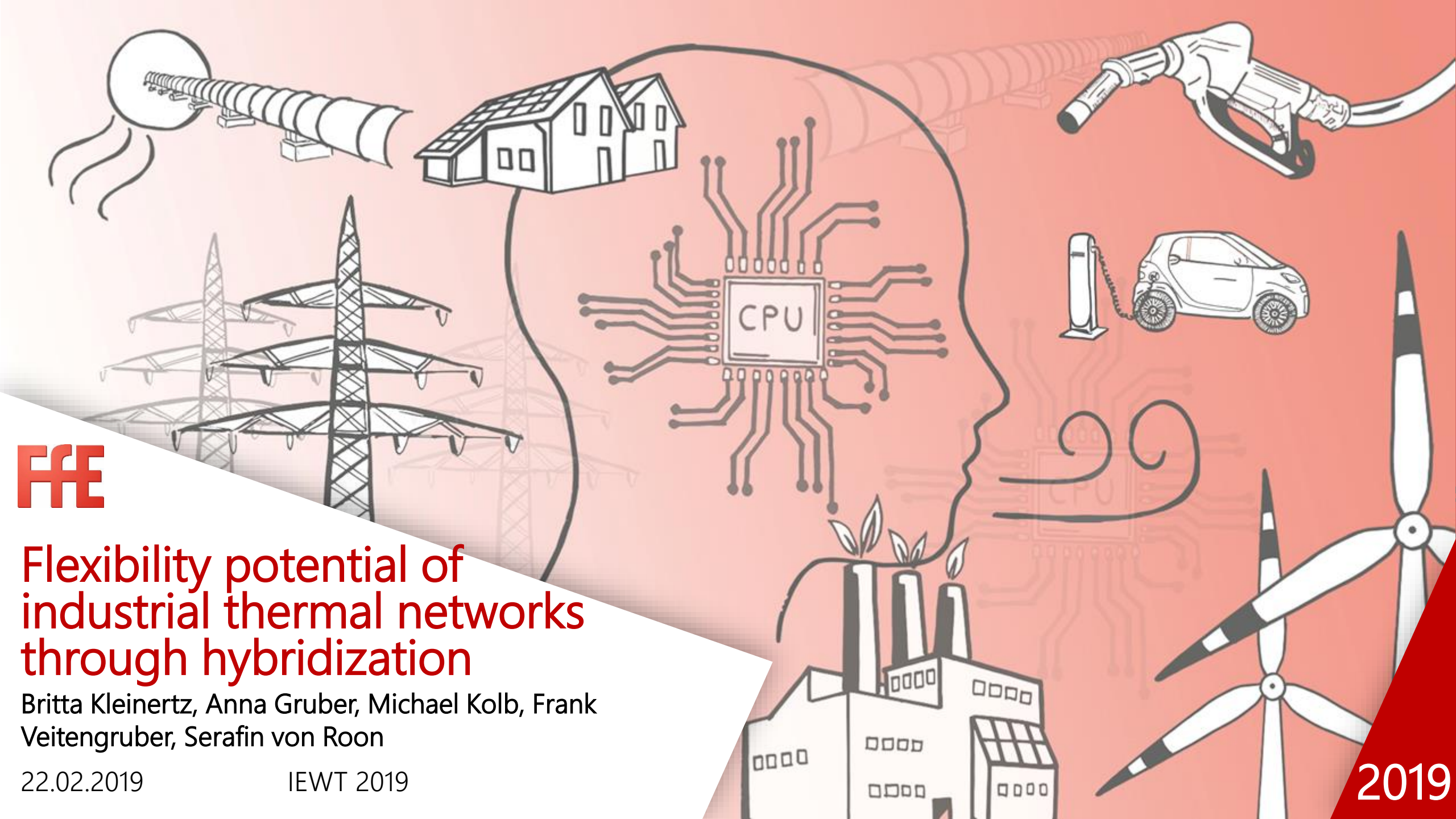

Flexibility potential of industrial thermal networks through hybridization

Britta Kleinertz, Anna Gruber, Michael Kolb, Frank Veitengruber, Serafin von Roon

22.02.2019 IEWT 2019

2019

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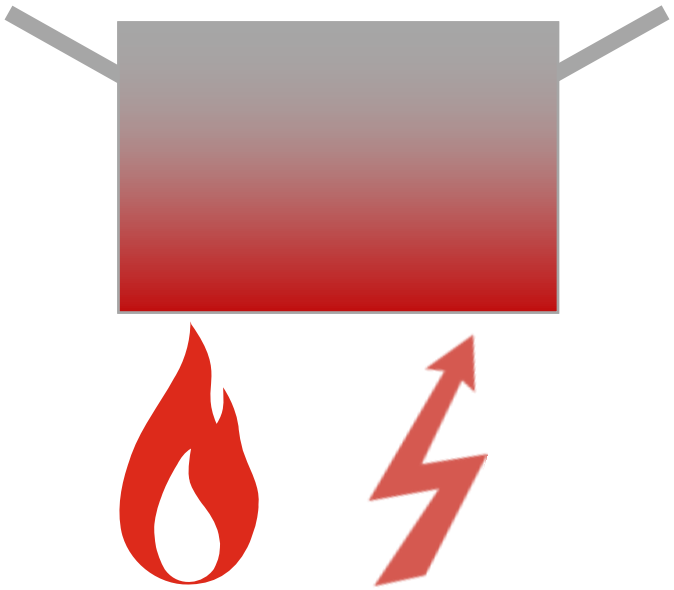
Hybridization as a suitable measure for system adapted thermal energy supply



