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# Optimizing energy transition paths of municipalities

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# Disclaimer

The author declares that this research was conducted independently and that no competing financial or personal interests may have influenced the described work. This work does not represent the official position of any affiliated institution.

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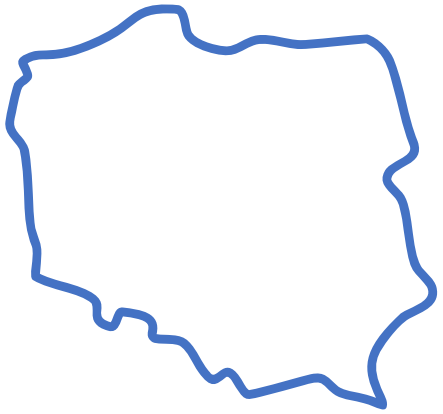
# Algorithms support investment decission process

**How to achieve selected goals at the lowest cost?**

ZEFIR



Country

Municipalities

Households / companies

# Zefir implementations

**Supporting municipalities in achieving clear air and climatic neutrality goals**

ZEFIR

NCBR Narodowe Centrum Badań i Rozwoju

KlastER

Forum Energii

Lead Air

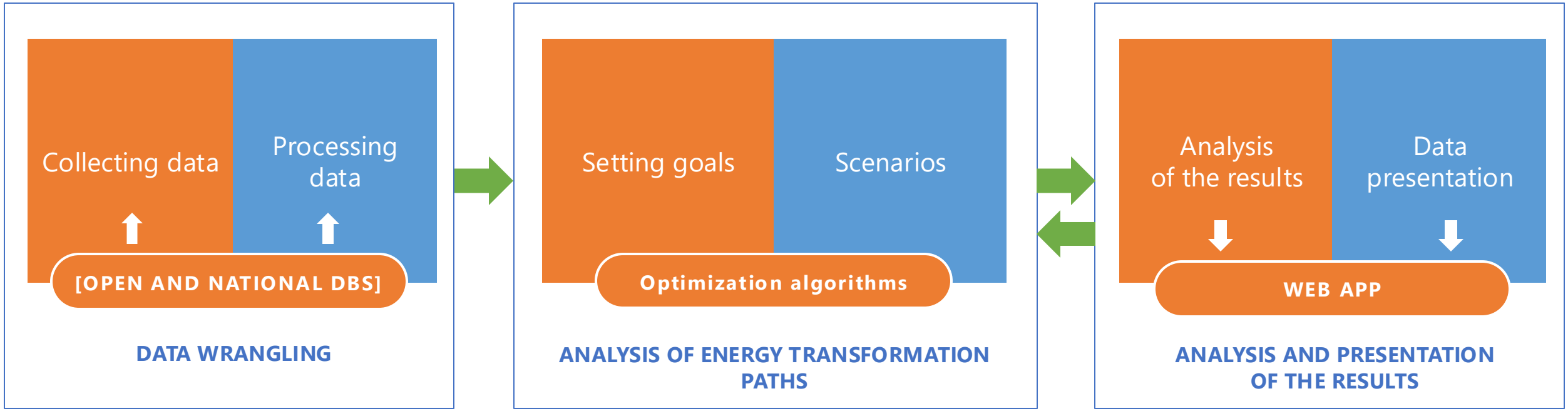
Narodowy Fundusz Ochrony Środowiska i Gospodarki Wodnej

