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WASTE HEAT RECOVERY FROM RENEWABLE HYDROGEN PRODUCTION INTO A DISTRICT HEATING NETWORK IN FINLAND

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HYDROGEN PRODUCTION AND WASTE HEAT

- A renewable energy system require renewable hydrogen, e.g. in the chemical industry, maritime and air transport, and steelmaking
- Water electrolysis, solar PV and wind power are key factors in green hydrogen production
  - Mature electrolysis technologies (AWE, PEMWE) typically operate at 50–80% efficiency → how is the cooling of electrolyzers managed, where is the waste heat directed?
- Challenges in utilizing electrolysis-based waste heat:
  - Low temperature: 60–80°C → booster heat pump or electric boiler to increase the temperature
  - Variable heat source → heat storage to match heat demand
  - Low full load hours (applies to all heat generation in Nordic conditions)

More on hydrogen economy: Breyer et al., 2024. The role of electricity-based hydrogen in the emerging power-to-X economy.

INTRODUCTION TO RESEARCH RESULTS

- Waste heat recovery from an off-grid AWE plant into a DH network in Finland was studied
  - Optimal dimensioning of waste heat recovery system components to minimize the levelized cost of heat supplied to the DHN
  - Utilization of measured data for electricity generation (solar PV and wind), DH demand, and components dynamics
  - Waste heat generation is based on a previous study, in which the dimensioning of the components and system control of the 100 MW AWE plant were cost-optimized based on the levelized cost of hydrogen

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Techno-economic evaluation of waste heat recovery from an off-grid alkaline water electrolyzer plant and its application in a district heating network in Finland

Altti Meriläinen [a], Antti Kosonen [a], Juha Jokisalo [b], Risto Kosonen [b], Pertti Kauranen [a], Jero Ahola [a]

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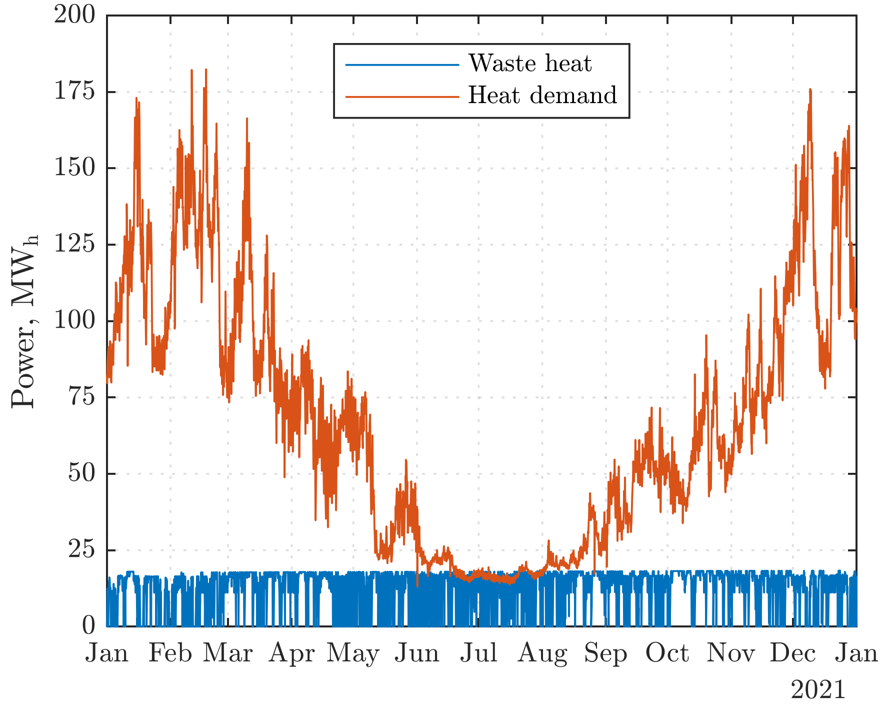
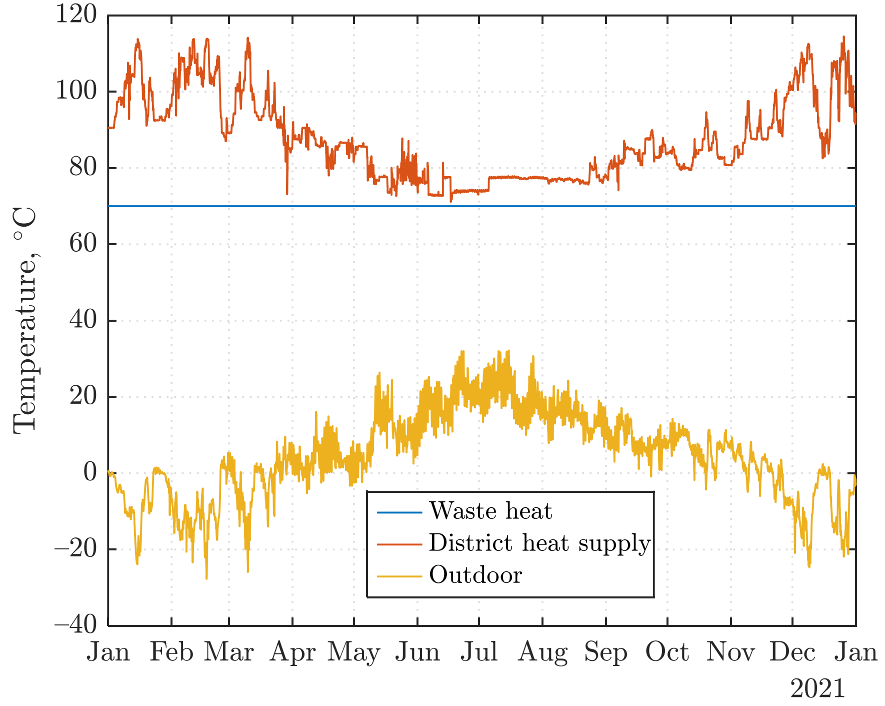
Meriläinen et al., 2024. Techno-economic evaluation of waste heat recovery from an off-grid alkaline water electrolyzer plant and its application in a district heating network in Finland.

