DTU

Preliminary results

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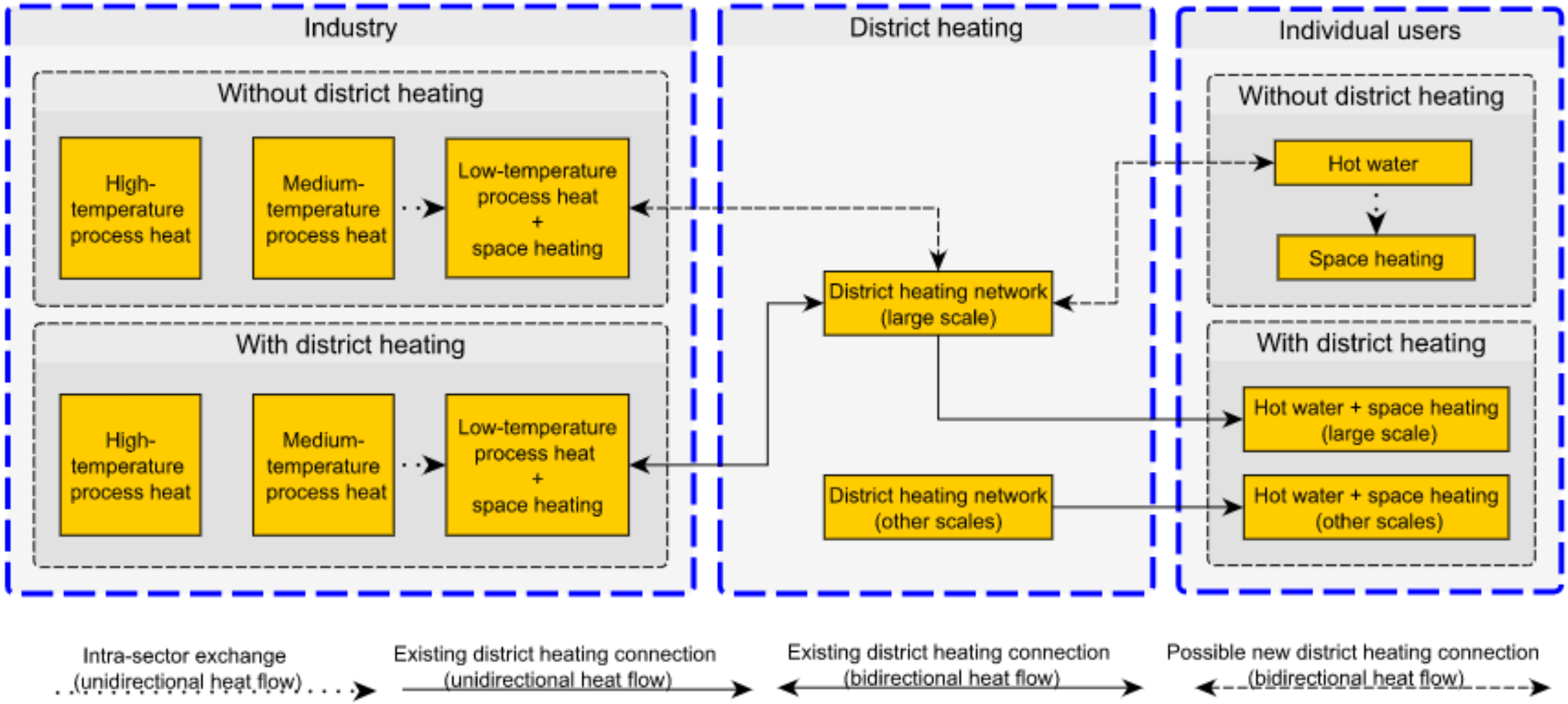
Francesco Gaballo