MIASTO Z KLIMATEM NAJLEPSZY ZREALIZOWANY PROJEKT

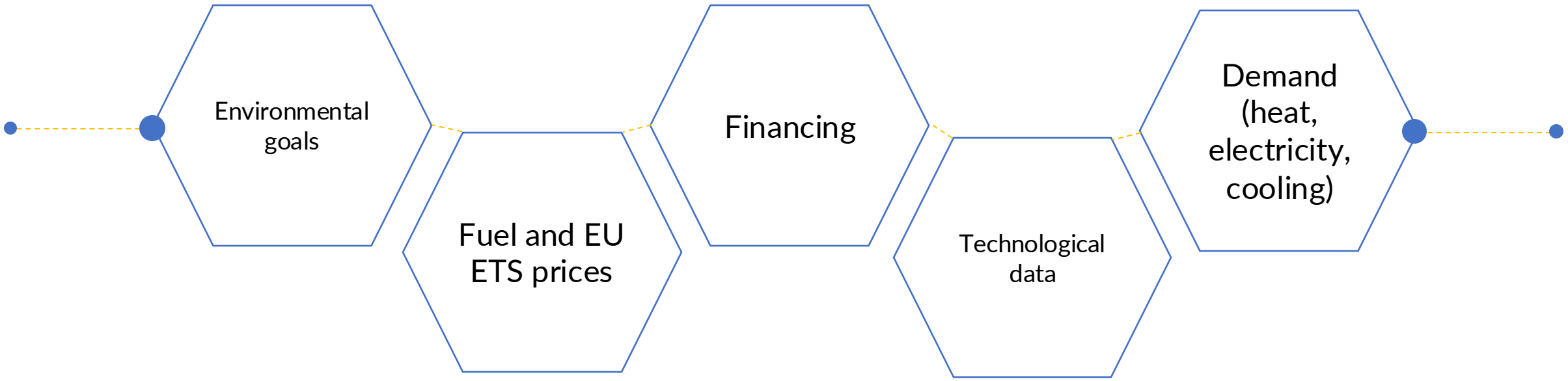
NEEST NetZero Emission and Environmentally Sustainable Territories

# Process – general view

**What does the city obtain?**



# Input data


Environmental goals
Fuel and EU ETS prices
Financing
Technological data
Demand (heat, electricity, cooling)

# Sectors under optimization

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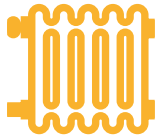
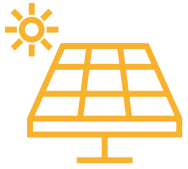
Heating



Including modernization of buildings

Electricity



Dynamic (nonnegative) prices

Cold

Demand satisfaction level rising for 20 years

# Buildings

Functional types

Single-family

Multi-family

Offices

Commercial and services

+

Remaining buildings

For functional types
x4 categories of
energy efficiency

=

17 aggregates corresponding to type and efficiency

- Building models prepared by KAPE
- Modernization rate – 4% of buildings per year

# Technologies

## Central

Heating and combined heating and power plants

Electrified:
- Large heat pumps
- Electric boilers

Large scale thermal energy storage:
- TTES
- PTES

## Local

Technological baskets corresponding to the heating

Existing
- Boiler coal
- Boiler gas
- Heat pump
- Electric heating
- District heating

Future
- Heat pumps
- Central heating V gen (with „booster")

Including storage of heat / electricity / cold

PV autoconsumption

# Scenarios

**Scenario 1 – Status Quo**

- Bussines as usual in heating sector
- Buildings do not increase energy efficiency

**Scenario 2:**

**Central heating of 5th generation**

- Low temperature in district heating
- Buildings remain connected to district heating
- Electrification of heating sector and large-scale storage

