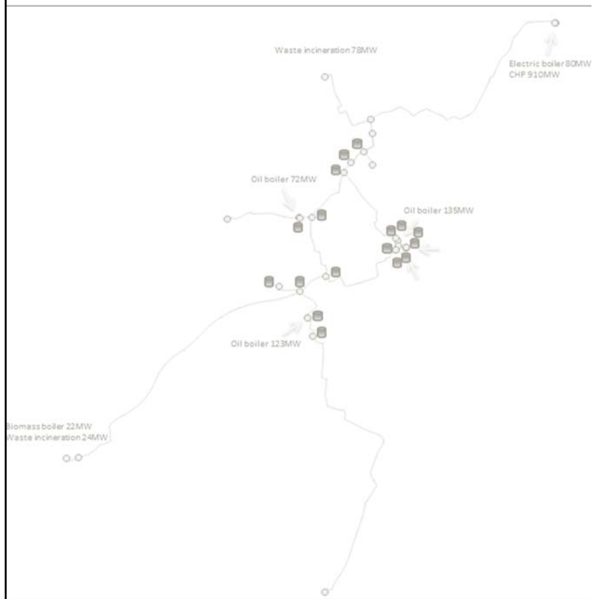
Sc2d:

Sc2c +4,8% heat demand

SCENARIOS DESCRIPTION







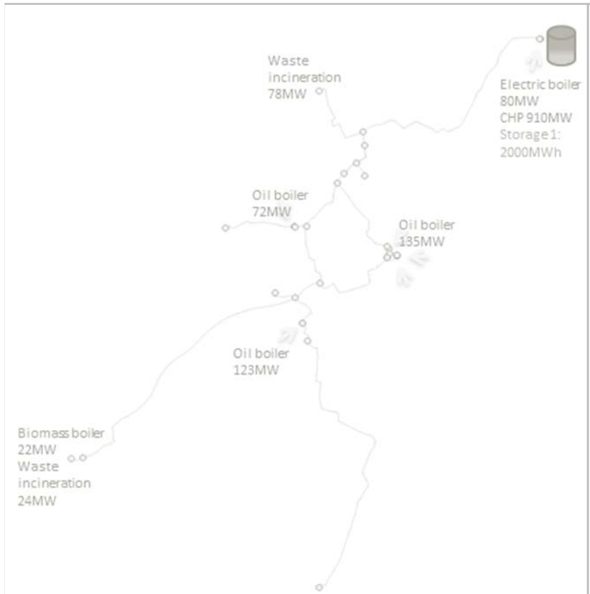
Sc2a:
Storage 1: Price strategy

Sc2b:
Storage 1: Price strategy
Storage 2: Peak strategy

Sc2c: Price/Peak strategy

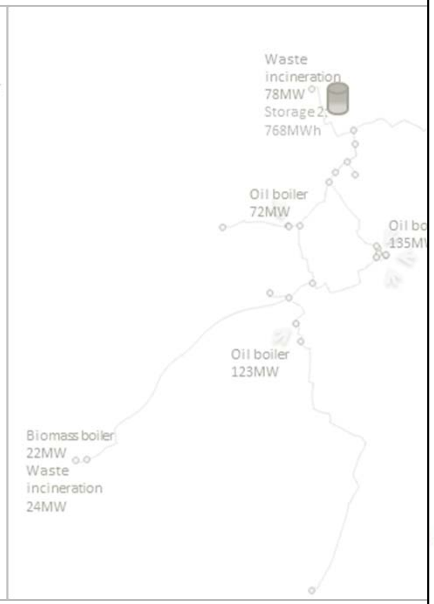
Sc2d:
Sc2c +4,8% heat demand

SCENARIOS DESCRIPTION



Sc2a:

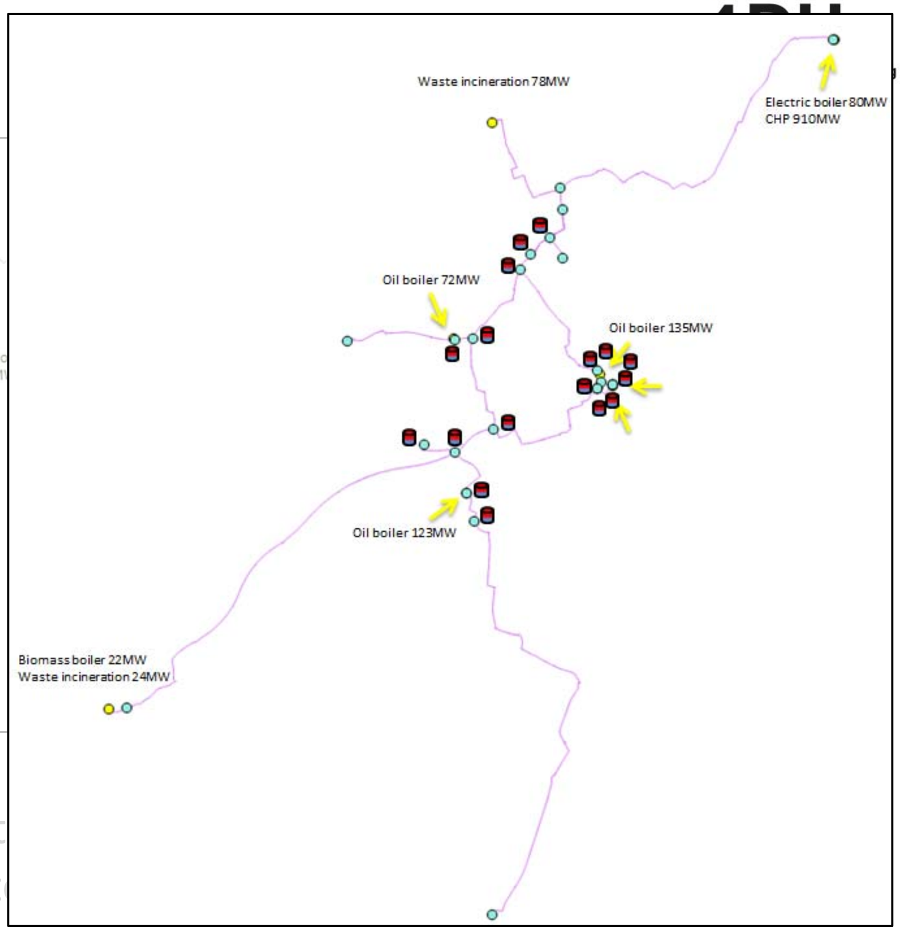
Storage 1: Price strategy



Sc2b:

Storage 1: Price strat

Storage 2: Peak strat



Sc2c: Price/Peak strategy

Sc2d:

Sc2c +4,8% heat demand

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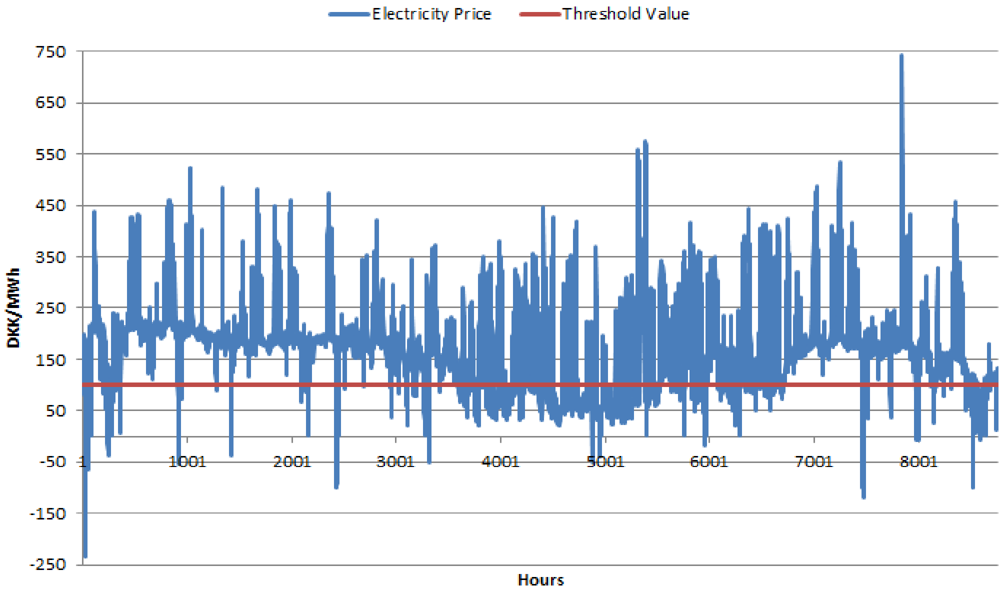
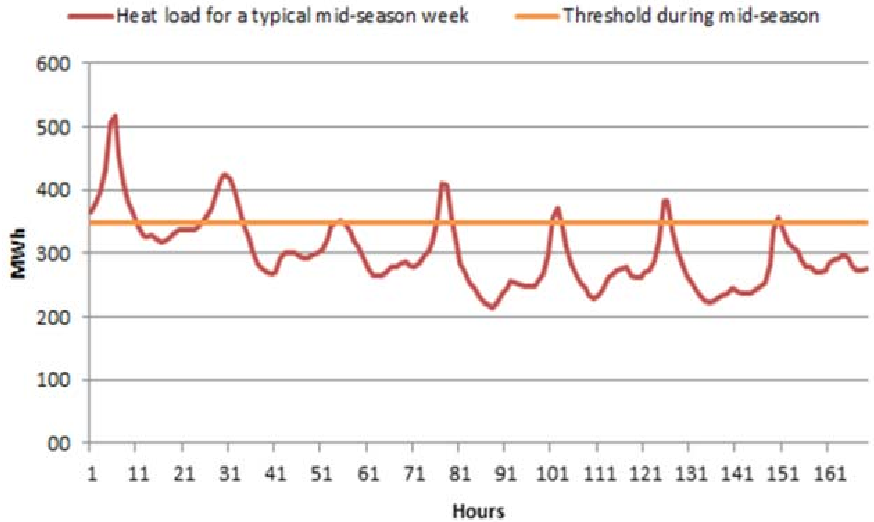
CONTROL STRATEGIES

Price based Strategy



Peak based Strategy

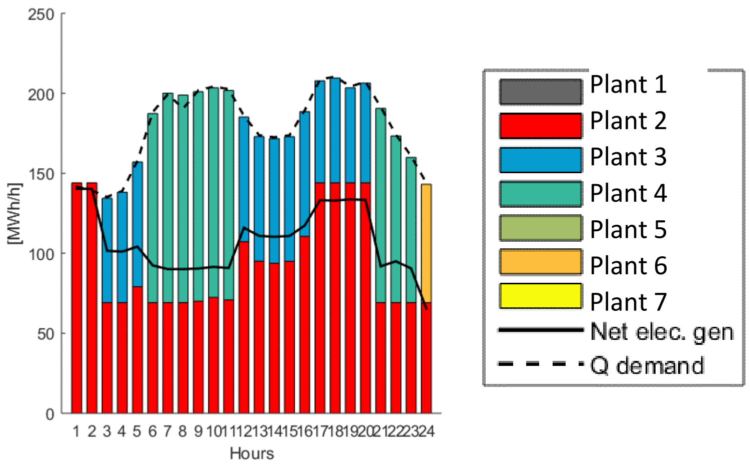


OPTIMIZATION TOOL – OPTIVAR

(**Opti**mised **var**iables)
Optimization of the scheduling of all supply units and storages on hourly basis (Mixed Integer Linear Programming)

Inputs	*Optimisation tool*	*Outputs*
Demand data: - Heat load **Supply data**: - Heat plants characteristics Storages characteristics - Operation costs - Priorities - Specific constraints	**Objective function**: - Minimisation of costs - Maximisation of profit **Set of constraints**: - Balance constraints - Operational constraints	**Operation profiles**: - Operation profiles - Fuel/electricity consumption **Economic costs breakdown:** - Operational costs of components - Total cost of the system