The role of district heating in future European energy systems

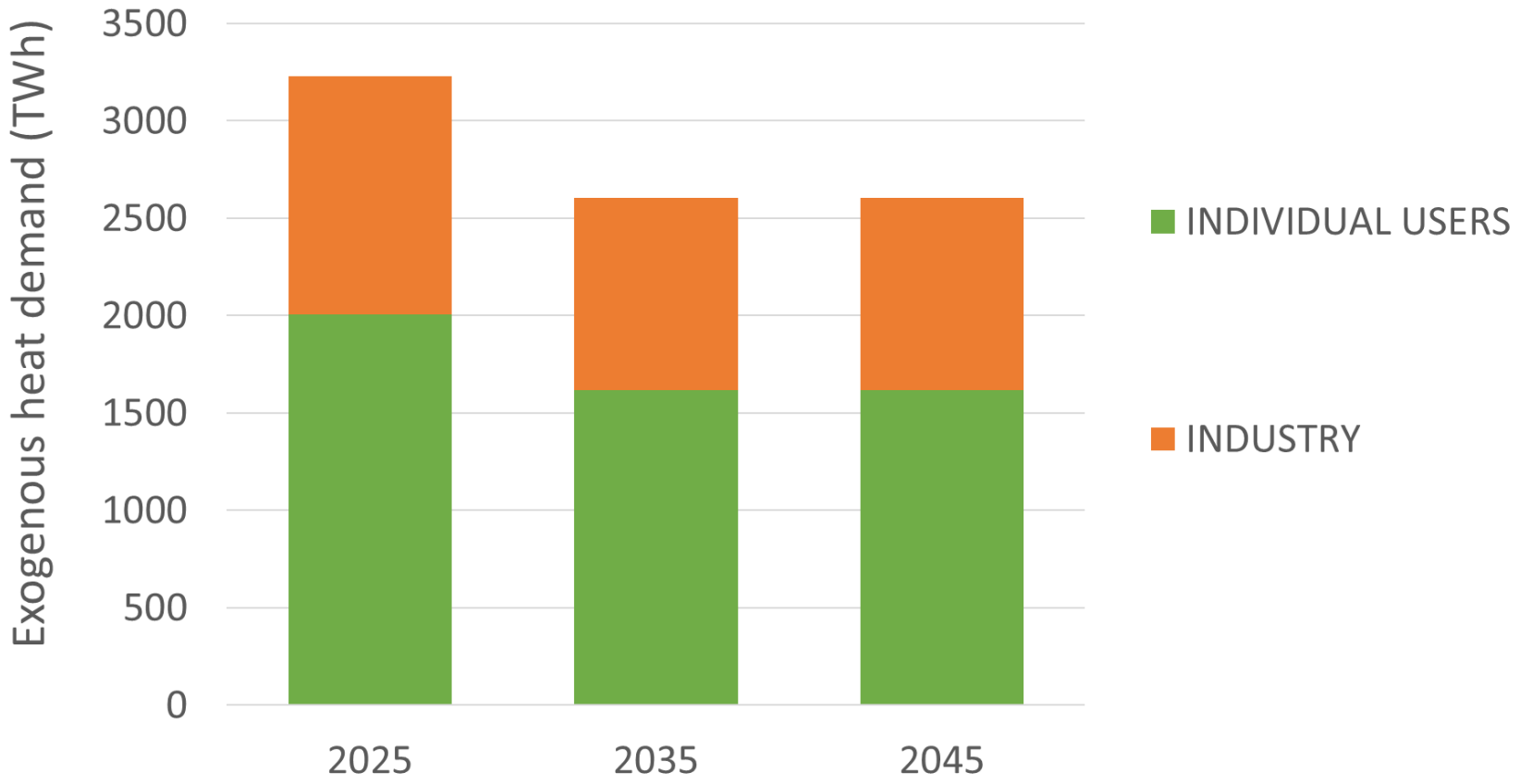
Energy system model

- Open source
- Deterministic
- Partial equilibrium
- Bottom-up
- Flexible modelling framework
- Energy sectors included: Electricity, heat and transport
- Objective function: Minimize system costs to satisfy energy demands

Heat sector modelling



Main assumptions in the heat sector



- Decreasing heat demand towards 2050 due to energy efficiency gains
- 30% reduction with respect to 2020 by 2030 based on European Commission scenarios

Main assumptions in the heat sector

- District heating (DH) expansion costs: 0.4 M€/MW$_{th}$
- DH loss: 10%
- Economies of scale in DH networks and industry
- Possibility to use excess heat from electrolyzers in DH networks
- Large-scale pit heat storage only possible in DH networks

Countries analysed:

- Denmark
- Germany
- Estonia
- Finland
- France
- Lithuania
- Latvia
- The Netherlands
- Norway
- Poland
- Sweden
- UK

Heat demand in the Countries:

Residential sector responsible of 54% of heating and cooling consumption in Europe.

	Res Heat Dem/Tot Heat Dem [%]	Dis Heat in Res Sector [%]	SH/Residential Heat Dem [%]	DHW/Residential Heat Dem [%]
DK	58	65	75	25
DE	43	14	80	20
EE	55	52	86	14
FI	33	38	82	18
FR	53	6	85	15
LT	50	56	89	11
LV	49	31	78	22
NL	37	4	79	21
NO	-	4	84	16
PL	52	42	80	20
SE	35	50	79	21
UK	54	2	79	21

Share of Residential Heat demand Source: Eurostat

Heat demand in the Countries:

	Share of Heat Dem in dense areas [%]*	Share of Heat Dem in highly dense areas [%]**	Avg Heat Demand in dense areas [MJ/m2]
DK	73	26	139
DE	87	24	142
EE	71	26	174
FI	74	38	181
FR	72	14	118
LT	61	12	153
LV	82	50	248
NL	90	4	121
NO	-	-	-
PL	62	20	139
SE	75	41	190
UK	88	11	107

*Dense areas:yearly heat demand above 50MJ/m2

**Highly dense areas: yearly heat demand above 300 MJ/m2 (Heat Roadmap Project)

Scenario characteristics:

- The BAU (Business as Usual) Scenario comprehend the electrification of the heating sector and the energy demand of the Transport sector with the aim of its decarbonization.
- The technology data are taken from the Technology Catalogue of DEA
- CO2 prices are based on Nordic Energy Technology Perspective (NETP) 2016

Factors analyzed potentially impacting DH expansion

- District heating (DH) expansion costs
- CO2 taxation
- Future heat demand for space heating