Pros

- Variable system adapted heat supply possible

Cons

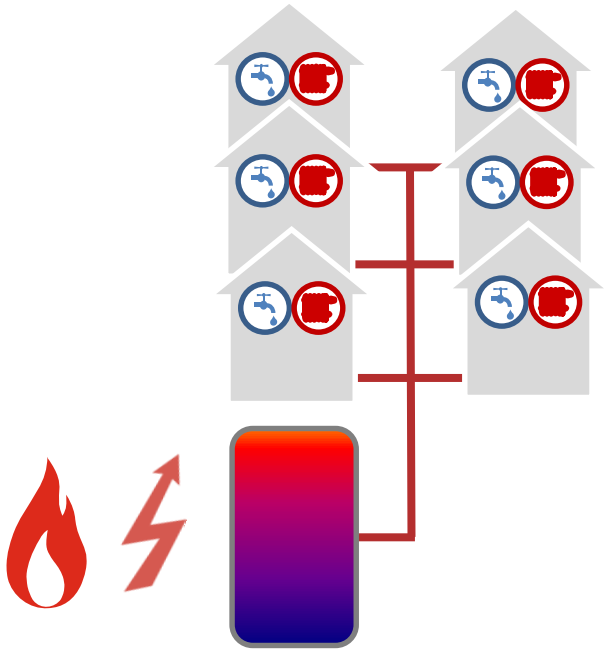
- High cost due to several units

➢ What are the suitable applications, designs and potentials?

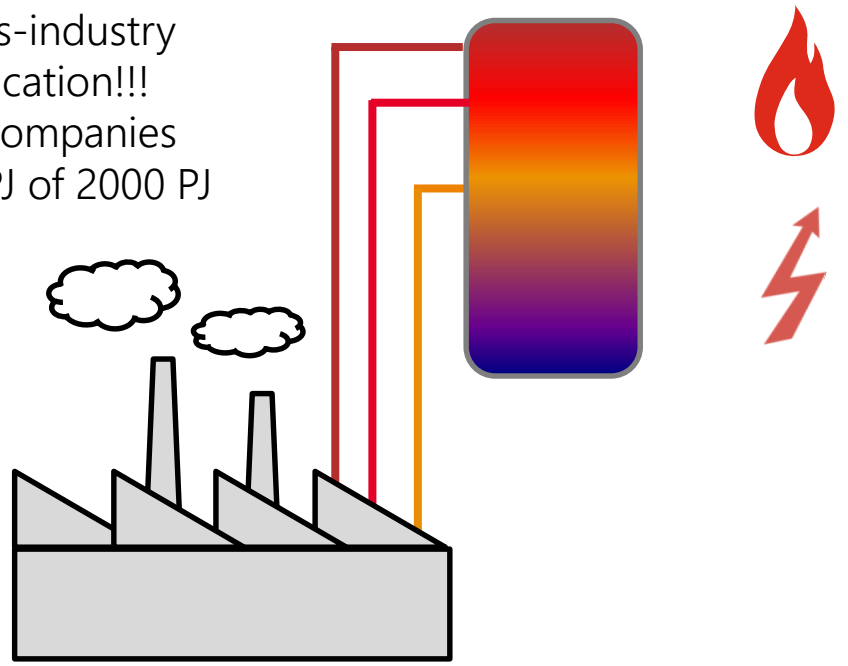
Possibilities for coupling electricity and heating sector

Decentral Power-to-Heat units
- 86 % of households

Centralized network-based Power-to-Heat units
- 14 % of households



Industrial network-based Power-to-Heat units
- Cross-industry application!!!
- ??? companies
- ??? PJ of 2000 PJ



Further advantages:
- Technicians on-site
- Always backup capacity available

Decrease in specific costs (investment, maintenance)

- Which designs are possible and which potentials exist?

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Current potential for hybridized industrial heat networks – a step-wise approach

Temperature levels | Energy demand | Limitations | Technologies | Interconnection | Flexible load