Example of plant scheduling



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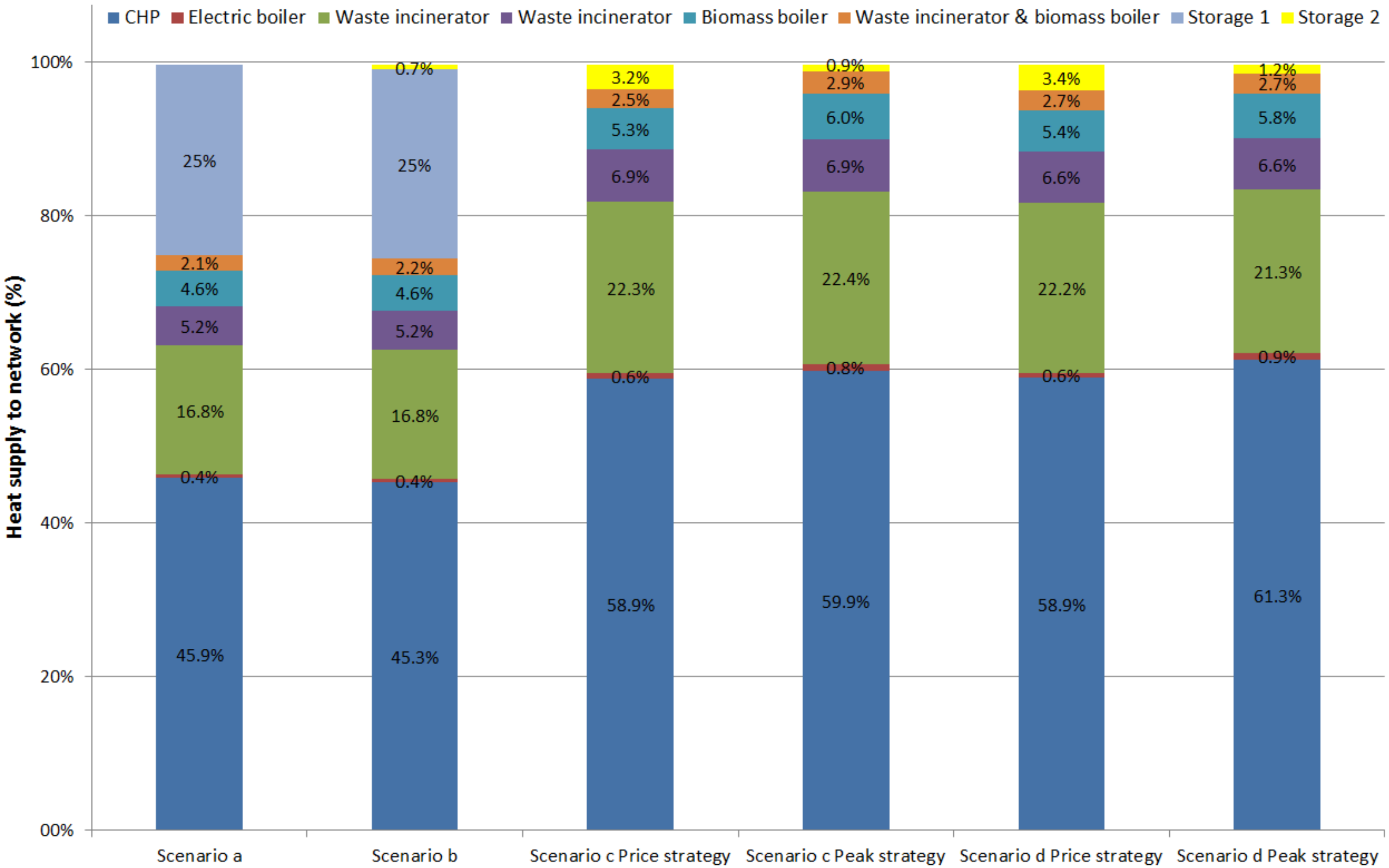
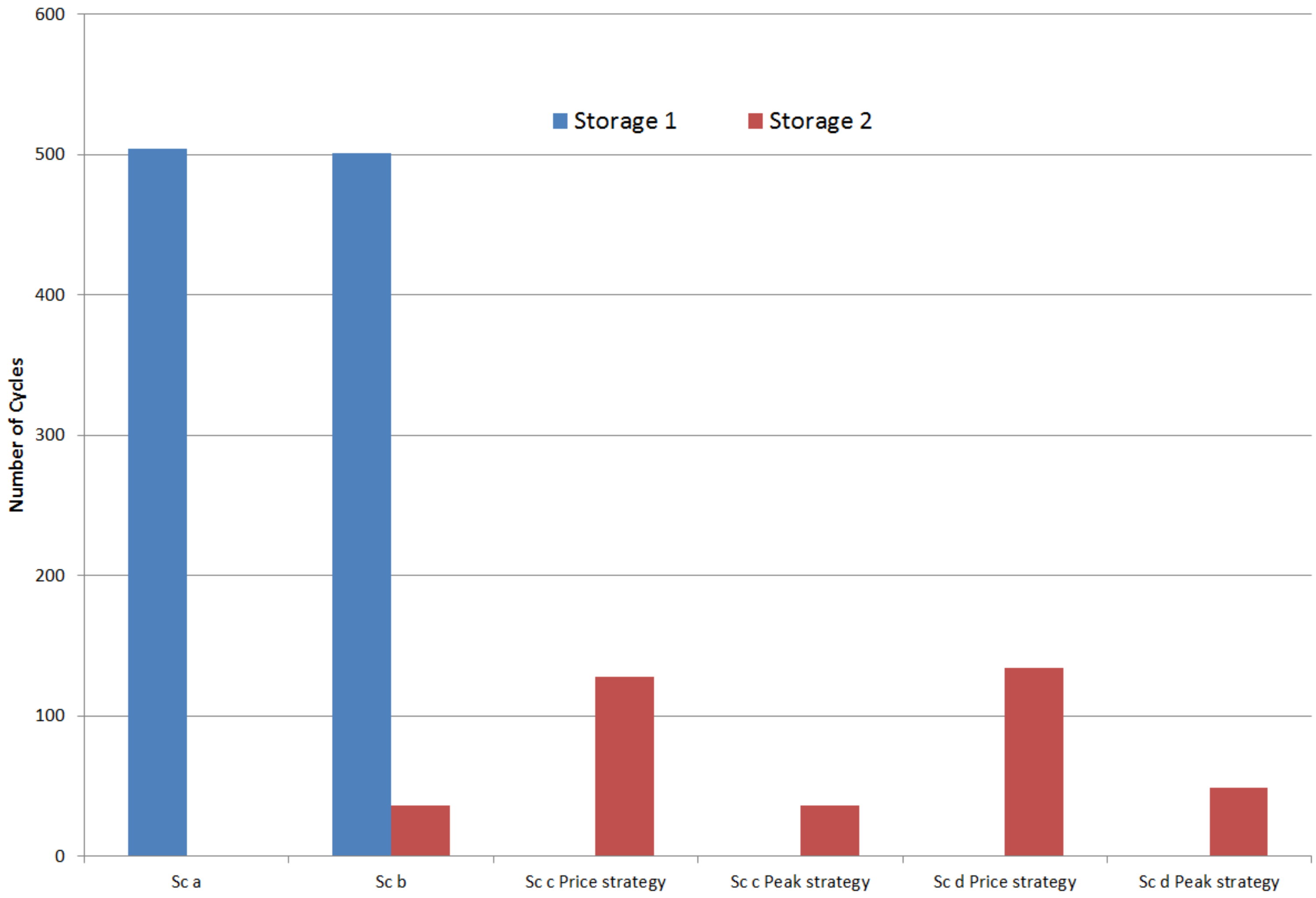
RESULTS – HEAT SUPPLY TO THE NETWORK