Uncertainties considered for the studied factors

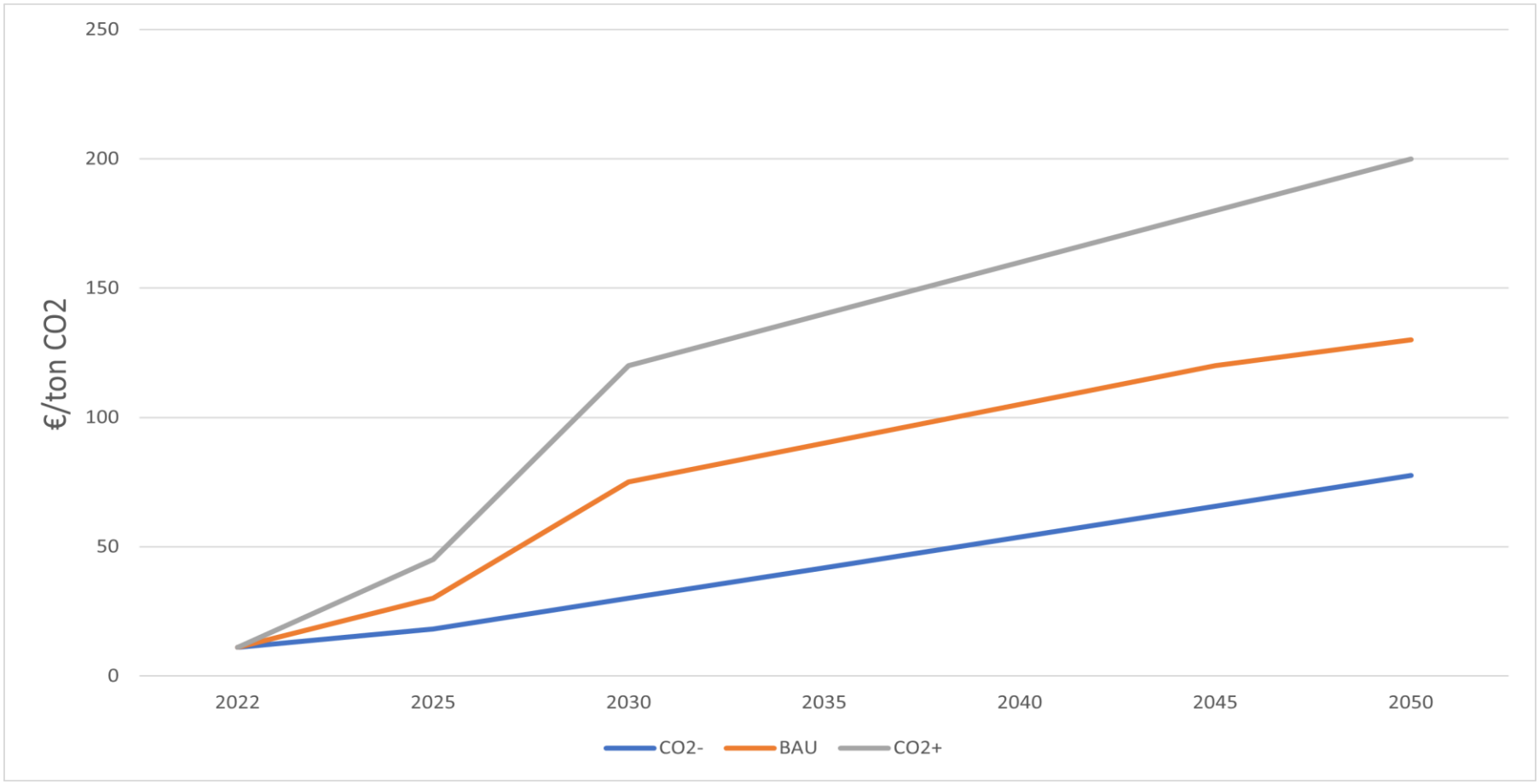
- District heating (DH) expansion costs ±30%
  INV+: +30% BAU investment cost
  INV- : -30% BAU investment cost
  (labour costs, material, R&D..)

- Future heat demand for space heating (Heating and Cooling Outlook).
  SH- : Decreased space heating demand compared to BAU (-20%)

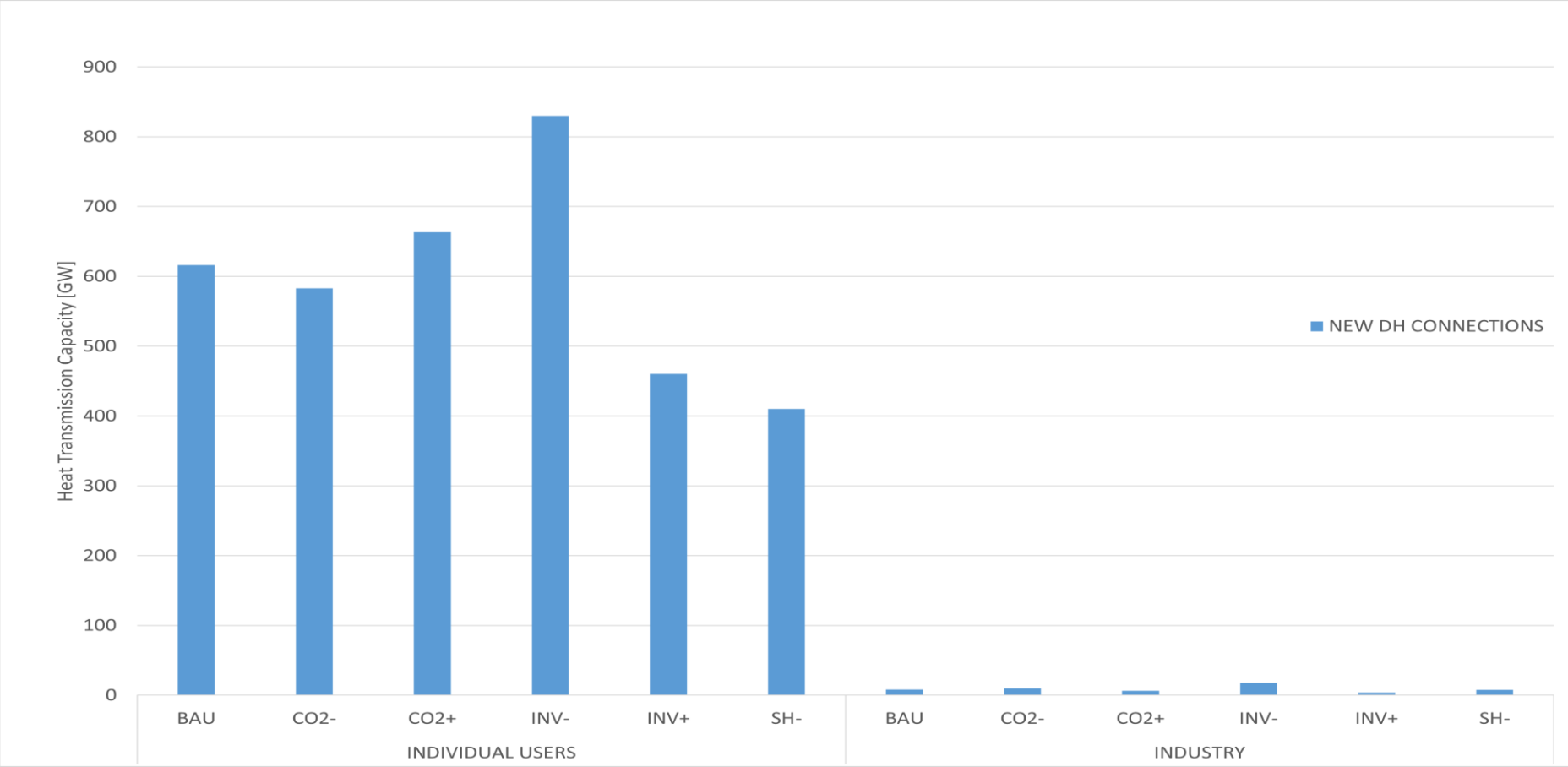
Uncertainties considered for the studied factors

- CO2 price levels in line with OECD Effective Carbon Rates 2021.