**Scenario 3:**

- **Scattered heat sources**

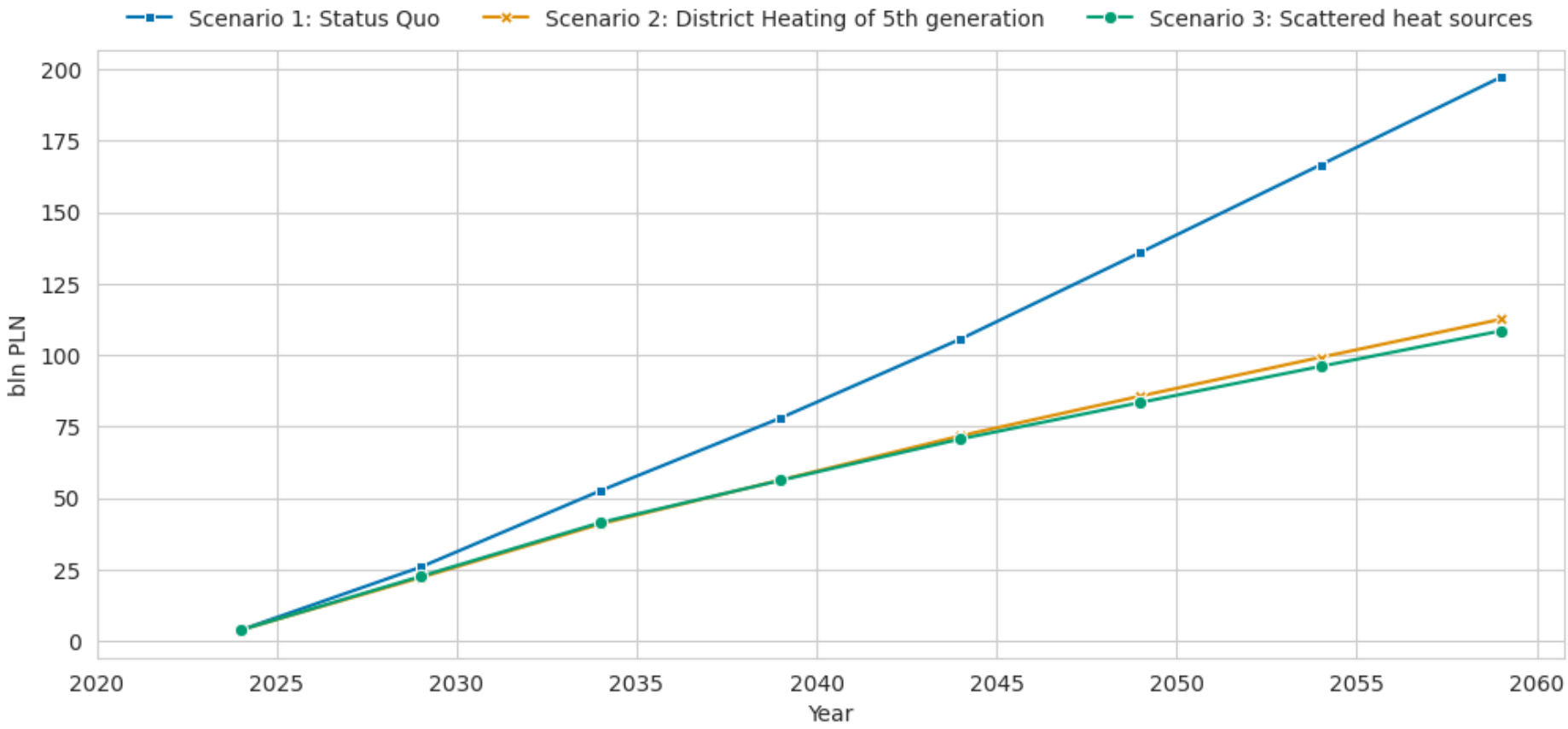
# What does the „cost” mean

- Costs are computed from the view of the whole system, not particular stakeholders or business actors as Energy companies, households or municipal authorities.

- CAPEX – discounted total cost of investment, including cost of debt

- Cumulated cost – sum of expenses incurred until given year
- Yearly cost – expenses incurred precisely in given year