HEAT DEMAND AND GENERATION

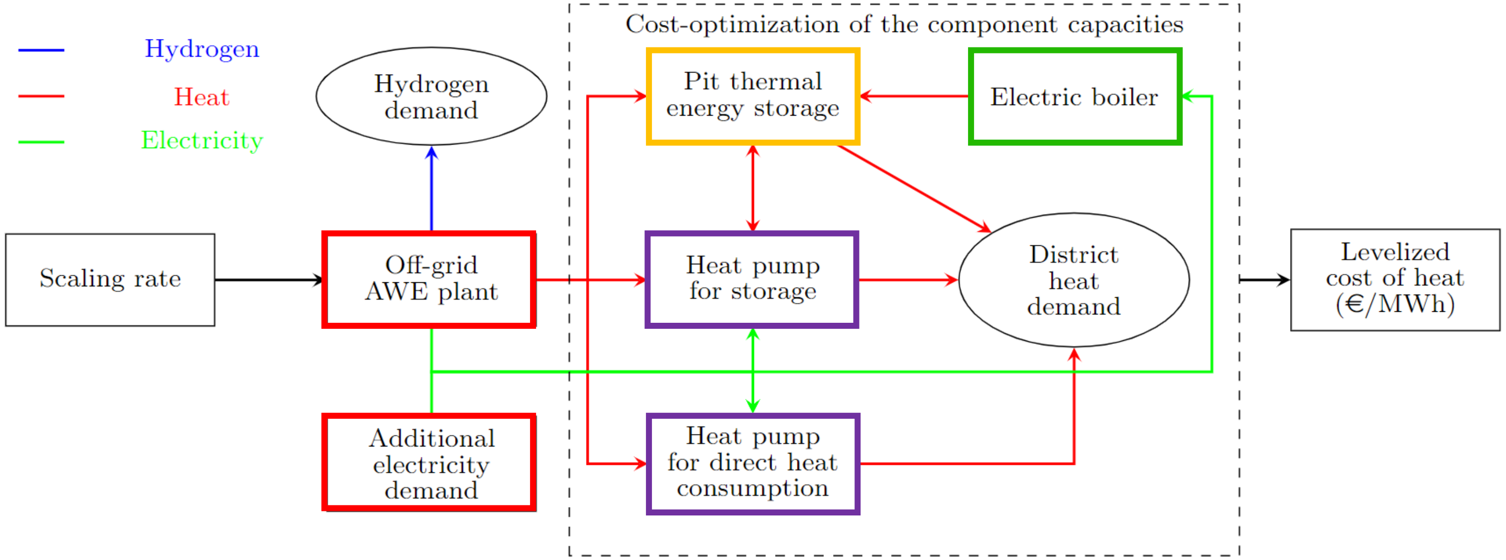
- Heat demand of a DH network in southeastern Finland in used (**592 GWh/a**)
- Heat generation is based on the modeled 100 MW off-grid electrolyzer plant (**97 GWh/a**)





