



Decarbonising process heat

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Institute for Resource Efficiency and Energy Strategies

RESEARCH INSTITUTE

Sustainable use of energy and resources

SINCE 2006

Founded as a spin-off from the Fraunhofer ISI in Karlsruhe
20 employees

CUSTOMERS

Federal and state ministries, cities, industrial companies / utilities, EU Commission, international organisations



ENERGY POLICY AND TECHNOLOGIES

Assessment and design of policy instruments in the buildings and industry sector
Scenario analyses building sector

SOCIAL SCIENTIFIC EVALUATION

Evaluation of research and funding programmes
Acceptance of energy technologies
Stakeholder participation

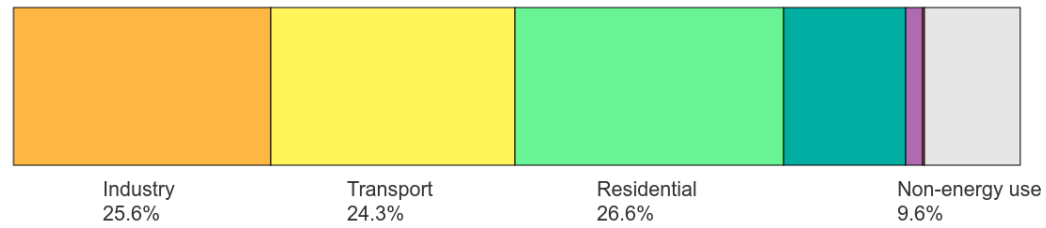
ENERGY MANAGEMENT AND ENERGY SYSTEM MODELS

Decarbonisation of heat supply infrastructures
Energy efficiency/climate neutrality strategies
Industrial companies

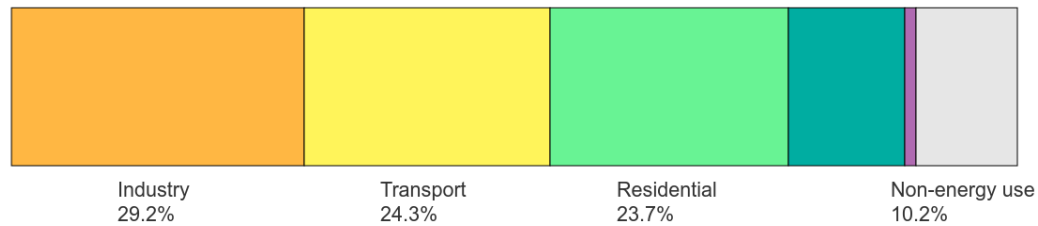
Energy consumption in Germany & Slovakia



Total final consumption, Germany, 2022



Total final consumption, Slovak Republic, 2022

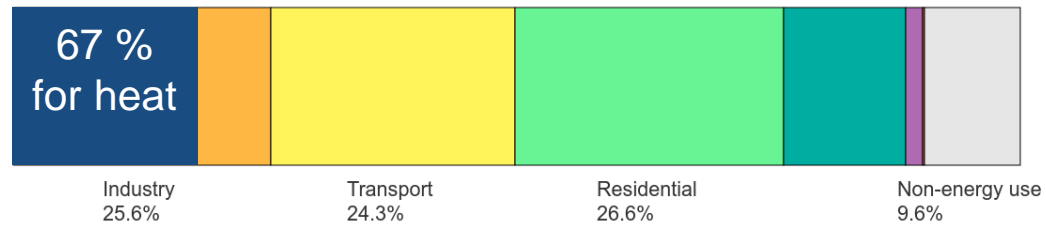


- Industry
- Residential
- Agriculture / forestry
- Transport
- Commercial and public services
- Non-energy use

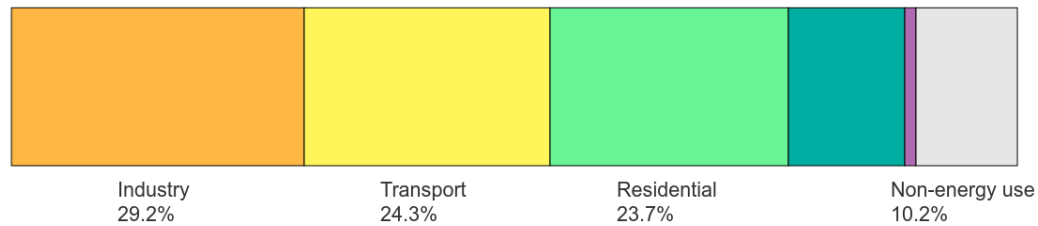
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Total final consumption, Germany, 2022



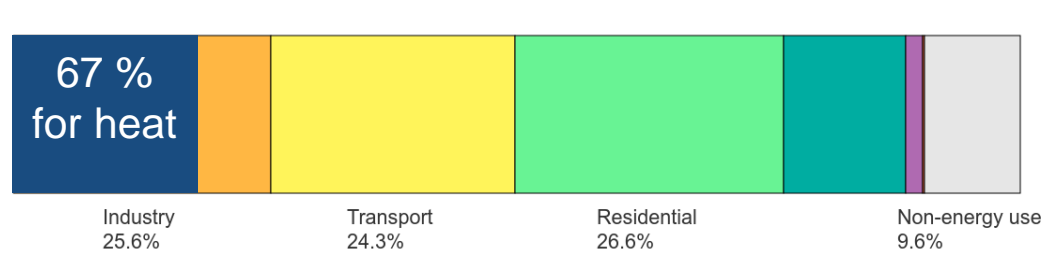
Total final consumption, Slovak Republic, 2022