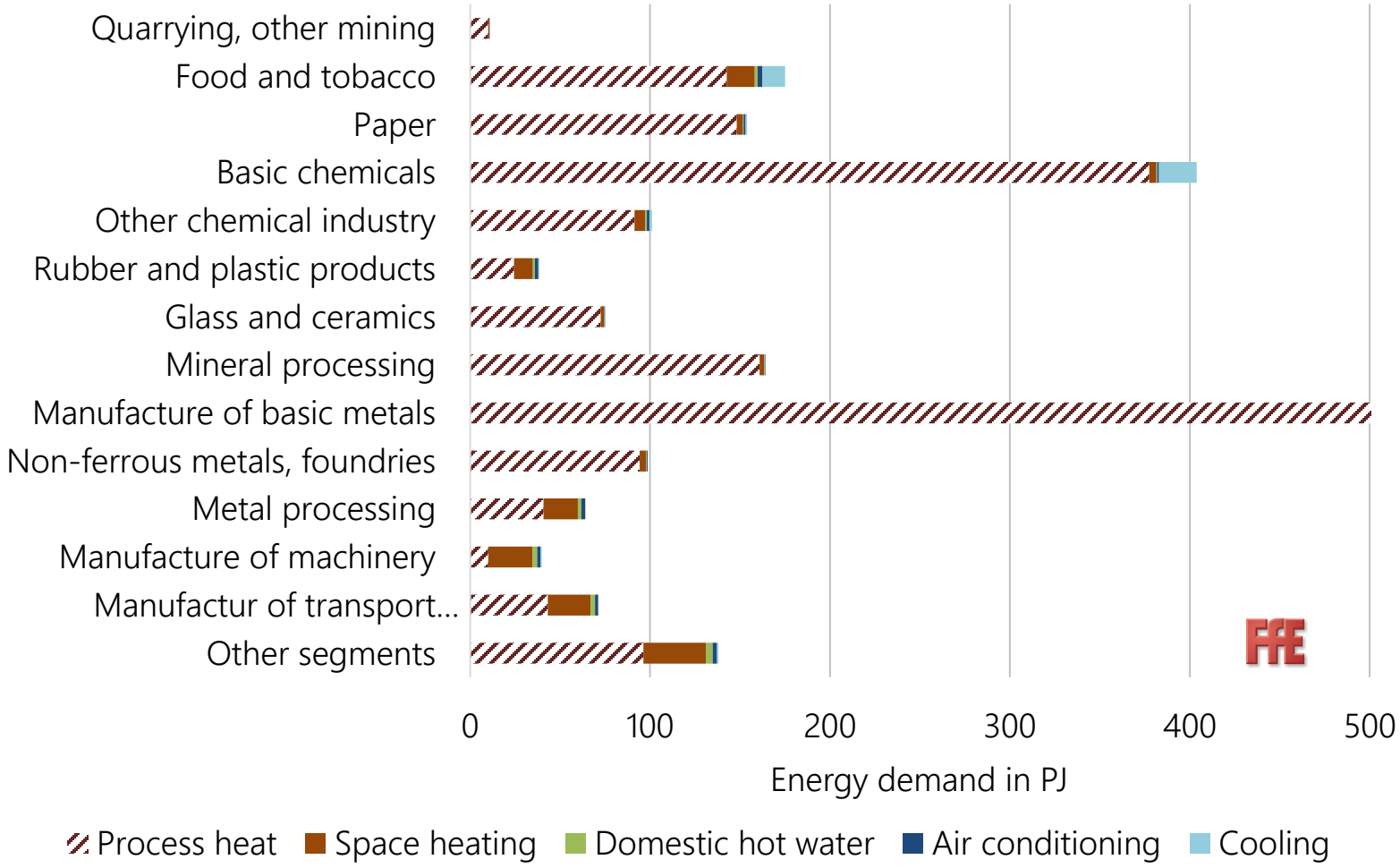
Potential for industrial heat networks - typical temperatures and application

Network	Flow temperature	Exemplary Application
High pressure steam	> 220 °C, max. 240 °C	Chemical reactions, drying
Medium pressure steam	> 160 °C	Chemical processes, Hygienic steam for food industry, paint shop
Steam	> 120 °C	Primary heat network temperature (temperature downgrade towards secondary network)
High temperature	~ 90 °C	Metal processing, surface heating, domestic hot water
Medium temperature	~ 50 °C	Surface heating

- Temperature levels differ by industrial branch and individual thermal requirements

Relevant heat demand can be differentiated into space heating, domestic hot water und process heating

Temperature levels | **Energy demand** | Limitations | Technologies | Interconnection | Flexible load