# Comparison of cumulated costs of scenarios for Cracow



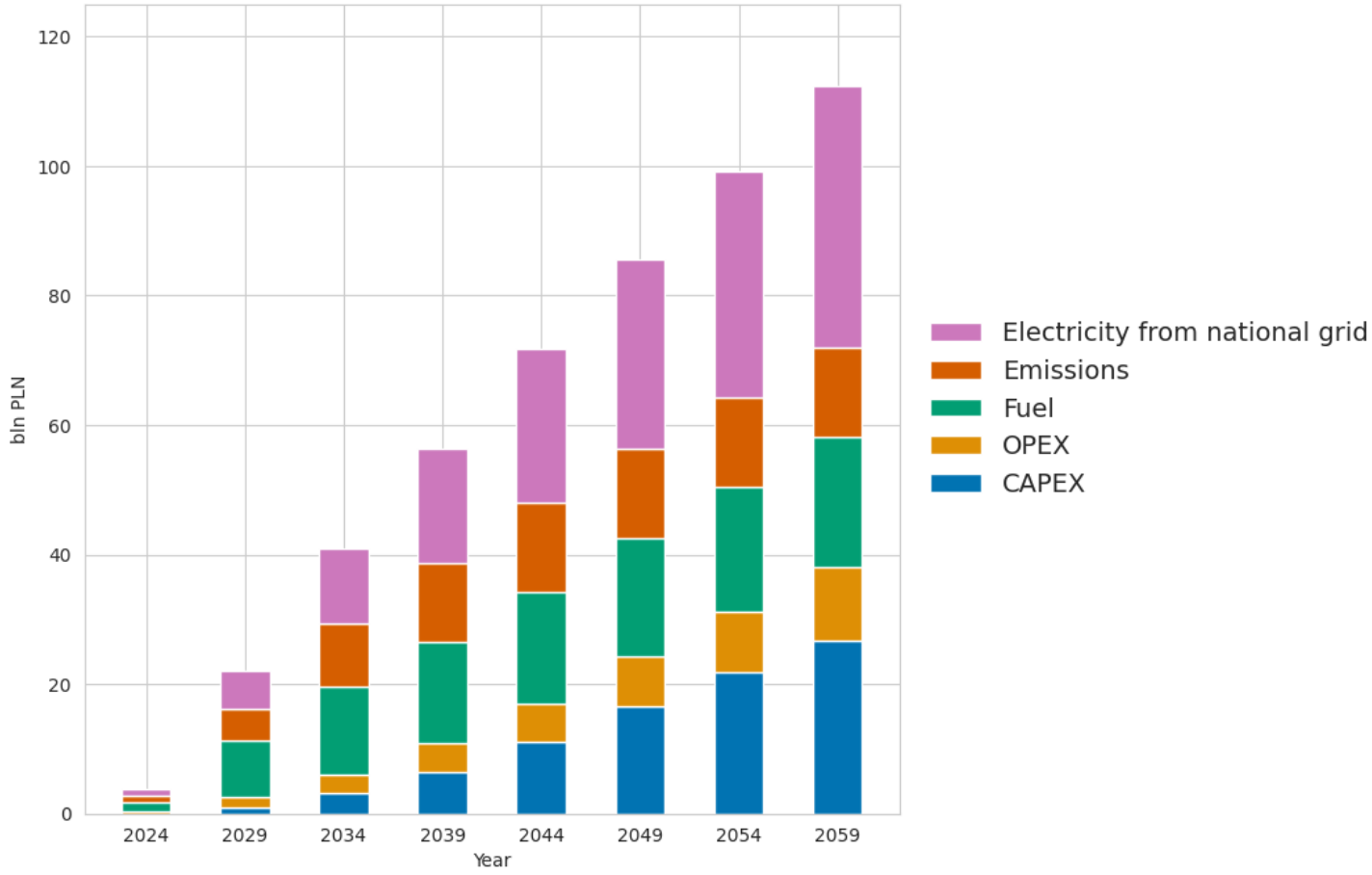

Status Quo scenario is **two times** more costly than others.