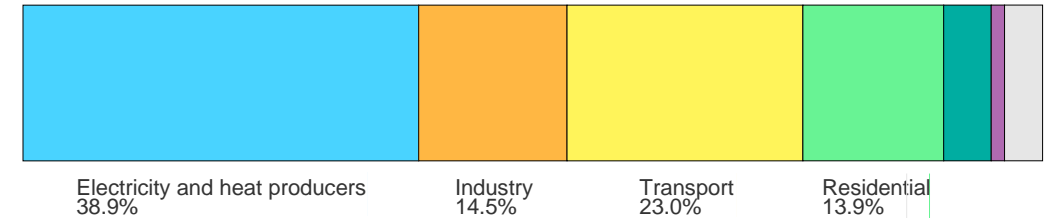
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Energy consumption in Germany & Slovakia

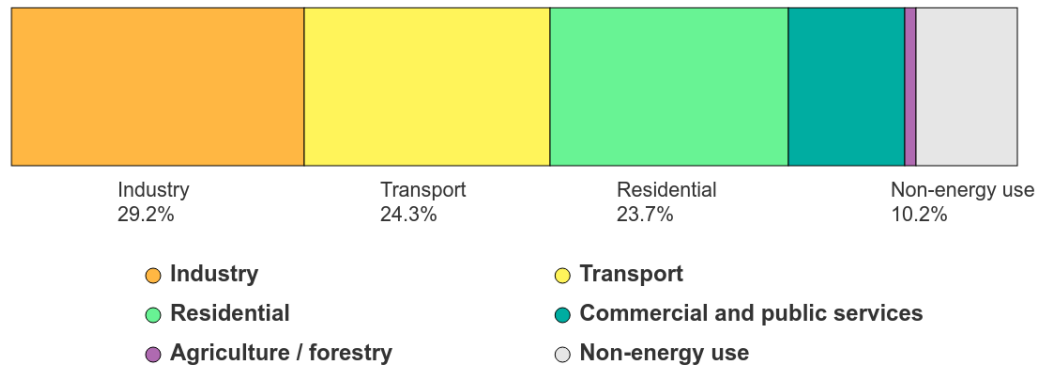
Total final consumption, Germany, 2022



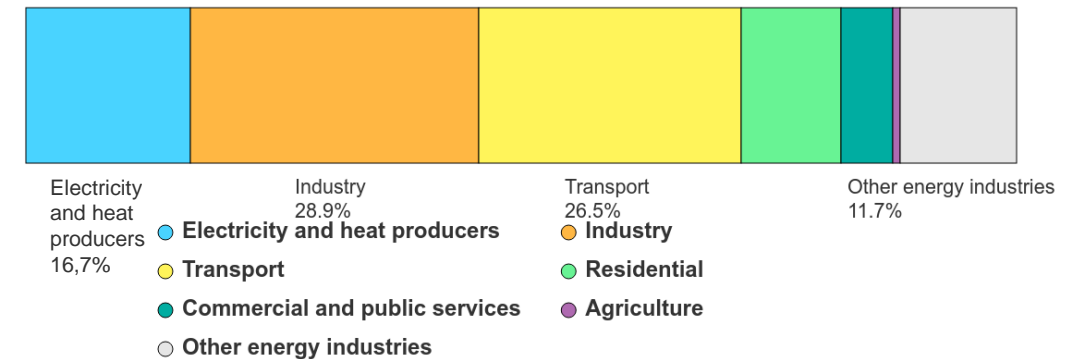
CO2 emissions by sector, Germany, 2022



Total final consumption, Slovak Republic, 2022

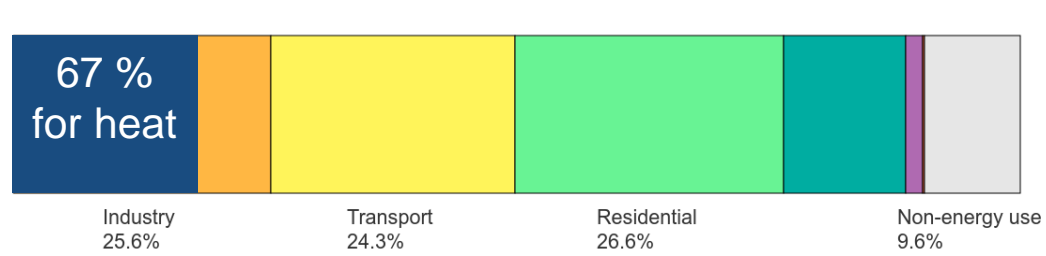


CO2 emissions by sector, Slovak Republic, 2022

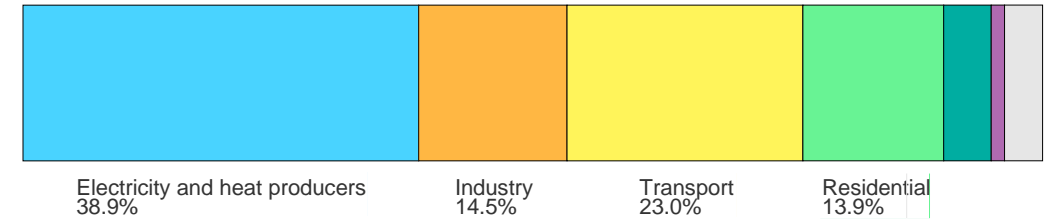


Energy consumption in Germany & Slovakia

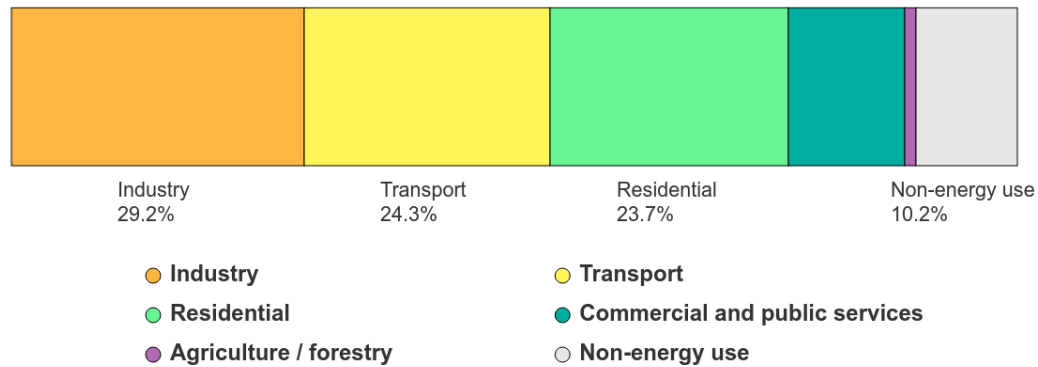
Total final consumption, Germany, 2022



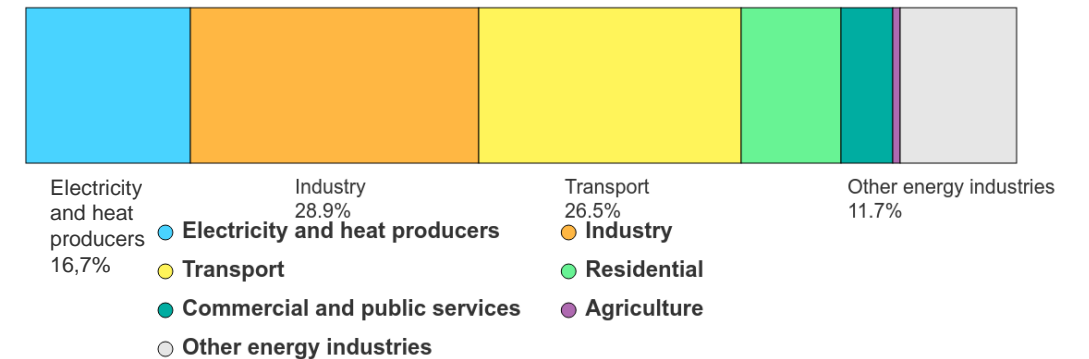
CO2 emissions by sector, Germany, 2022



Total final consumption, Slovak Republic, 2022



CO2 emissions by sector, Slovak Republic, 2022



Project: Decarbonising Process Heat in SMEs in Hamburg, Germany



- Recommendations for the design of funding instruments for the decarbonisation of industry in Hamburg



- Enable local companies to embark on the decarbonisation and climate neutrality pathway



- The analysis focuses on process heating and cooling demand/generation in small and medium-sized enterprises (SMEs) in industry and the tertiary sector.

Project: Decarbonising Process Heat in SMEs in Hamburg, Germany



1 Which sectors require much energy?

11 relevant industry sectors

2 Which processes in these sectors require heating and cooling?

Focus: heating
↓
53 processes

3 Processes in detail:

Temperature level
+
Heat transfer medium

4 Process heat technologies:

Fossile energy carrier
Renewable energy carrier €?

Analysis of current process technologies and future decarbonised technologies for different temperature levels & heat transfer medium



“Industry” by Unknown author is licensed according to [CC BY-NC-ND](#)

Main technologies <120°C

<120 ° C

Fossil fuel technologies

Large-capacity water boiler

Tube water boiler

Combined heat and power

Burner for direct firing, e.g. for oven, drying or cooking processes