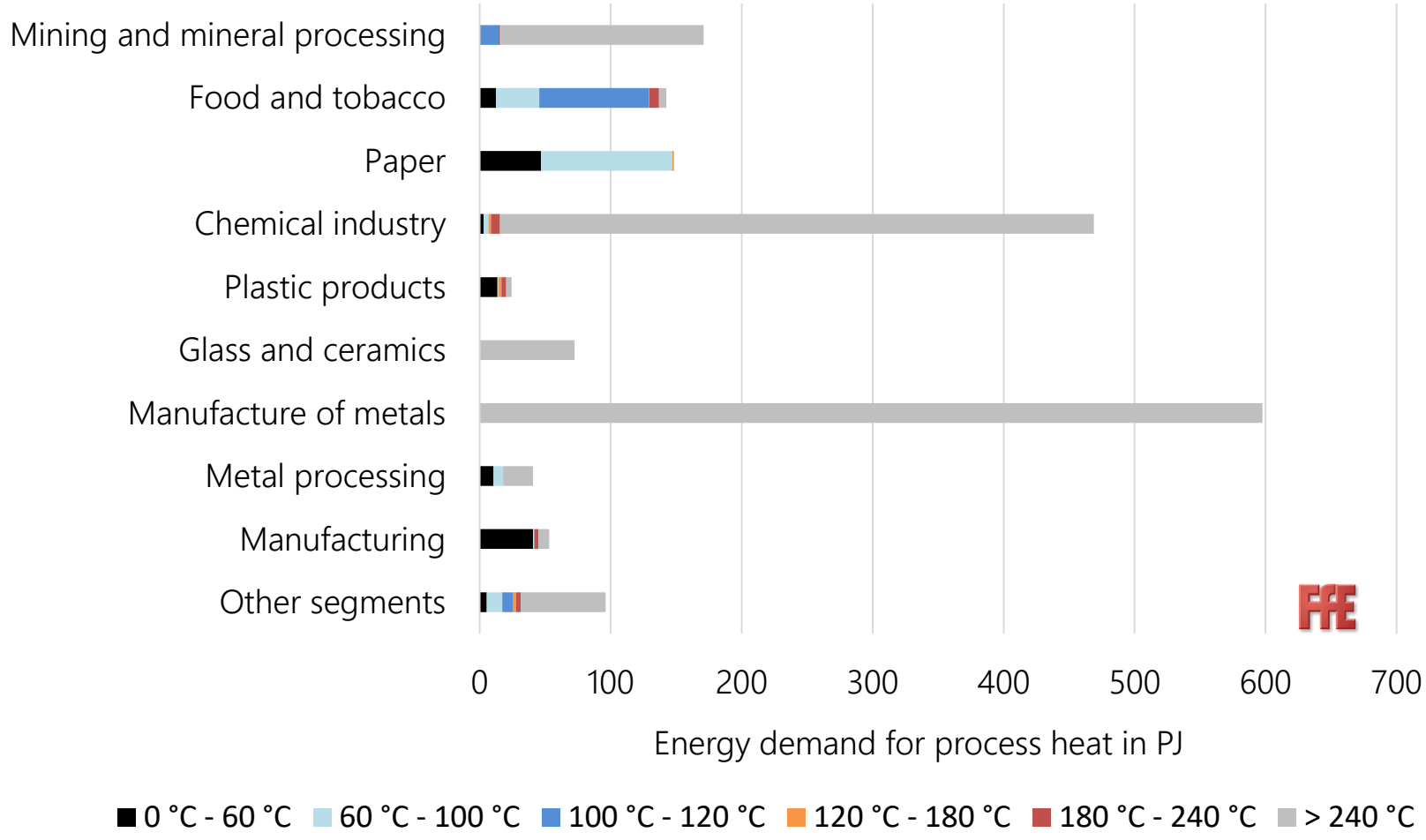
Fraunhofer ISI: Anwendungsbilanz 2017

- Industrial energy supply by demand type, industrial branch and energy source:
  - Thermal energy demand: 2,039 PJ
  - Heat demand: 1,984 PJ
  - Process heat demand: 1,815 PJ

➢ Process heat accounts for 86 % of industrial thermal energy demand

➢ For process heat an in-detail analysis of temperature levels is needed

Relevant is only the process heat demand below maximum network supply temperatures



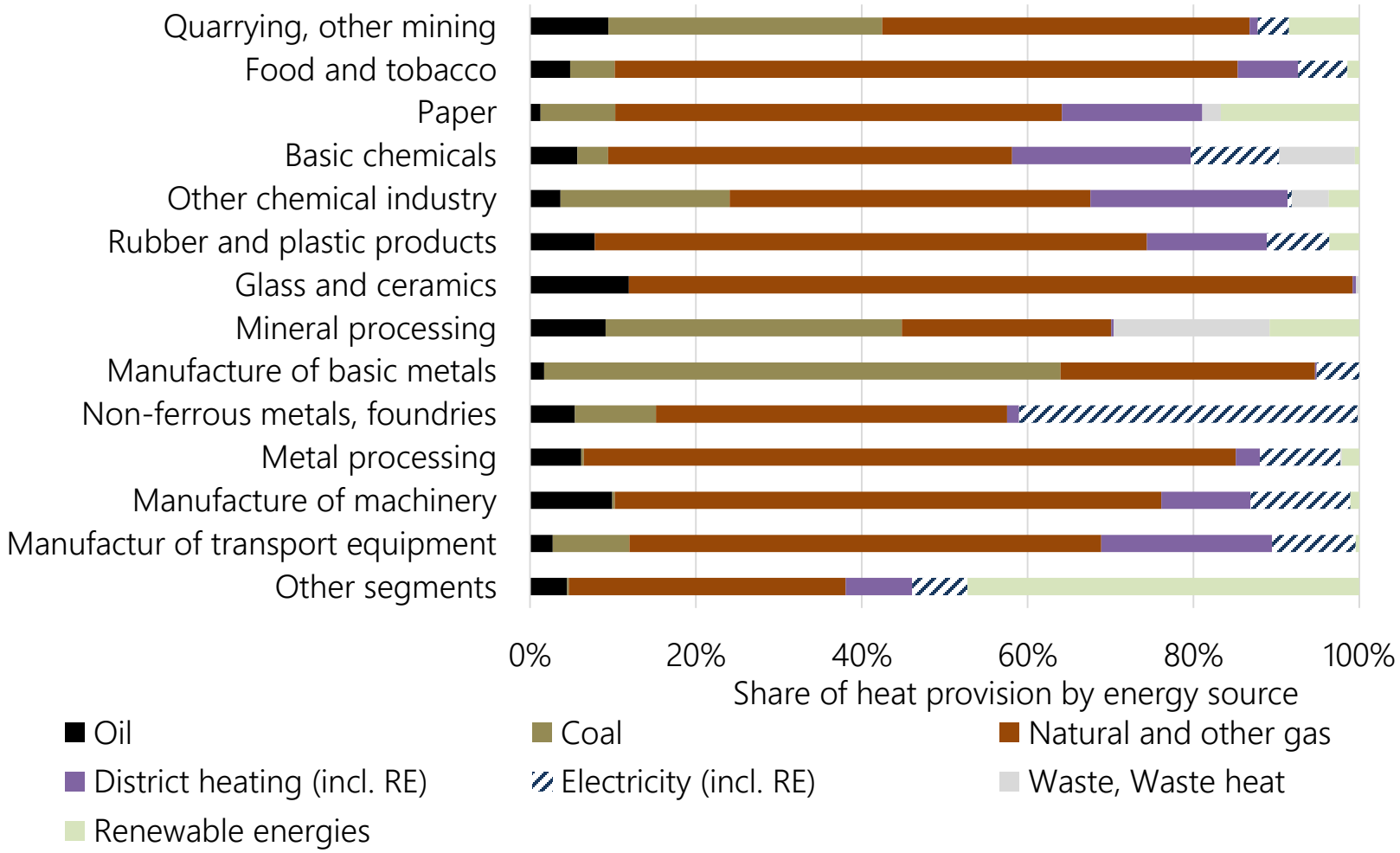
Quelle: Blesl, Kessler: Energieeffizienz in der Industrie