# Cumulated cost of Scenario 2

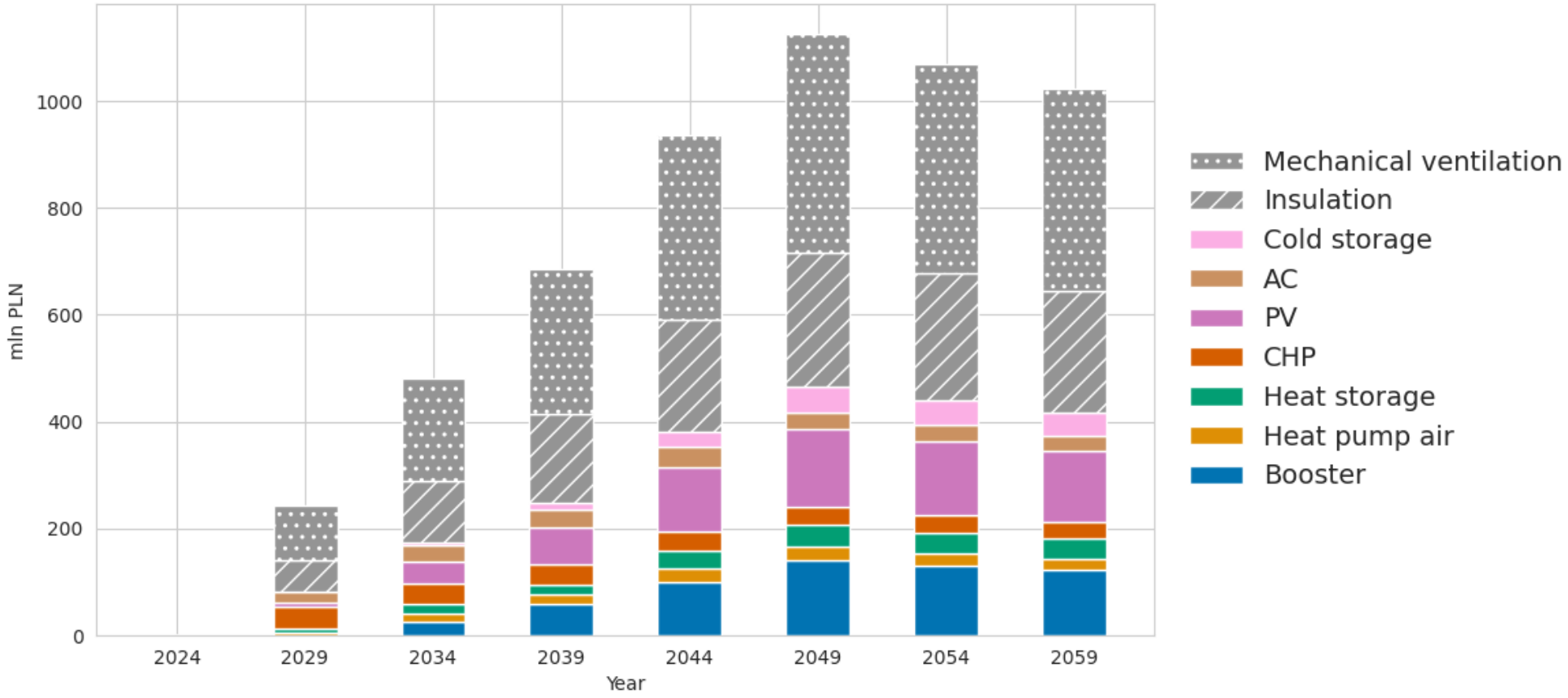
Electricity costs are the prevalent expenses.

CAPEX constitutes only 25% of total sum.

No emissions after 2049.