Non-fossil fuel technologies

Heat pump

Biomass boiler

Solar thermal

Burner with renewable fuels

District heating

H₂- boiler

Electric boiler

Resistance heating

Fuel cell

Main technologies <120°C

<120 ° C

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Large-capacity water boiler

Tube water boiler

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Biomass boiler

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H₂- boiler

Electric boiler

Resistance heating

Fuel cell

Heat transfer medium

Water

Steam

Exhaust gas

Air

Thermal oil

Energy carrier

Heating oil

Natural gas

coal

Energy carrier

Biomass

H₂ / synthetic fuels

District heating

Electricity

Main technologies $>120\text{ }^{\circ}\text{C}$ and $<300\text{ }^{\circ}\text{C}$

$>120\text{ }^{\circ}\text{C}$ and $<300\text{ }^{\circ}\text{C}$

Fossil fuel technologies

Steam boiler

Gas turbine

Thermal oil boiler

Burner for direct firing, e.g. for oven, drying or cooking processes

Non-fossil fuel technologies

Heat pump

Steam compressors

Solar thermal

Burner with renewable fuels

Infrared

H₂- boiler

Electric boiler

Resistance heating

Hot air blower

Induction

Microwave

Main technologies >120 °C and <300 °C

>120 ° C and <300 ° C

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Gas turbine

Thermal oil boiler

Burner for direct firing, e.g. for oven, drying or cooking processes

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Heat transfer medium

Steam

Exhaust gas

Air

Thermal oil

Energy carrier

Heating oil

Natural gas

coal

Energy carrier

Biomass

H₂ / synthetic fuels

Electricity

Main technologies >300 °C

>300 ° C

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Non-fossil fuel technologies

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Resistance heating

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Infrared

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>300 ° C

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Non-fossil fuel technologies