WASTE HEAT RECOVERY SYSTEM

- Waste heat recovery system include:
  - Pit thermal energy storage (PTES)
  - Heat pumps (2 pcs)
  - Electric boiler (possible additional source of heat)
- In addition to waste heat, surplus electricity is generated that is not used for hydrogen production
  - Waste heat and surplus electricity are assumed to be cost-free

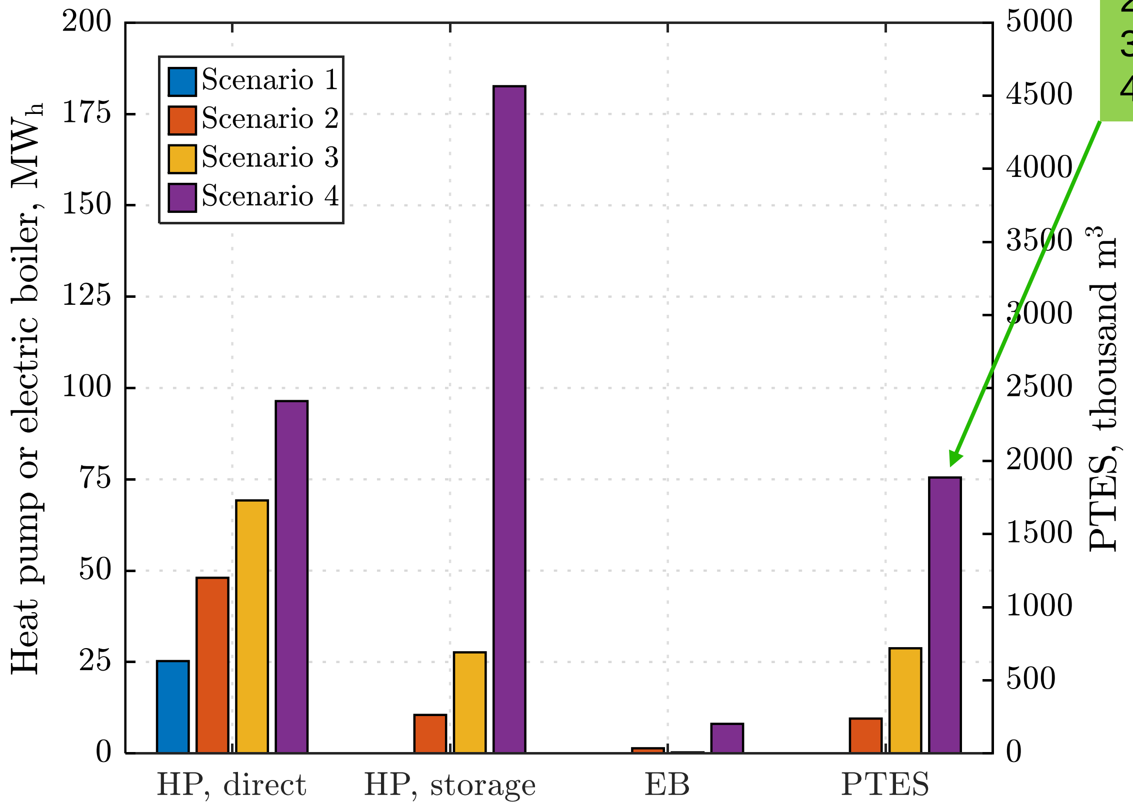


DIFFERENT OPTIMIZATION SCENARIOS