- Heat demand by temperature level for several industrial branches
- Demand at temperatures over 240 °C subtracted from potential

➢ Potential of process heat demand decreases to 441 PJ

➢ Focus on process heat demand T < 240 °C, domestic hot water and surface heating, approx. 601 PJ

Relevant is only the process heat currently provided by fossil fuels



Fraunhofer ISI: Anwendungsbilanz 2017

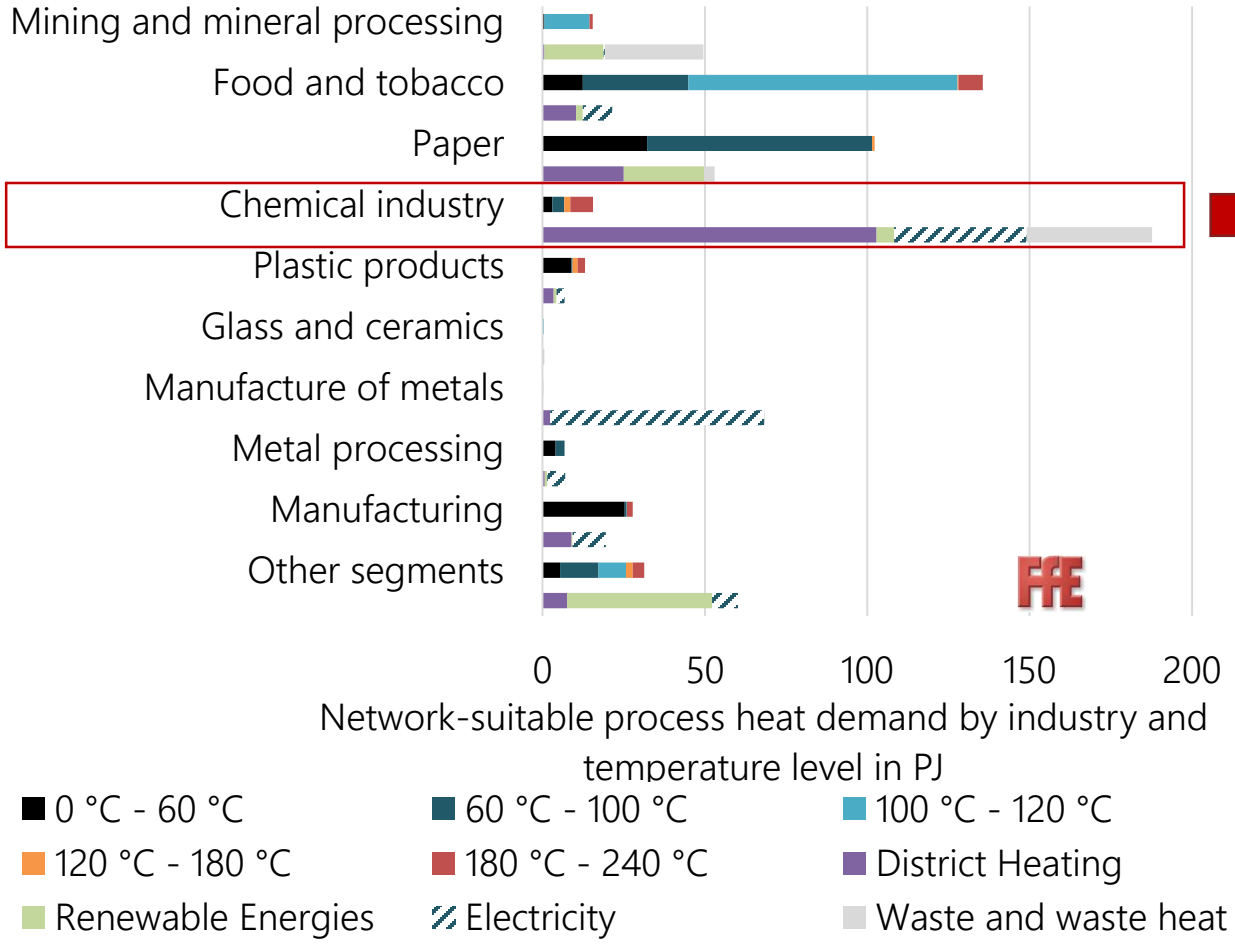
- Industrial energy supply by demand type, industrial branch and energy source