  CO2- : 30 €/t CO2 2030 , BAU: 75€/t CO2 2030, CO2+: 120€/t CO2 2030

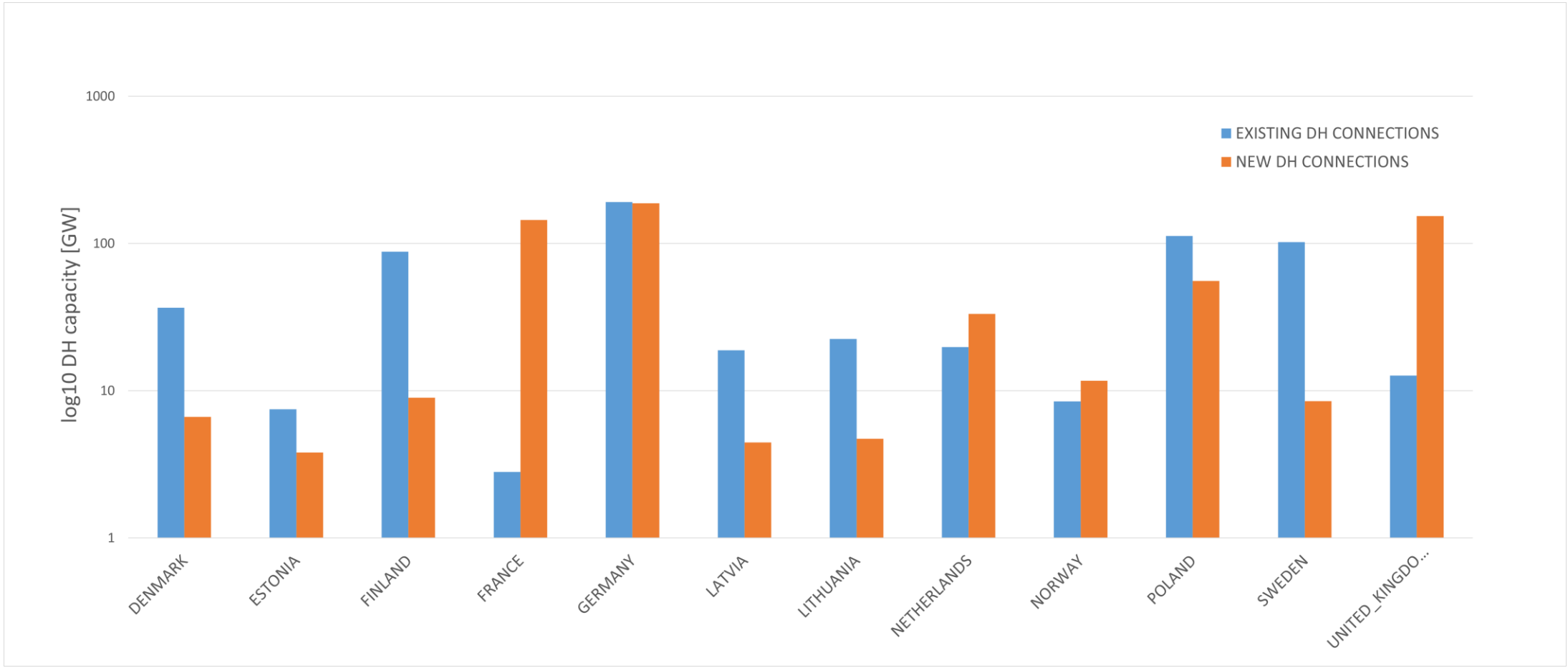


Preliminary results:
Role of the scenarios on DH expansion towards 2050



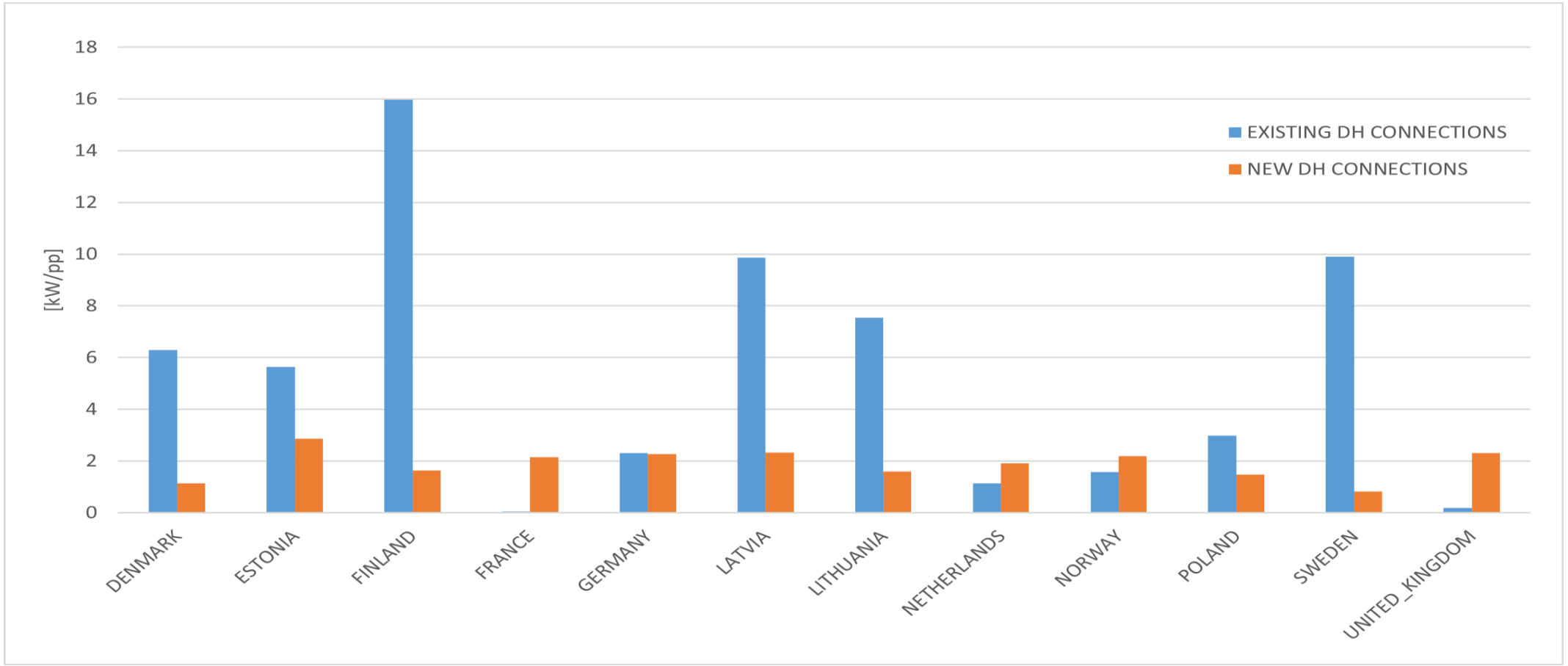
Co2 cost and Investment cost seem to highly affect DH expansion in Europe