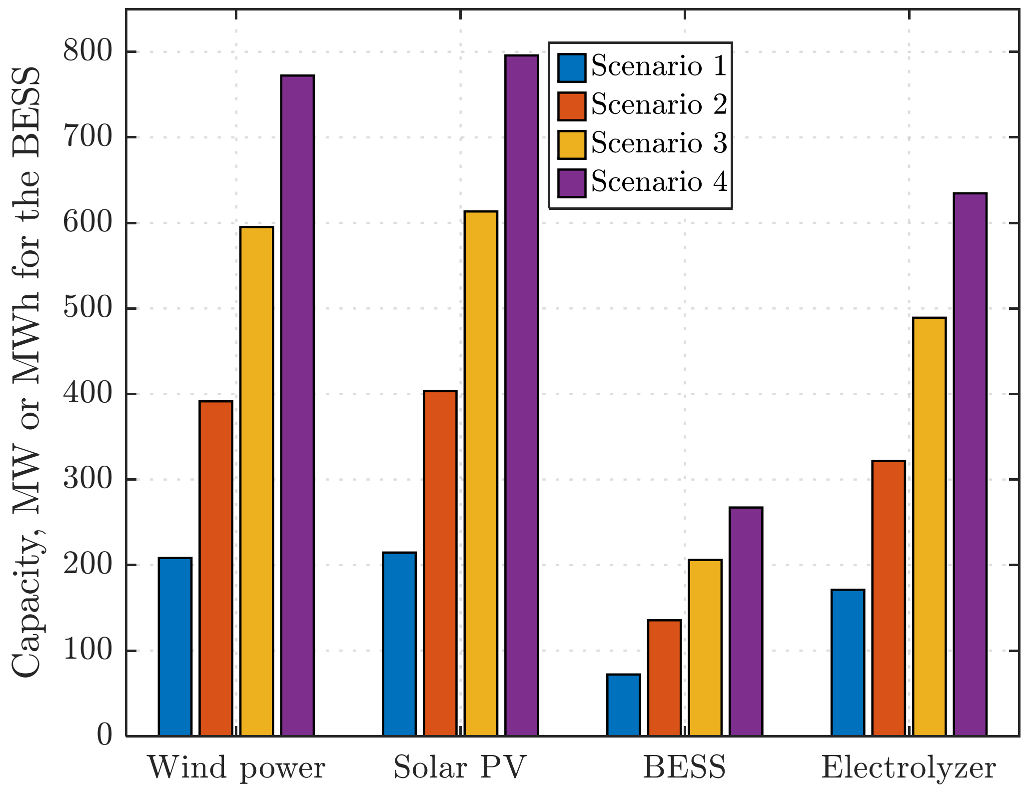
- Component dimensioning as well as the AWE plant scaling is cost-optimized in 4 scenarios:
  - 1: Maximization of DH energy demand coverage rate without PTES and electric boiler
  - 2: 50% DH energy demand coverage
  - 3: 75% DH energy demand coverage
  - 4: 100% DH energy demand coverage
- In addition, at least 95% of the generated waste heat must be recovered → AWE plant scaling is minimized