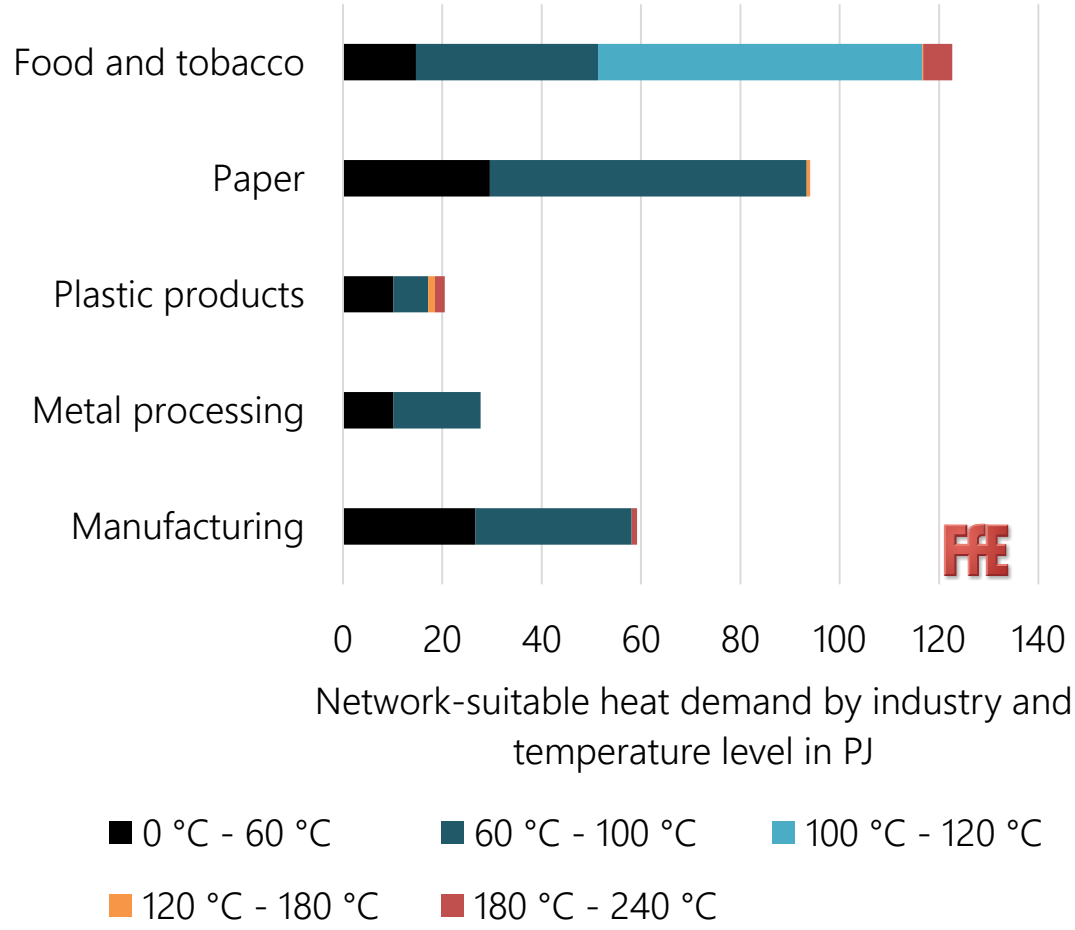
- Non-fuel heat supply is subtracted
  - ➢ Renewables, District heating at T < 240 °C
  - ➢ Electricity, waste and waste heat at all temperatures

➢ Focus only on T < 240 °C and fossil fuelled heat supply

Data combination leads to exclusion of several industrial branches

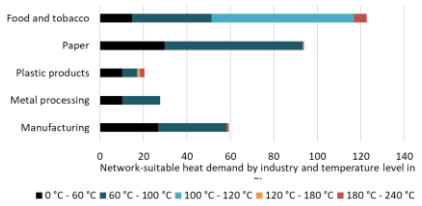
Temperature levels | **Energy demand** | Limitations | Technologies | Interconnection | Flexible load





➢ Focus only on T < 240 °C and fossil fuelled heat supply, approx. 324 PJ

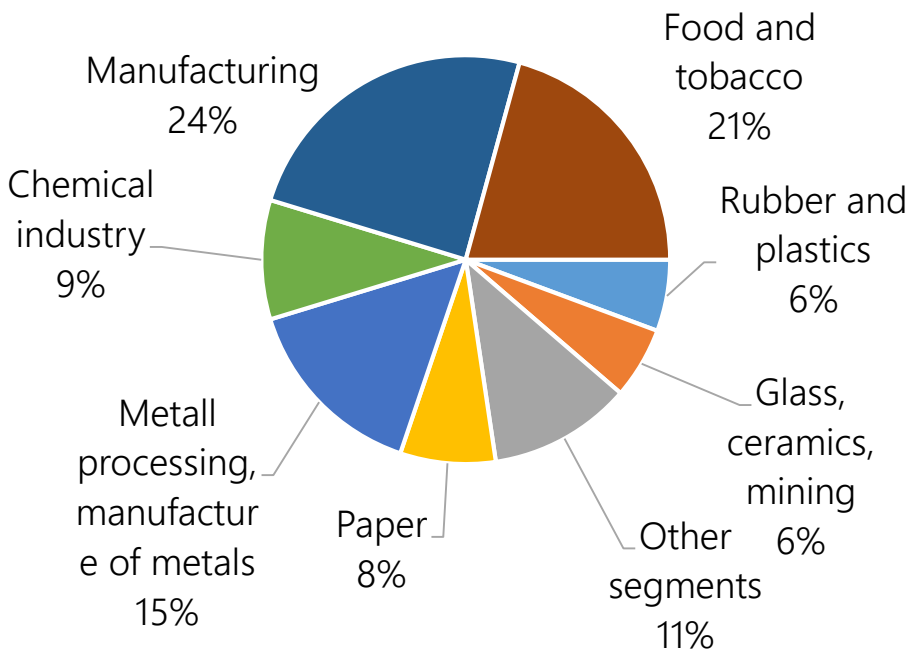
Relevant is only the currently central provided heat