Expansion of district heating in the Countries



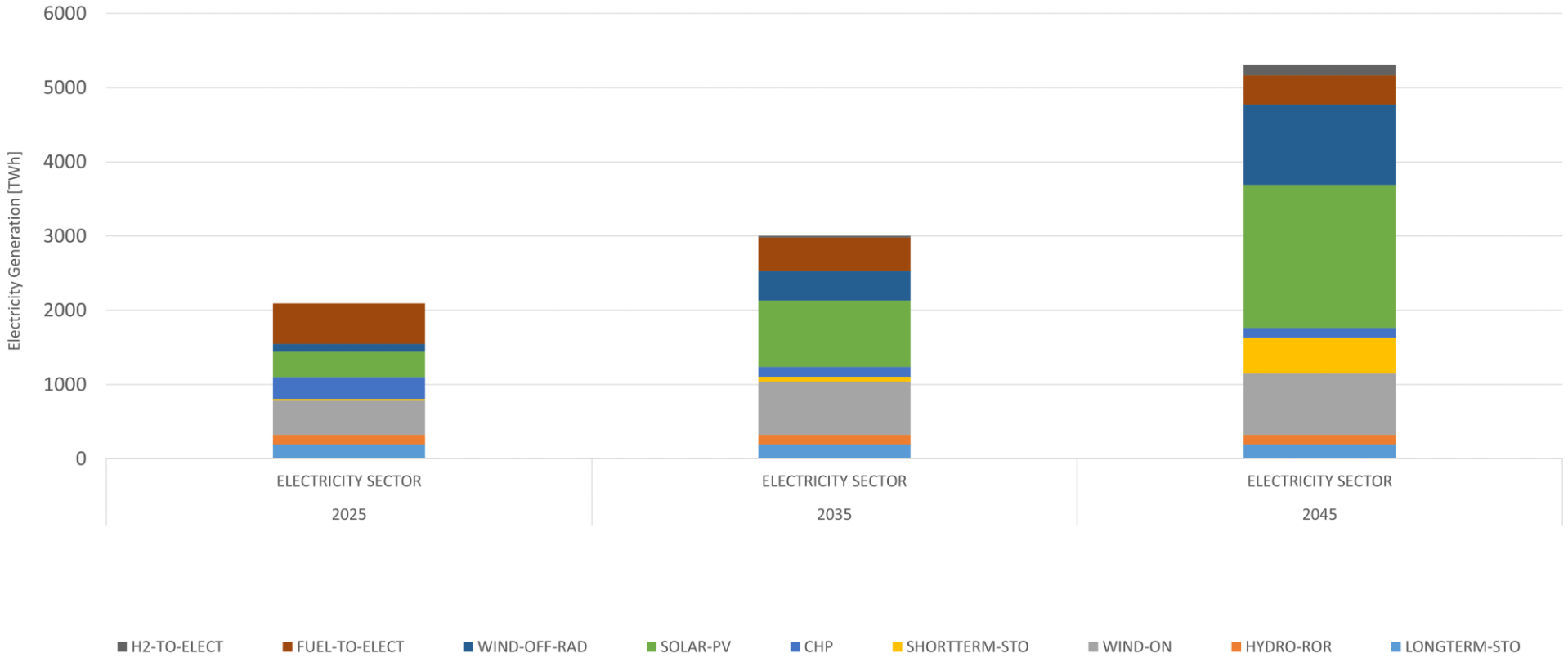
Level based on BAU scenario, cumulated new DH connections towards 2050 per Country in Log10 base .