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Resistance heating

Hot air blower

Induction

Infrared

Microwave

Heat transfer medium

Exhaust gas

Air

Energy carrier

Heating oil

Natural gas

coal

Energy carrier

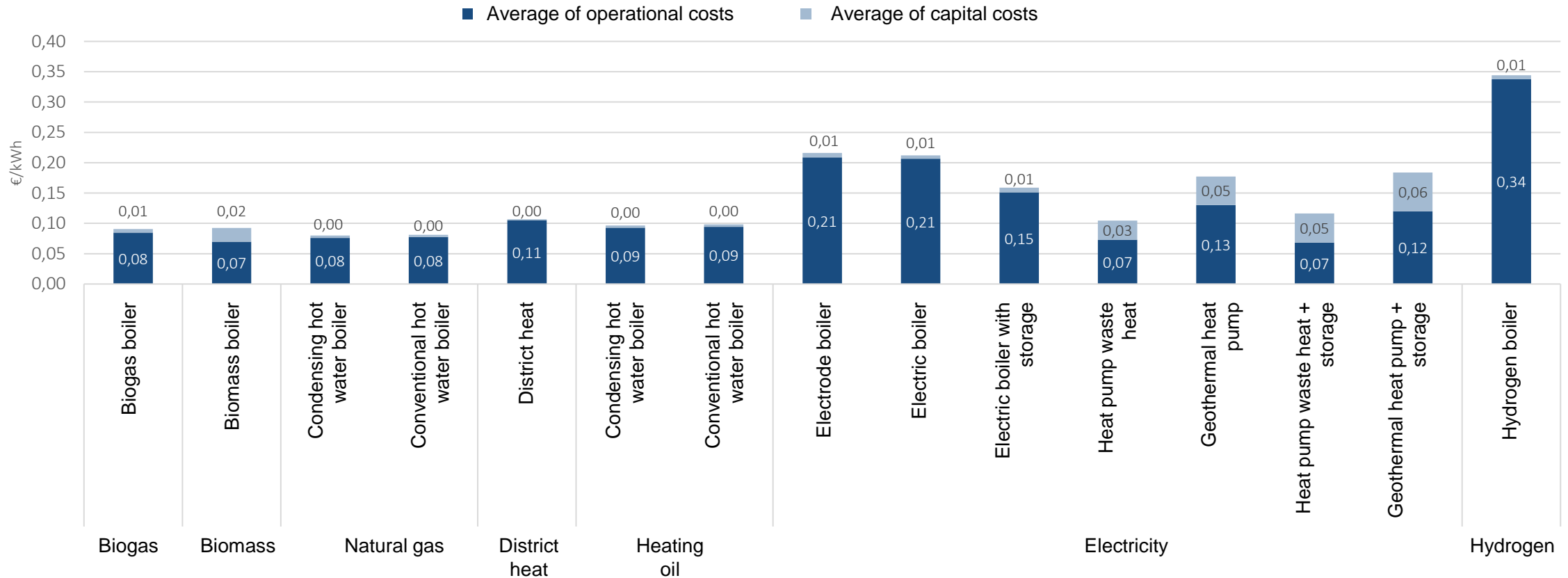
H2 / synthetic fuels

Electricity

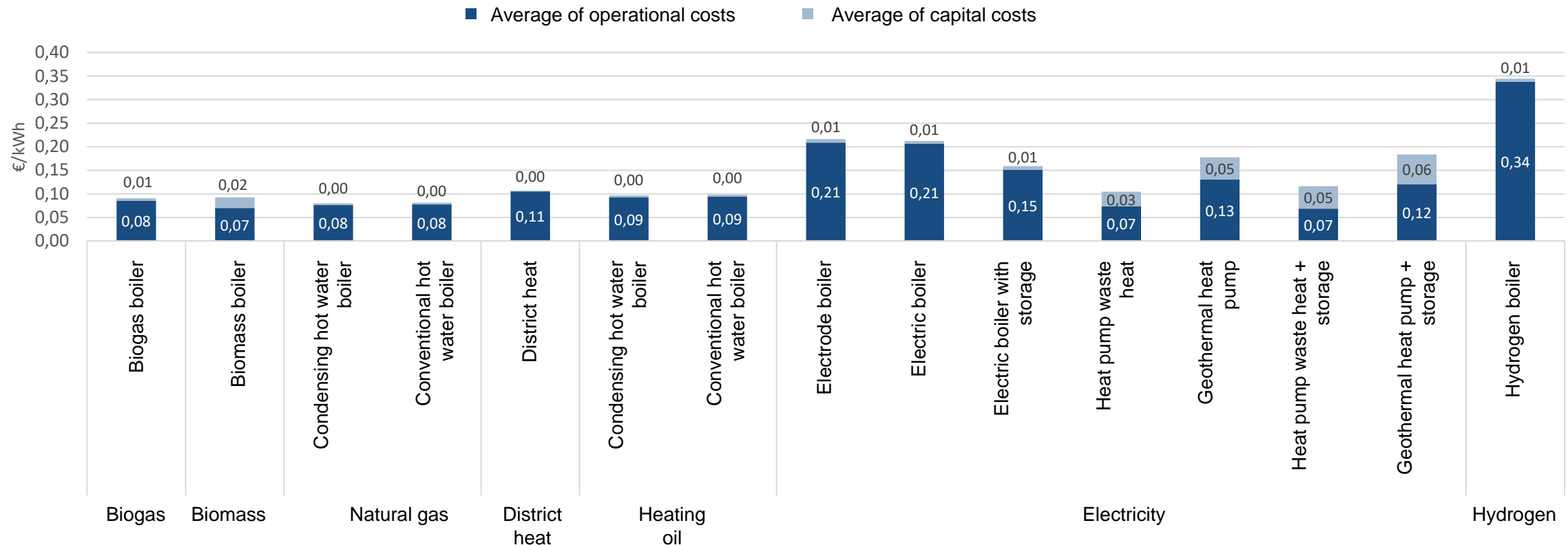
Heat generation costs



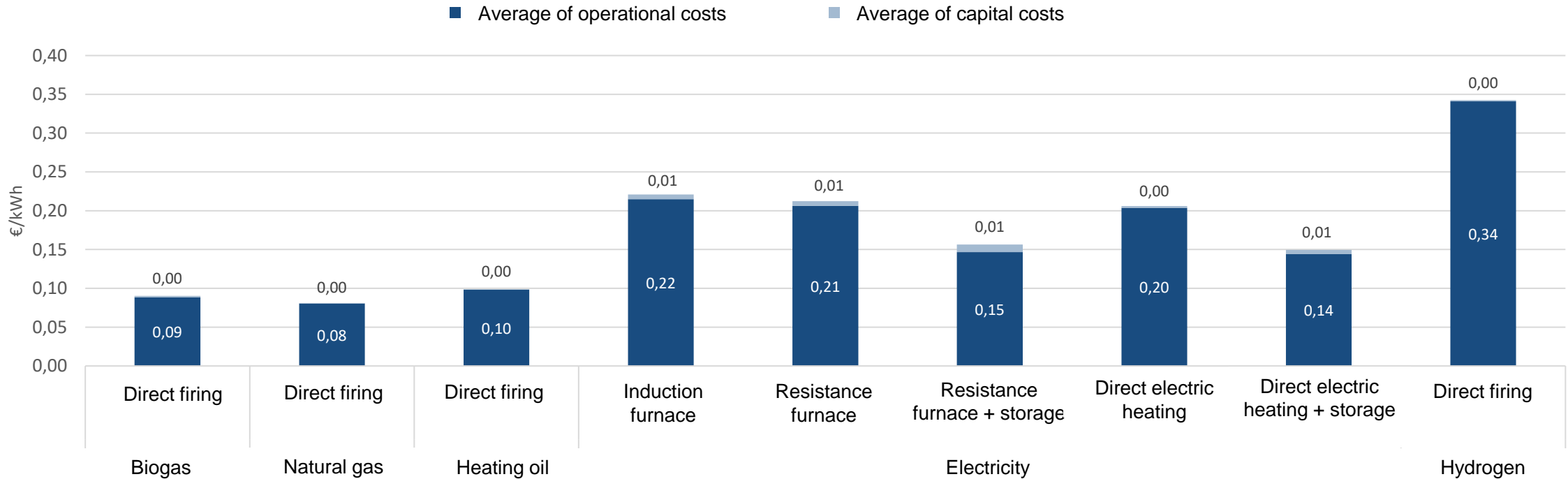