COST-OPTIMAL DIMENSIONING

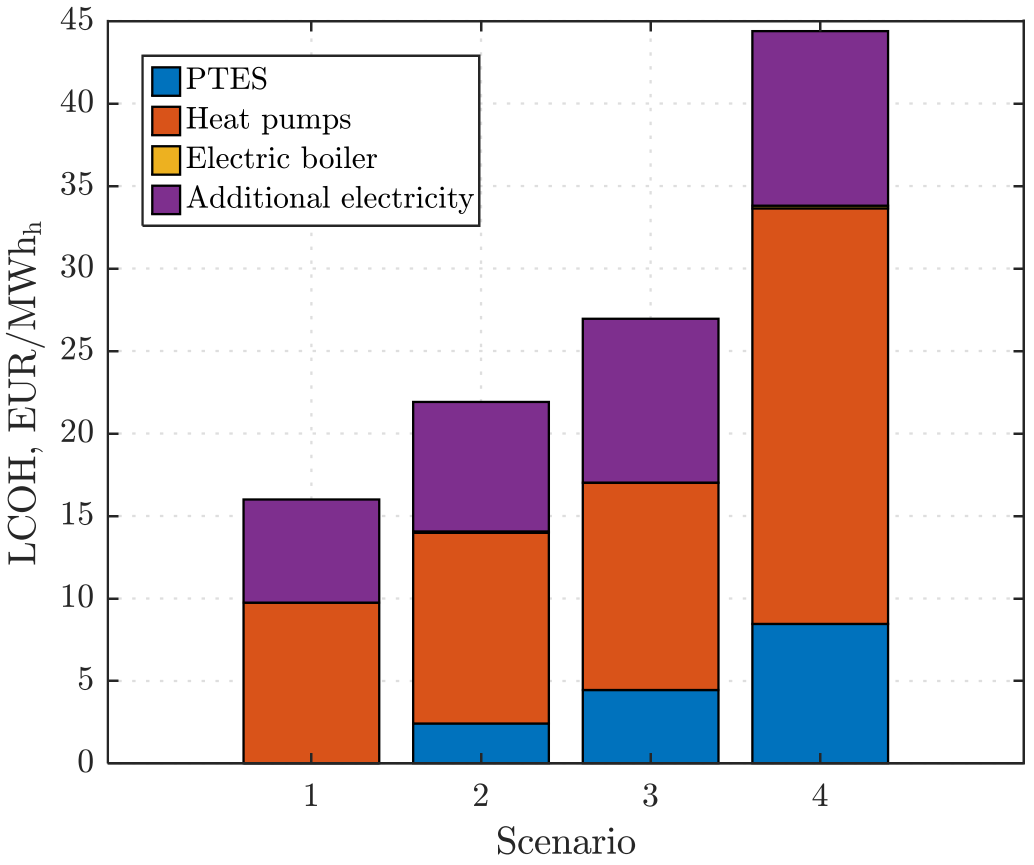
Corresponding in GWh
2: 26 GWh
3: 79 GWh
4: 162 GWh