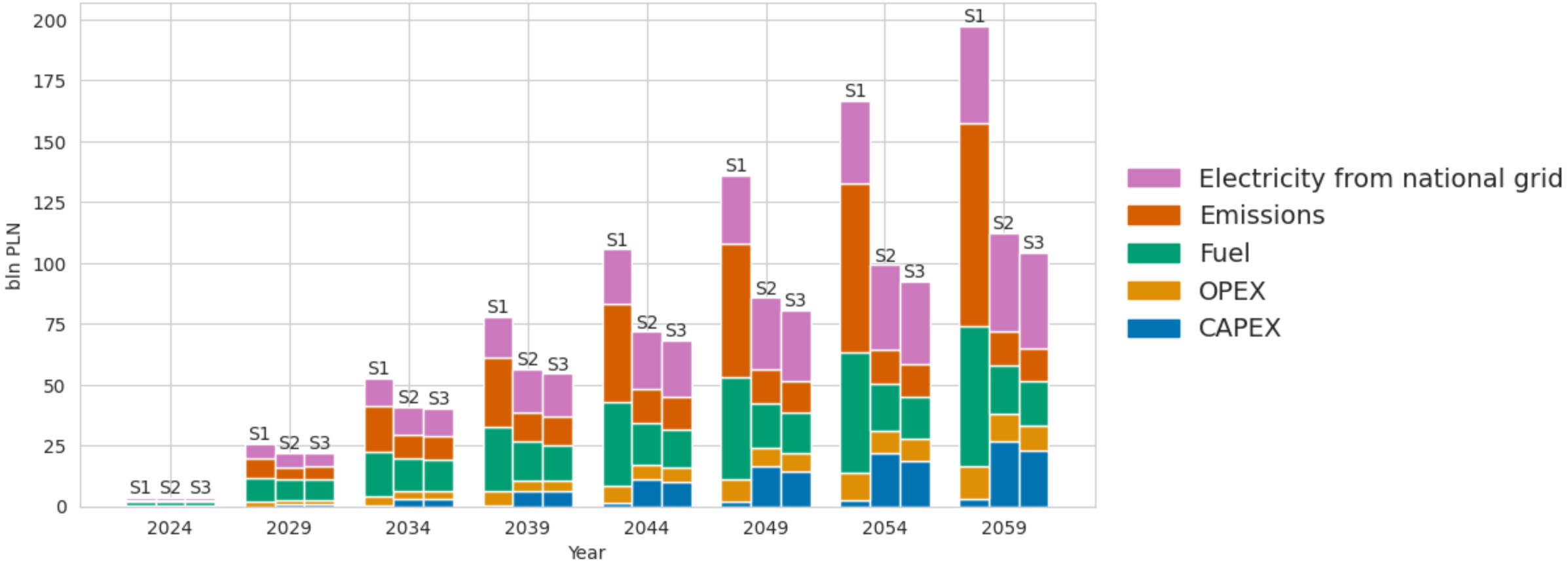
# Yearly CAPEX in Scenario 2




Most CAPEX expenses are incurred due to fast pace of building modernization – 4% of buildings per year.

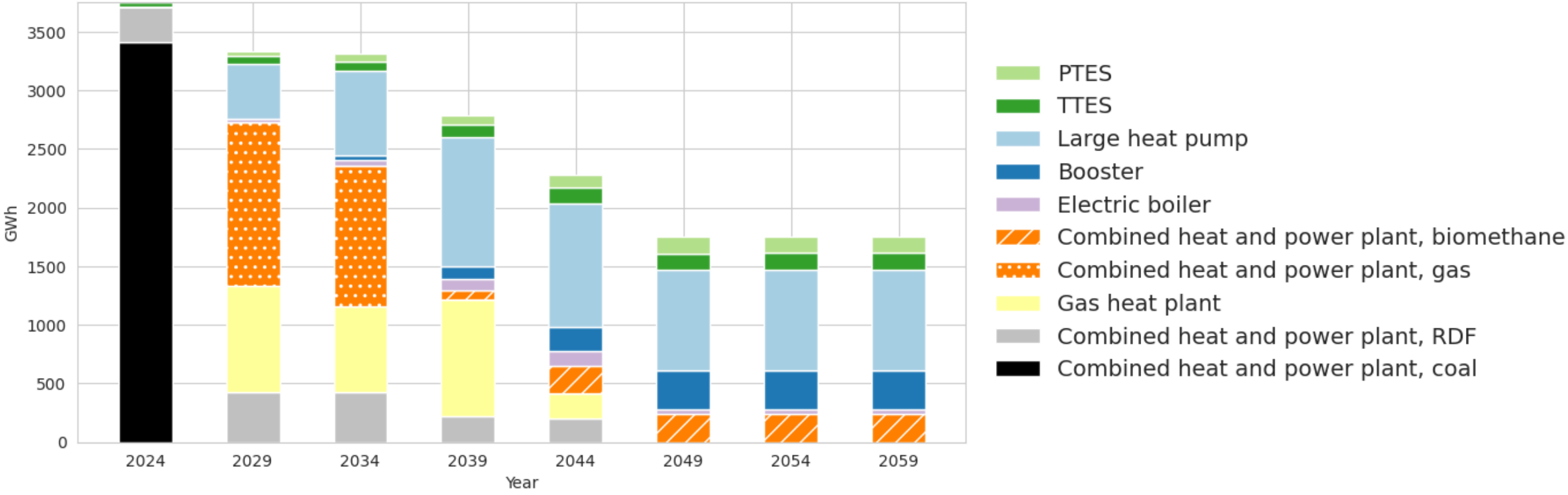
# Comparision of cost categories between scenarios

Large emission costs in Status Quo scenario.
Even without them we are still incurring more expenses as in other scenarios.