Heat generation costs for technologies with hot water as the heat transfer medium and 120 °C



Heat production costs of technologies for process heat generation with steam as heat transfer medium and at 200°C



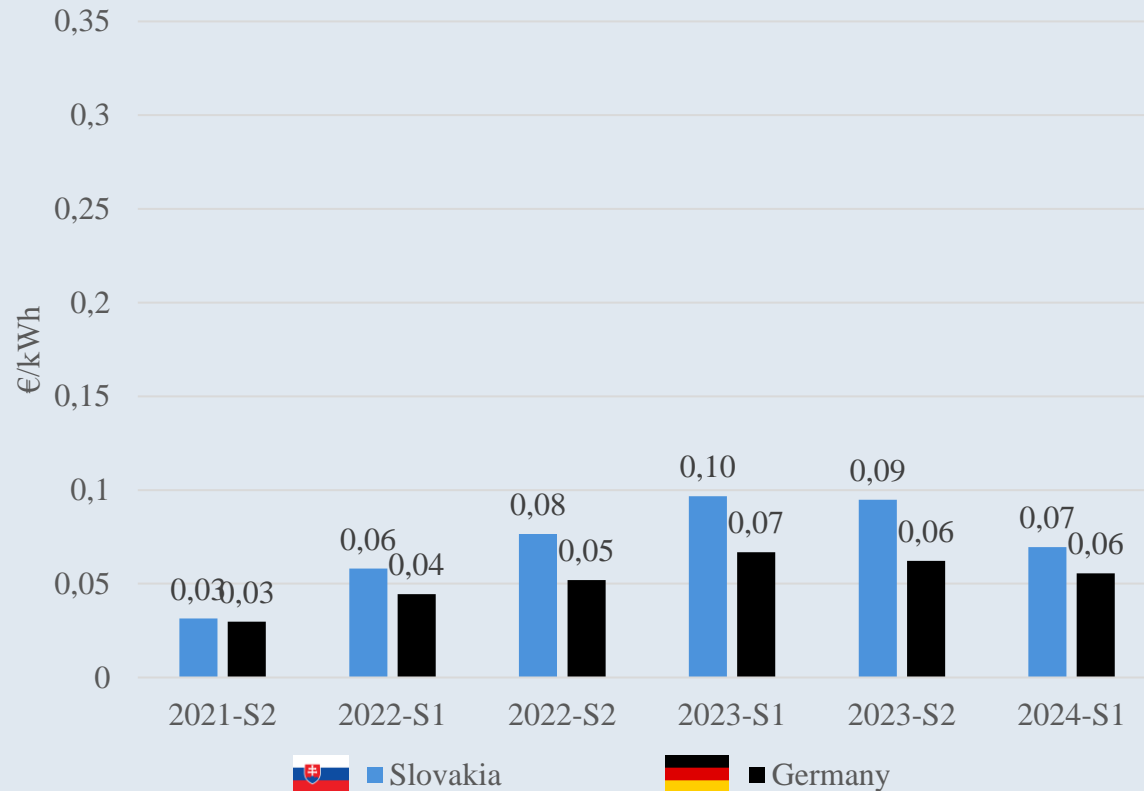
Heat production costs of technologies for process heat generation with gas as heat transfer medium and at 500°C