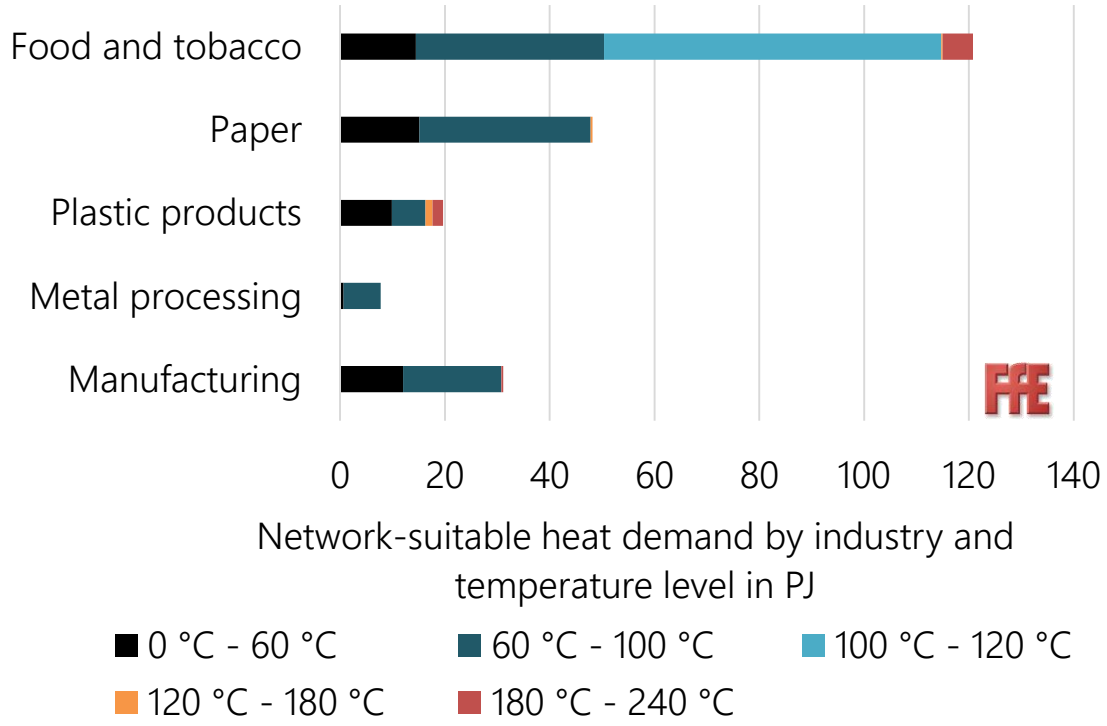


\+

Real data from 53 companies

- Decentral versus central heating





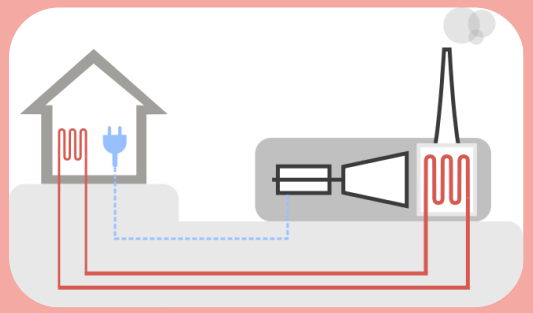
- Overall 235 PJ or 12 % of industrial thermal energy demand

- Focus on T < 240 °C, fossil fuelled and centrally provided heat, approx. 235 PJ

Relevant technologies for hybridization and application priority

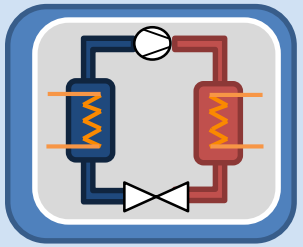
Decrease in ratio of electricity-to-fuel costs