Expansion of district heating in the Countries



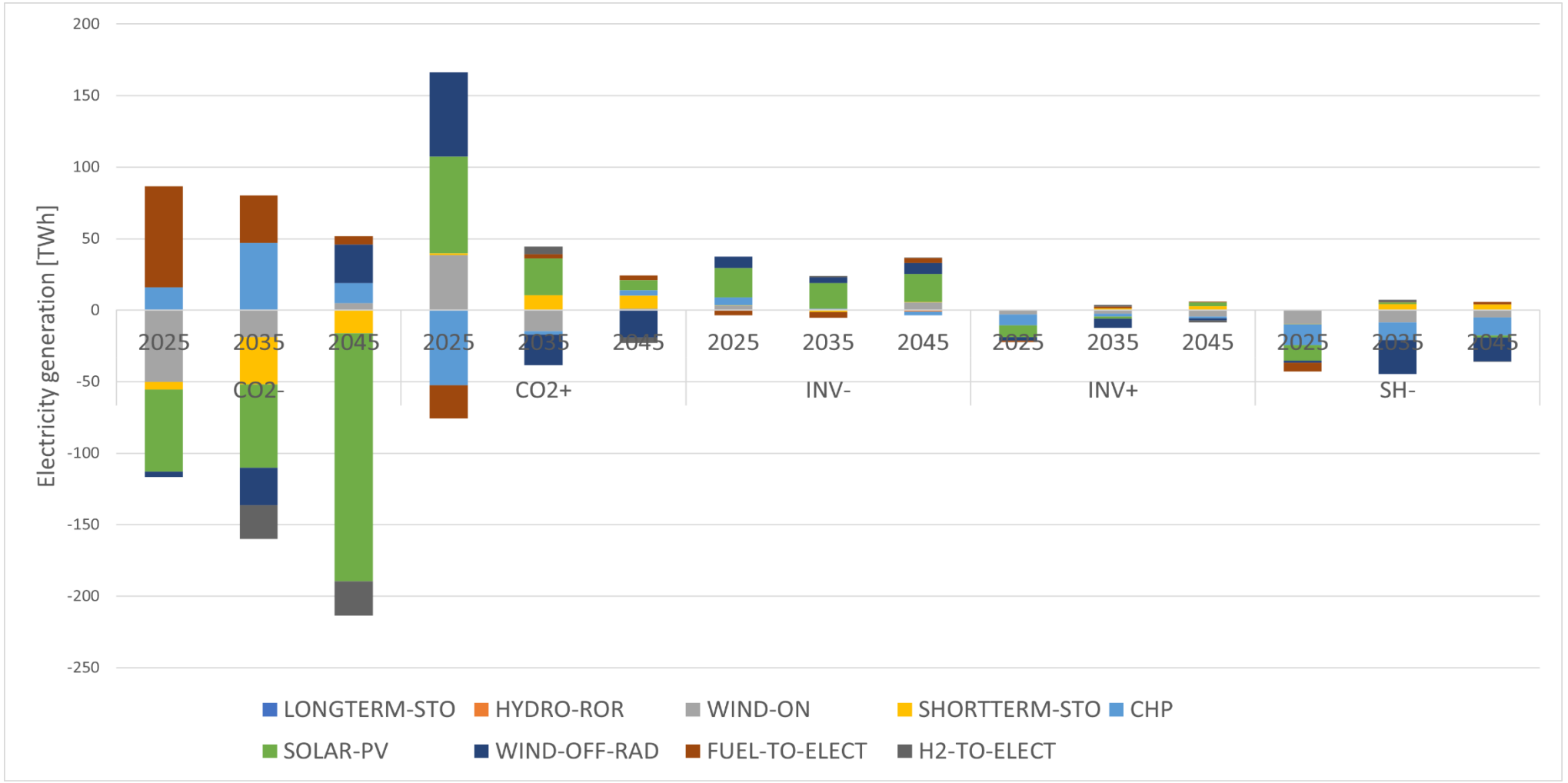
Cumulated new DH connections per capita towards 2050, high potential among all Countries analysed

Business As Usual EU electricity generation towards 2050



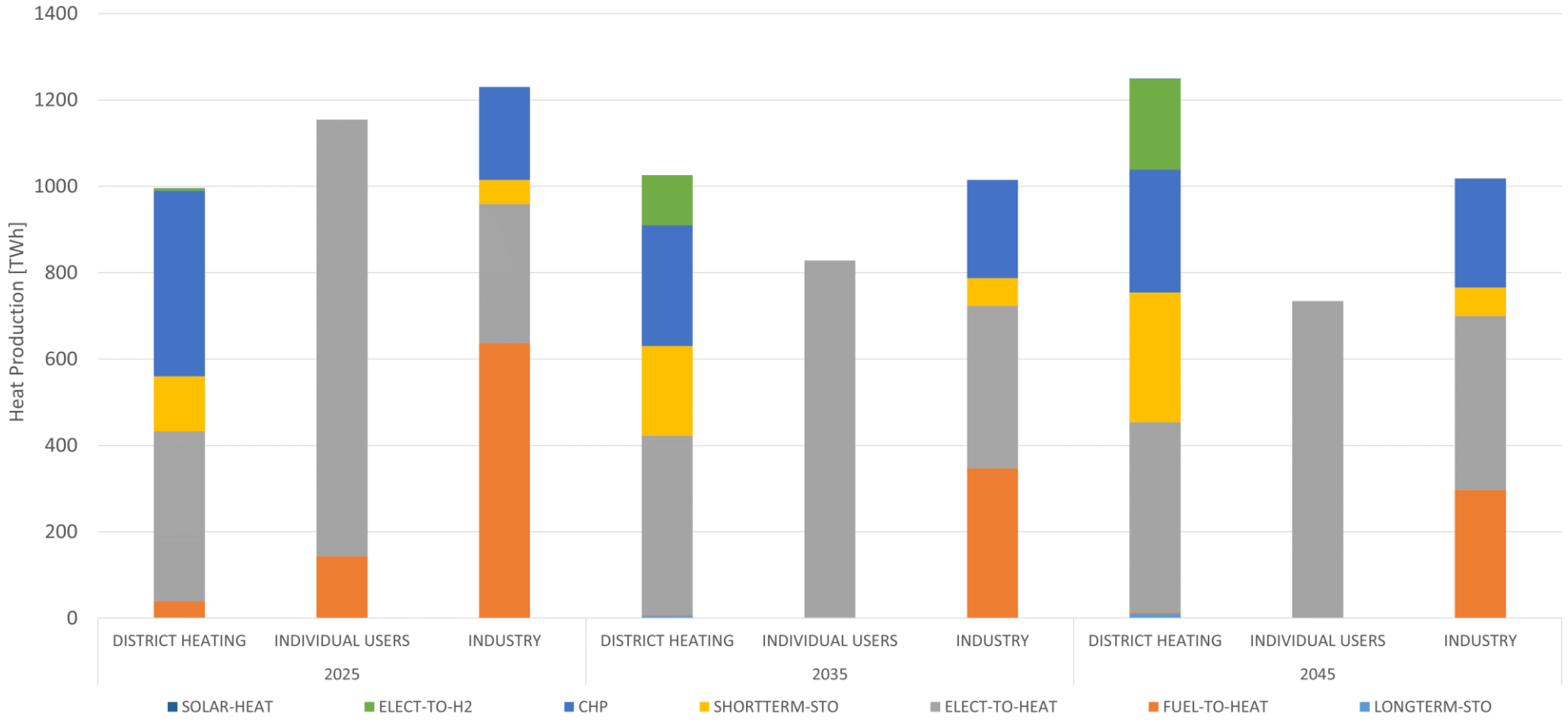
Increasing of RES share in the total mix and overall electrification with higher total demand.