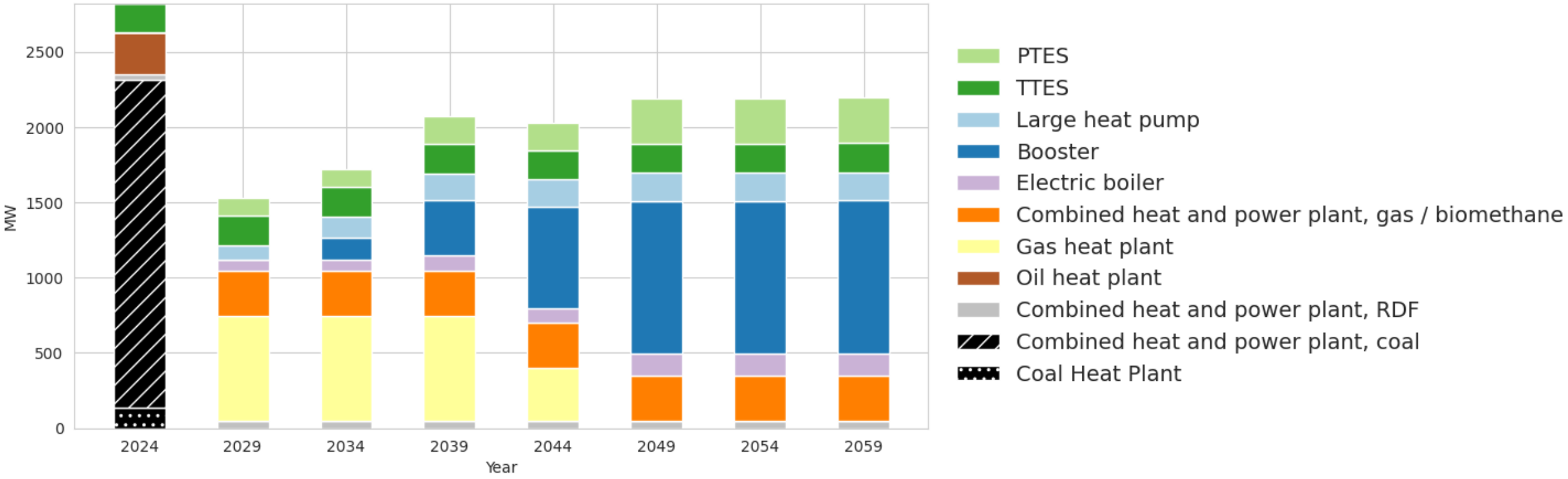
# Heating production, Scenario 2

Waste heat from boosters providing cold in summer is a significant amount of energy that can be reused in winter.



# Installed power in district heating, Scenario 2

Waste heat from boosters providing cold in summer is a significant amount of energy that can be reused in winter.



# Conclusion 1/2

- The use of ZEFIR tools makes it possible to plan investments that are cost-effective from a long-term perspective.
- Each city requires a customized approach, especially the estimation of the potential of individual technologies.
- The need for thoughtful development and integration of national databases collecting information on building parameters such as:
  - Energy efficiency class,
  - Heating demand,
  - Heating source.

# Conclusion 2/2

- Carrying out a cost-effective energy transition from fossil fuels will require electrification of the district heating industry, increasing energy efficiency of buildings measures and effective use of biomethane potential.

- Well-conducted electrification of the heating industry will be instrumental in avoiding oversizing the electricity grid and the associated social costs. This will require the implementation of local energy regulations.

- Natural gas is the cheapest transition technology.

- Designing effective ways to finance the transition requires a holistic vision that includes the entire energy system rather than individual technologies.

# Thank you for your attention!

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