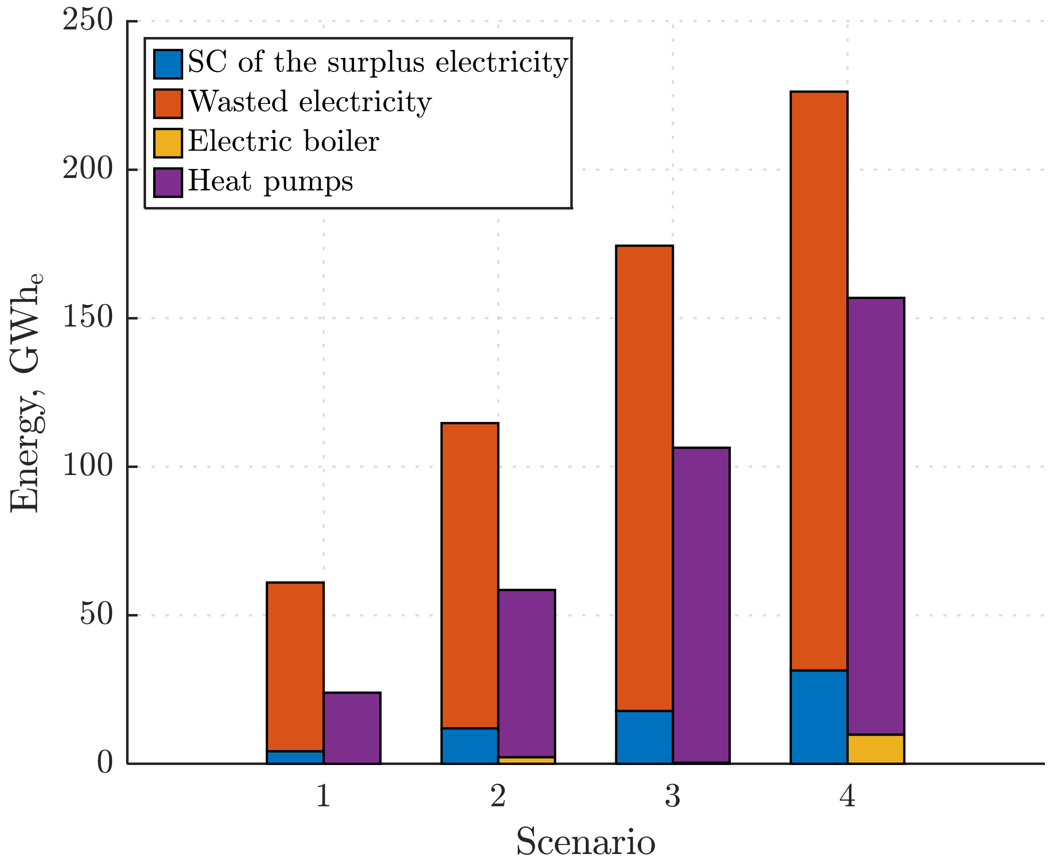
AWE PLANT SCALING



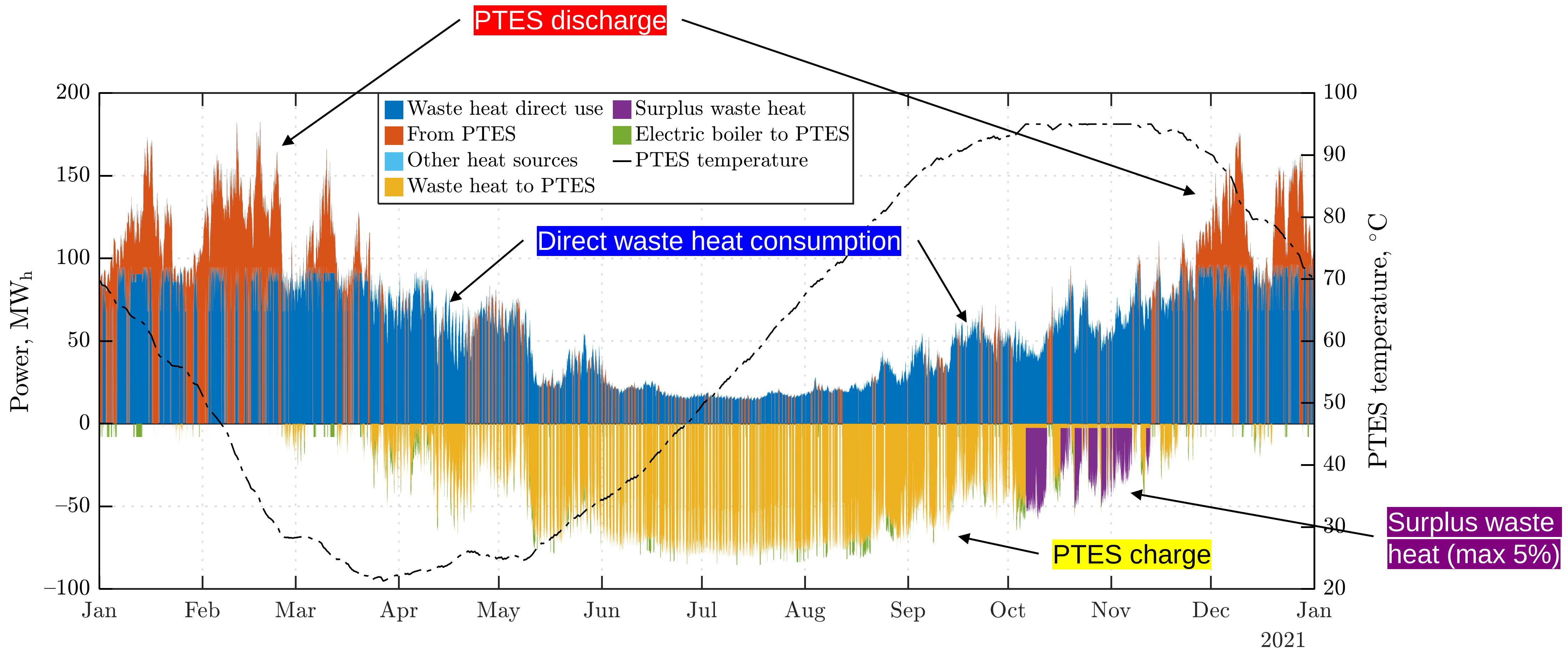
LEVELIZED COST OF HEAT



ANNUAL ELECTRICITY BALANCE



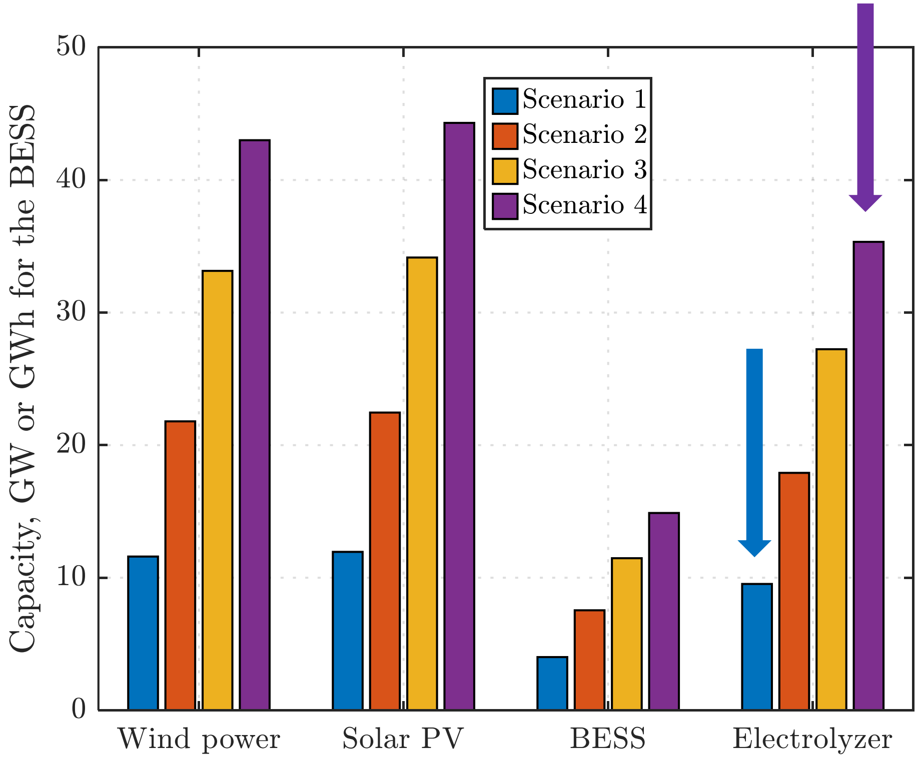
SYSTEM OPERATION OVER A YEAR



WASTE HEAT POTENTIAL OF THE WHOLE OF FINLAND

- DH demand in Finland in 2022: 33 TWh
  - Scaling factor for the results: $\left(\frac{33}{0.592}\text{TWh}\right) \approx 56$

Estimates for renewable H_2 production capacity in Finland by Fingrid and Gasgrid Finland (TSO's)	2030	2040
Electrolyzer capacity, GW	10–12	23–41
Wind and solar PV capacity for H_2 production, GW	17–22	36–60



Sources: Fingrid & Gasgrid Finland, 2023. Energian siirtoverkot vetytalouden ja puhtaan energiajärjestelmän mahdollistajina.
Energiateollisuus ry, 2023. Kaukolämpötilasto 2022.

CONCLUSIONS

- Levelized cost of heat <45 €/MWh can be reached in current DH networks
- Heat pumps constitute the largest single cost (about 45–60%)
  - Is it possible to eliminate heat pumps?
    - Decrease in DH network temperature?
    - Increase in waste heat temperature?
- PTES is a cost-effective seasonal heat storage (3–9 €/MWh)
- The Nordic countries (and other world) will bathe in waste heat if the estimated electrolyzer capacity is realized with AWE/PEMWE
  - How hydrogen production facilities should be located to ensure maximum utilization of waste heat?

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THANK YOU!
QUESTIONS?

Link to the publication:


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