Effect of scenarios on EU electricity generation towards 2050



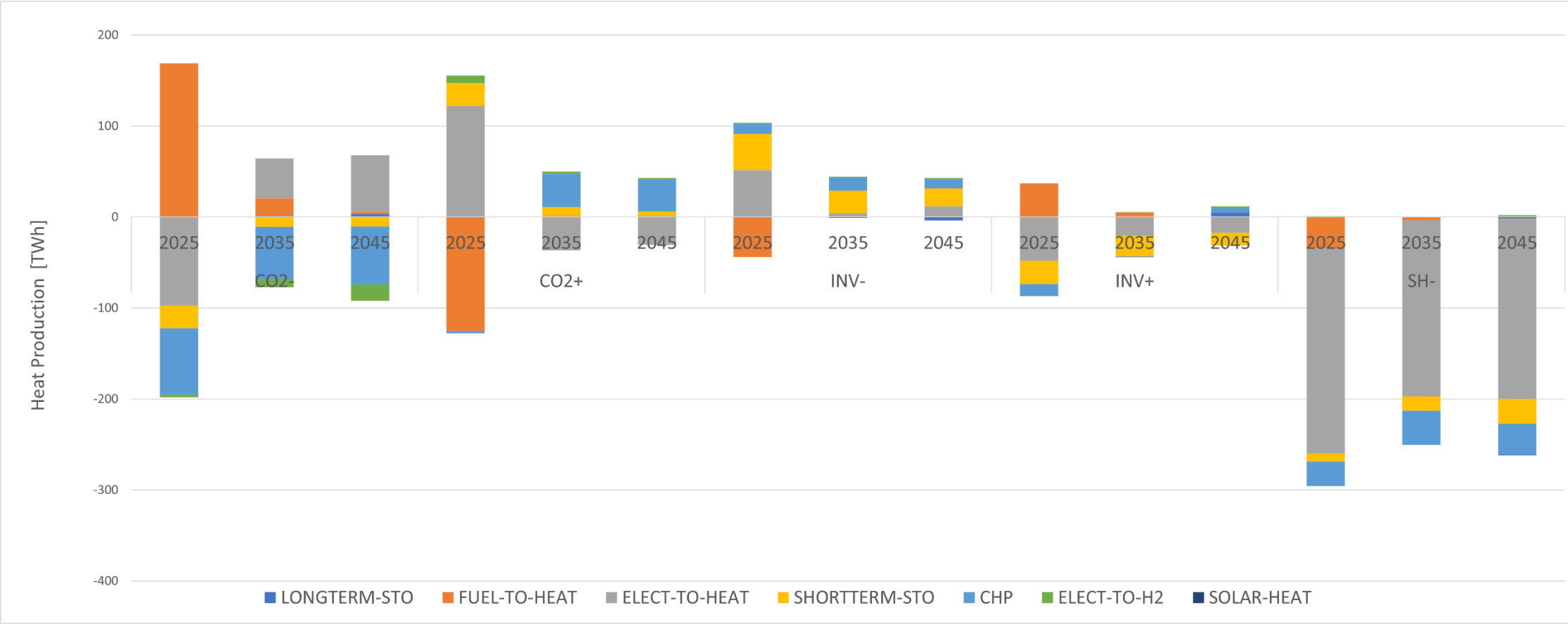
Solar PV highly dependent on CO2 price, higher investment in DH suggest higher electrification of the heating sector

BAU heat production towards 2050



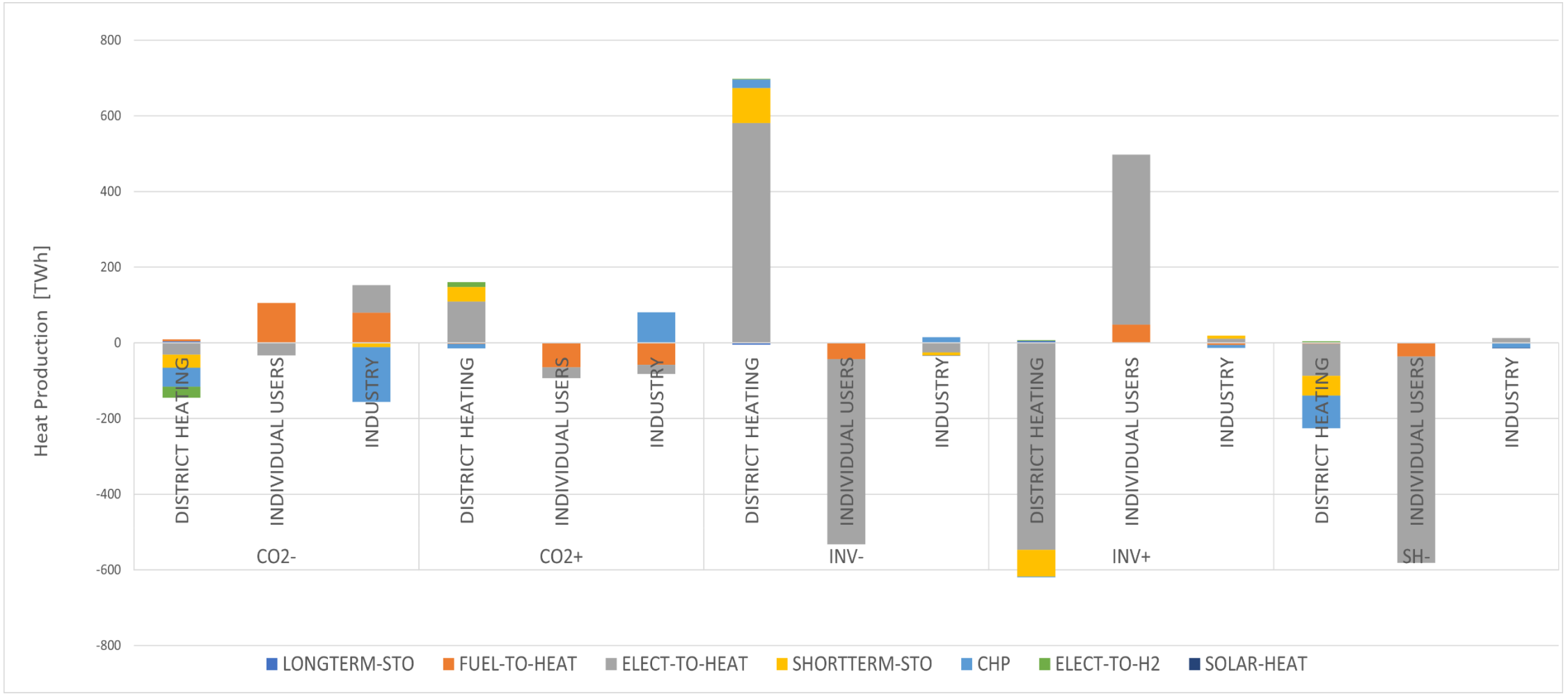
Elect-to-heat takes over the fuel-to-heat, in DH more important role of electrolyzers towards 2050