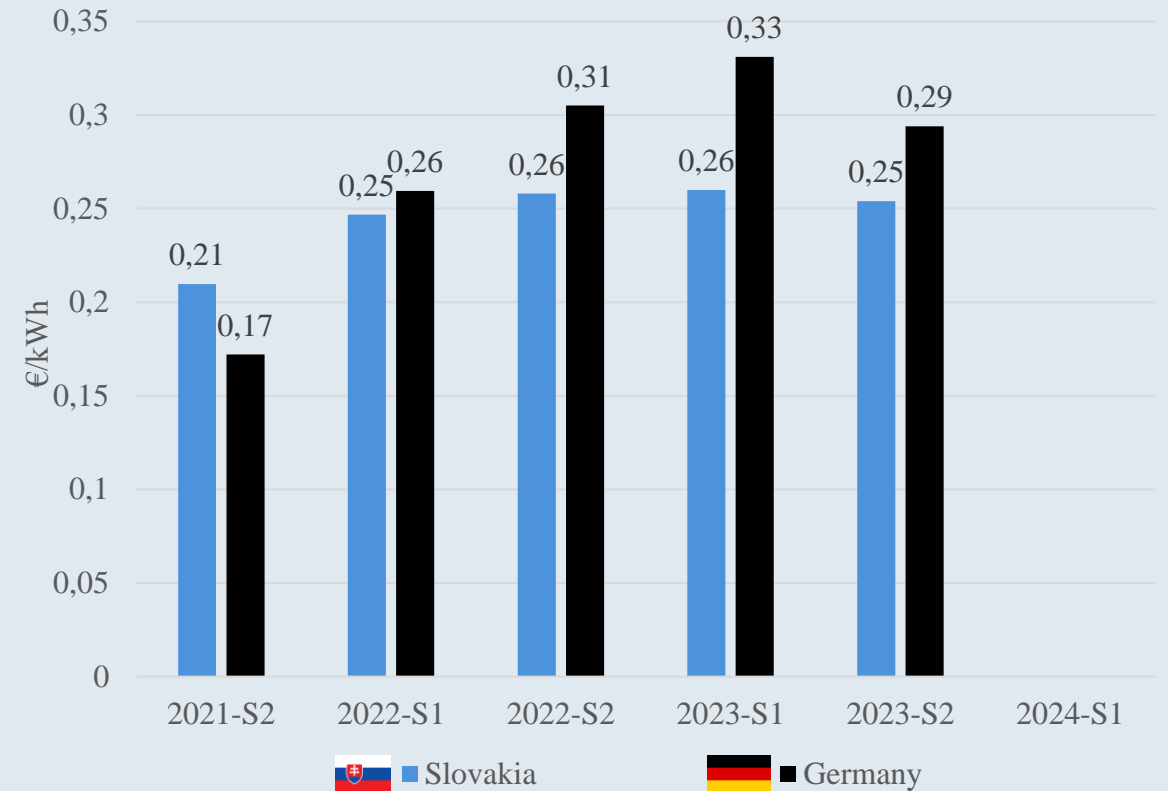
Across all temperatures, operating costs are responsible for a large proportion of total costs!