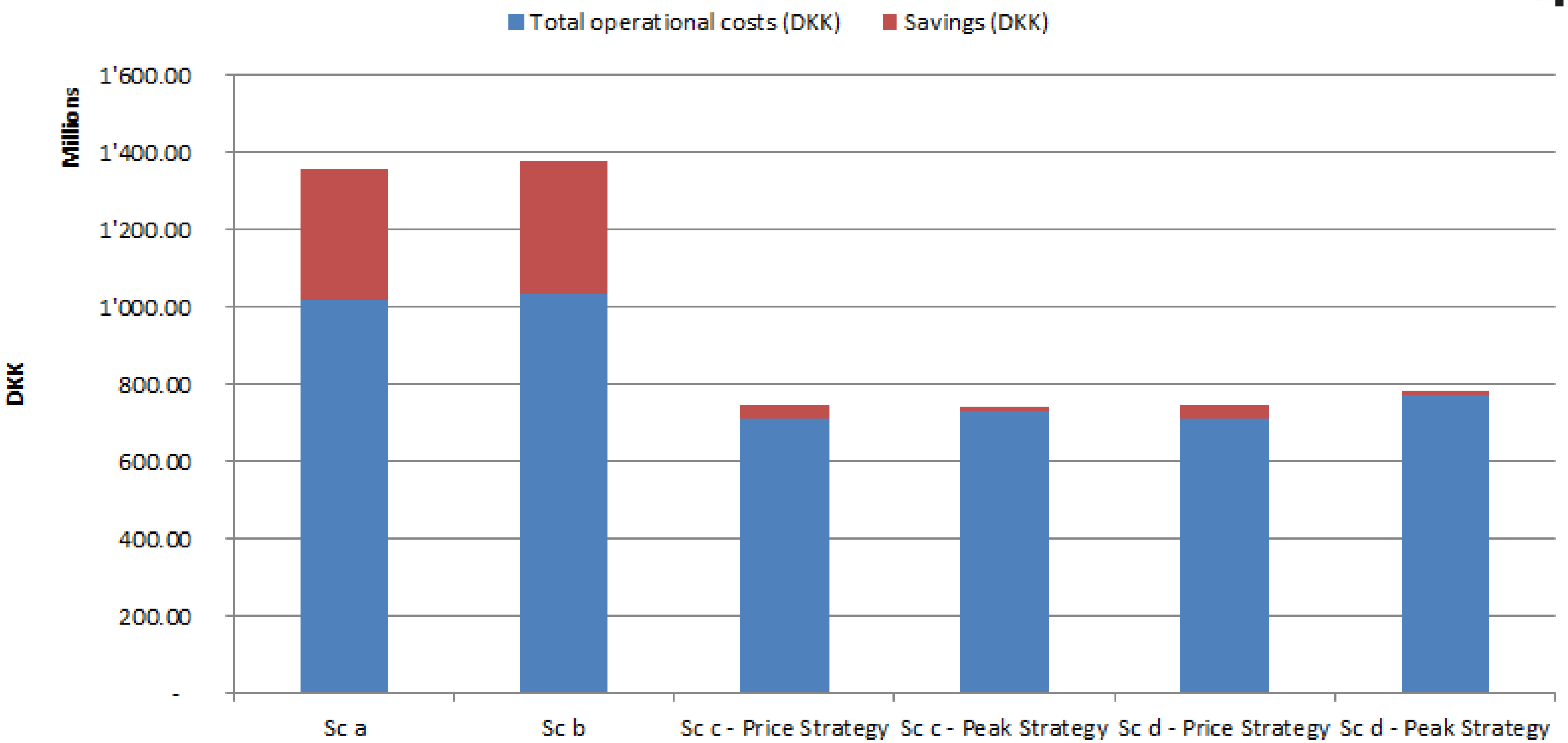
Storage 1: 2000 MWh
Storage discharge

Storage 2: 768 MWh
Storage discharge (Scenario 2b) or decentralised storages discharge (Scenario 2c & Scenario 2d).