Effect of scenarios on EU heat production towards 2050



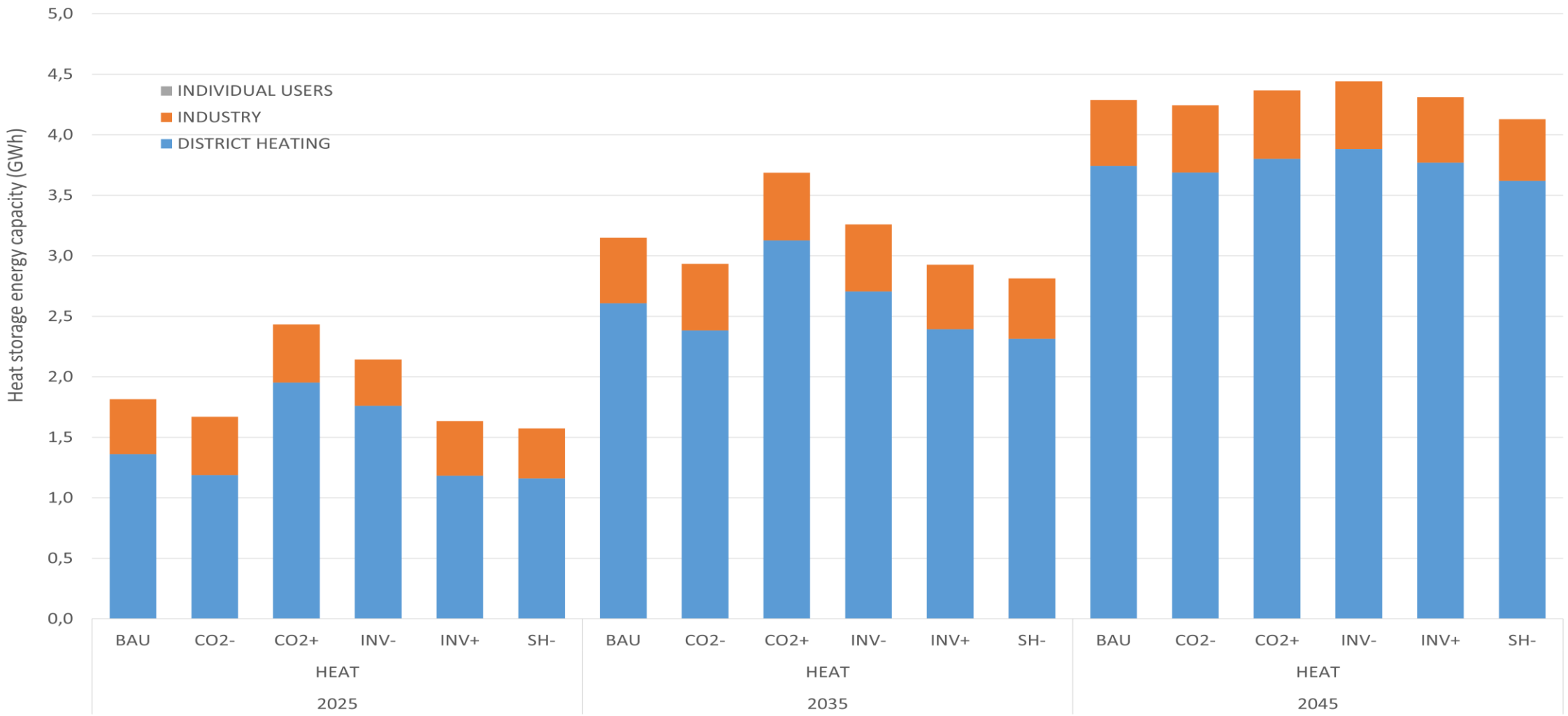
Higher CO2 price and the lower DH investment cost take to substitute part of the fuel-to-heat to elect-to-heat.

Effect of scenarios on EU heat production towards 2050



The district heating sector takes over part of the heat production of individual users and industry.

Effect of scenarios on heat storage towards 2050



Discussion

- DH has a high potential in all the countries analysed even if the heat demand present different characteristics in each Country.
- Higher investment costs in DH expansion have similar trend of lower CO2 price confirming high potential of DH for decarbonization of heating sector.
- Most heat storage units are located in DH networks, a minor share is connected to industries.

Future work:

- Analysis on specific national markets focussing on the influence of the factors above cited and specific regulations for DH
- Analysis on the specific role of electrolyzers in the expansion of the DH network (sensitivity analysis)
- More detailed analysis on the role of longterm and shortterm storage in relation with district heating expansion.
- Accounting the CO2 reduction of investment in DH.

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The role of district heating in future energy systems