Energy prices in Slovakia & Germany

Gas prices for non-household consumers

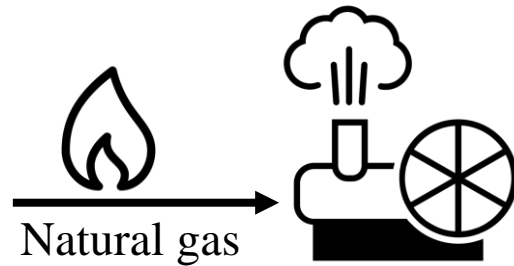


Electricity prices for non-household consumers

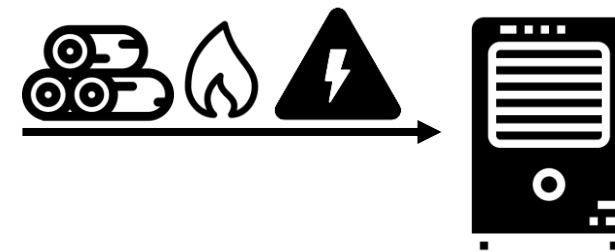


Costs of replacing fossile with renewable technologies to generate process heat

Reference technology

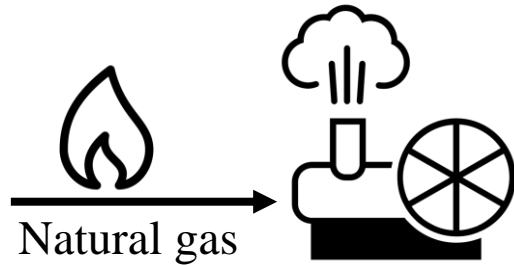


Decarbonisation technology

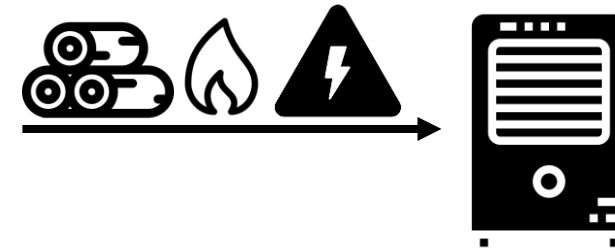


Costs of replacing fossile with renewable technologies to generate process heat

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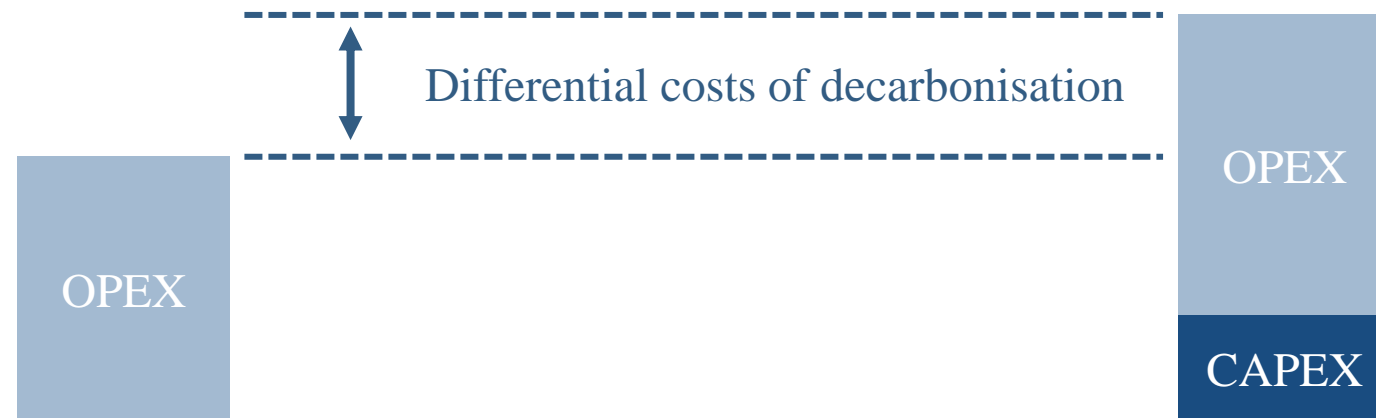


Decarbonisation technology



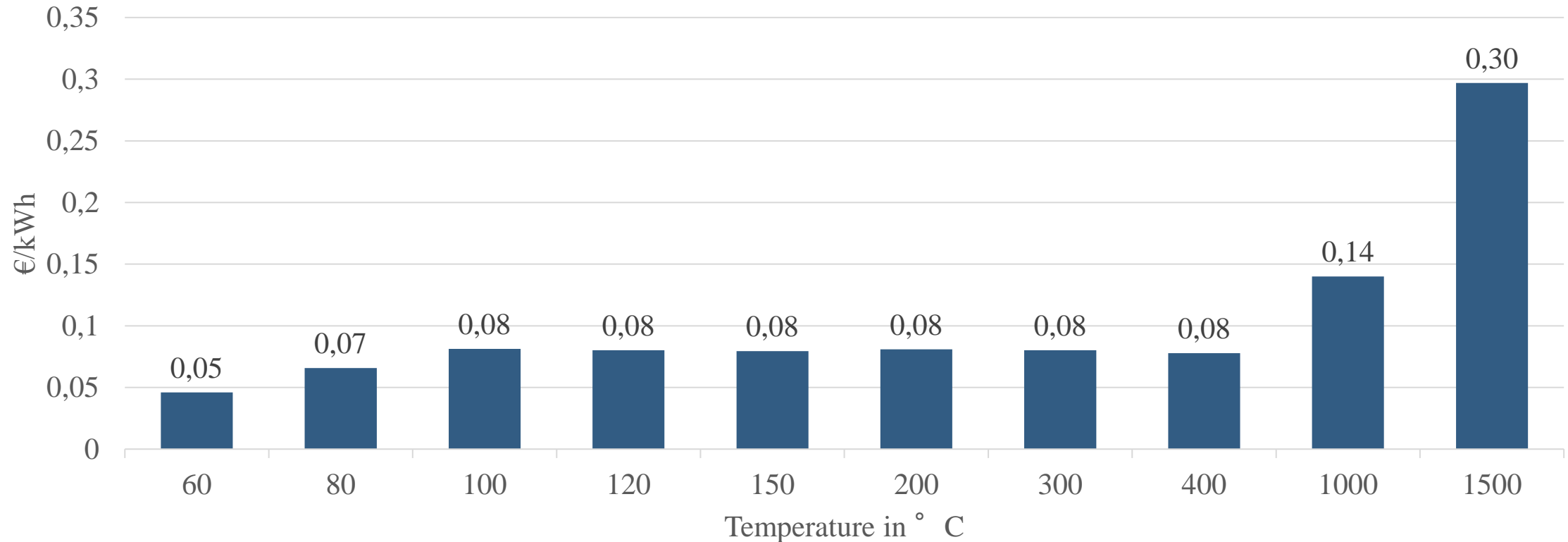
Cheapest replacement

Assumption:
Capital costs
already
amortized



Cost of decarbonising process heat in Germany

Specific differential costs of decarbonisation by temperature level



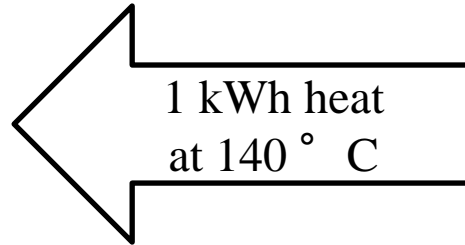
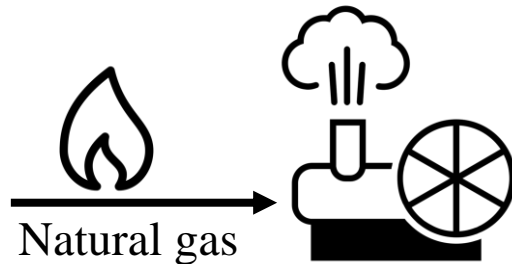
Based on the results an OPEX support scheme for additional operation expenditure of decarbonisation has been implemented in Hamburg