RESULTS – STORAGE CYCLES



RESULTS – STORAGE CYCLES



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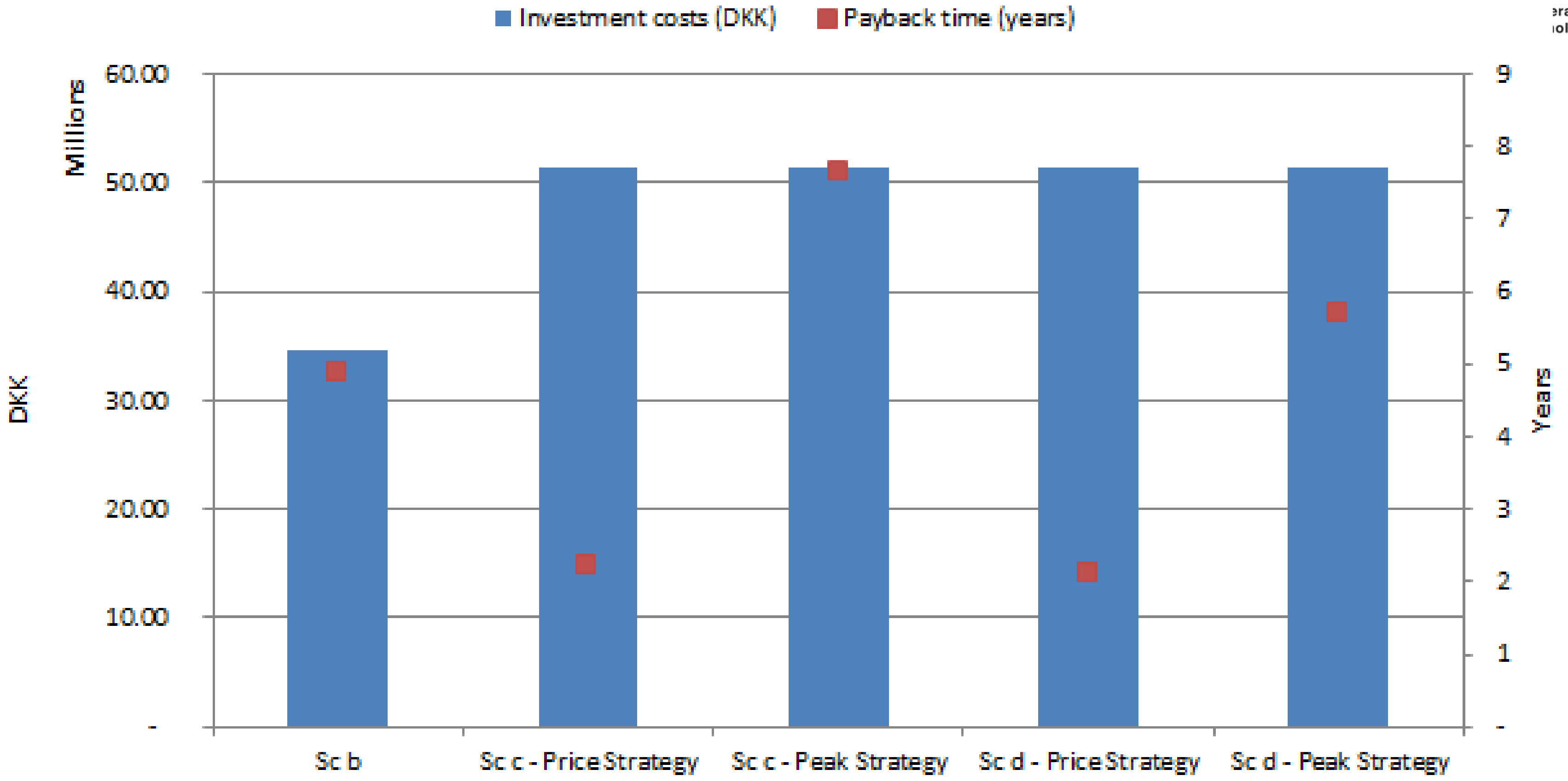
RESULTS – STORAGE CYCLES



MAIN CONCLUSIONS

- **Centralised storage / Peak strategy:**
  - ¼ of the energy supplied to the network
  - Negligible rise of operational costs
- **Decentralised storages / both strategies:**
  - Small contribution to the heat supplied to the network
  - Decrease of more 7% of operational costs
- Decentralized storages are more costly, centralized storages allow more savings on the long term.
- Scenarios with **price strategy** more expensive than scenarios with **peak strategy**.

➔ *Centralised/decentralised storages and the operation strategies depends on the characteristics of the heat demand and on the challenges that should be addressed.*

Thank you for your attention

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