UfR – Unternehmen für Ressourcenschutz: Förderschwerpunkt 4: Decarbonizing process heat generation

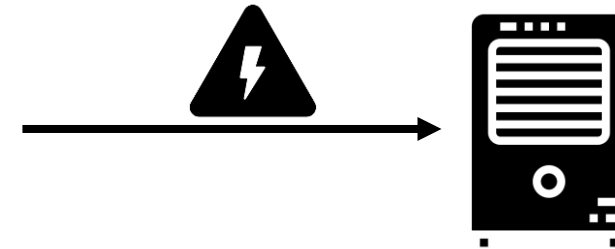
- Support scheme covers additional operation expenditures (differential costs of decarbonisation) of renewable process heat technologies
- Fossil-fuel plants are replaced by district heat or heat pumps
- Funding for additional operating costs is granted for 5 years

Costs of replacing fossile with renewable technologies to generate process heat

Steam boiler



Heat pump



$$\frac{\text{Natural gas price}}{\text{efficiency}} = \text{OPEX}$$

$$= \frac{7,1 \text{ ct/kWh}}{90\%}$$

$$= 7,89 \text{ ct/kWh}$$

$$\frac{\text{Electricity price}}{\text{COP}} = \text{OPEX}$$

$$= \frac{29 \text{ ct/kWh}}{1,38}$$

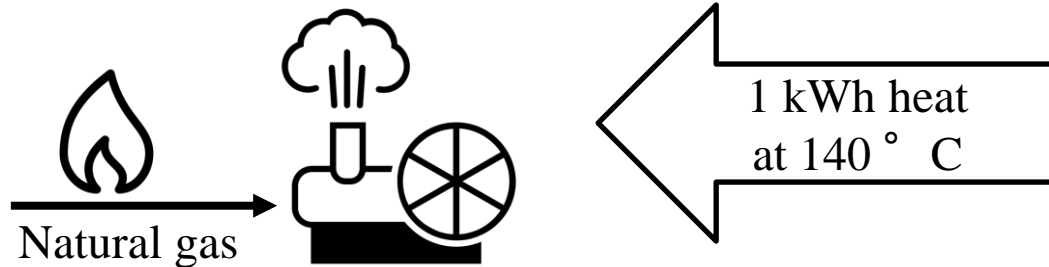
$$= 21,01 \text{ ct/kWh}$$

CAPEX

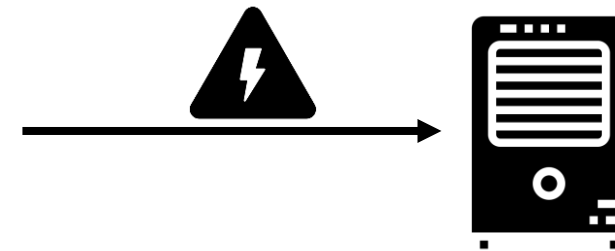
Not significant & other funding in Germany

Costs of replacing fossile with renewable technologies to generate process heat

Steam boiler



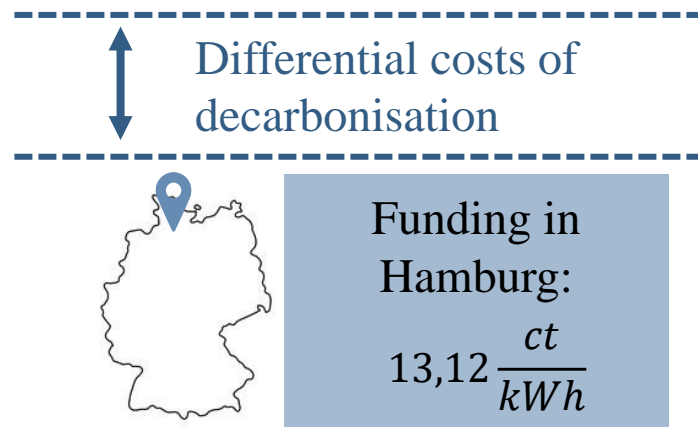
Heat pump



$$\frac{\text{Natural gas price}}{\text{efficiency}} =$$

$$= \frac{7,1 \text{ ct/kWh}}{90\%}$$

$$= 7,89 \text{ ct/kWh}$$



$$\frac{\text{Electricity price}}{COP} =$$

$$= \frac{29 \text{ ct/kWh}}{1,38}$$

$$= 21,01 \text{ ct/kWh}$$

Not significant & other funding in Germany

Conclusion

Process heat is significantly increasing emissions:



Decarbonise electricity system for emission saving in cooling

Defossilise heat production for emission saving in heating



Costs of defossilising heat production are increasing with increasing temperature



Operational costs are the main contributor to overall heat production costs



To decrease the differential costs of decarbonisation, funding needs to be applied to the operational costs



Federal Ministry
for Economic Affairs
and Climate Action



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ENERGY SOLUTIONS
MADE IN GERMANY

Thank you for your attention!

Vanessa Schindler

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and Energy Strategies

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Facilitator