Combined Heat and Power

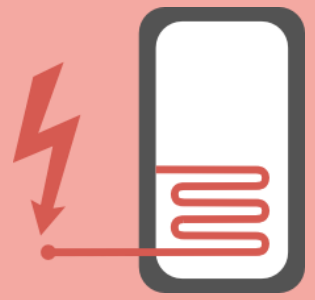


Fuel-based boiler

Heat pump



Electrode boiler

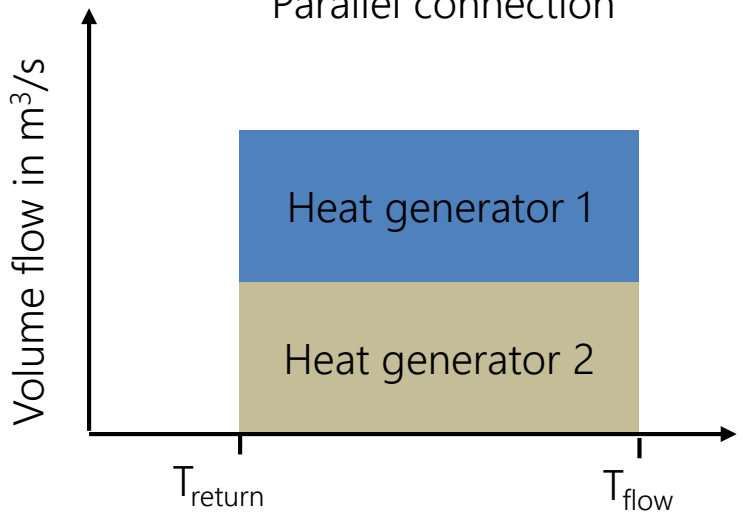


- Priority between technologies depends on temperature and economic conditions

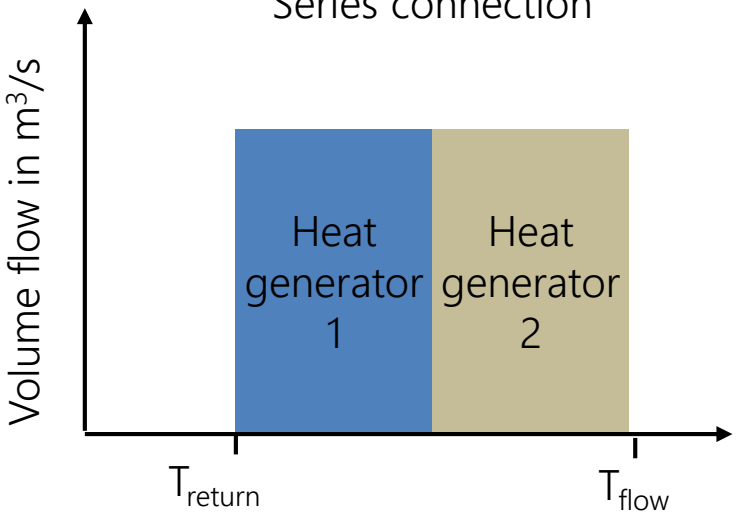
Situation-dependent interconnection of heat supply units

$$\dot{Q}_{supply} = \dot{V} \cdot \rho \cdot c_p \cdot (T_{flow} - T_{return})$$

Parallel connection



Series connection

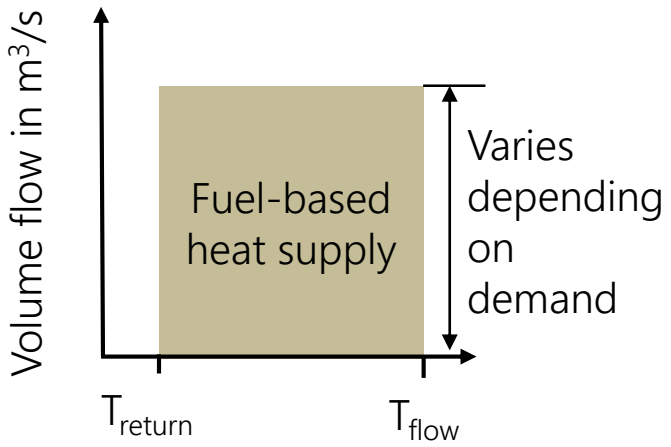


Heat pump + fuel-based technology + electrode boiler -> Extreme boundary situations

Decrease in ratio of electricity-to-fuel costs

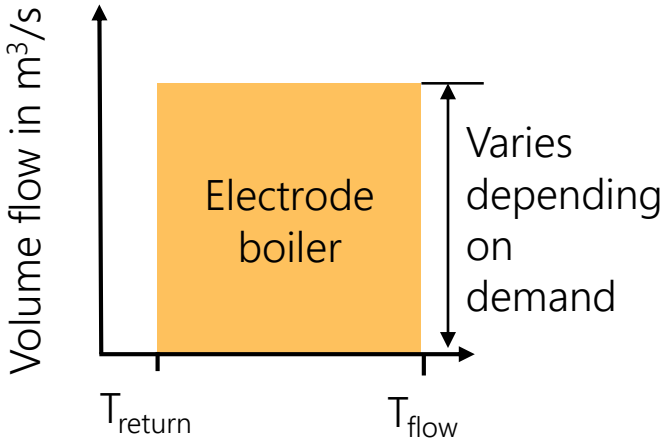
Fuel-based suitable

- Positive electricity demand needed



Negative electricity prices

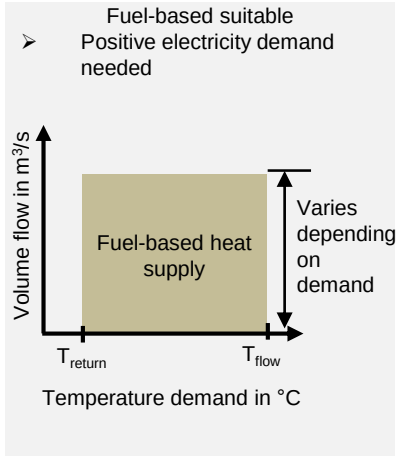
- Negative electricity demand needed

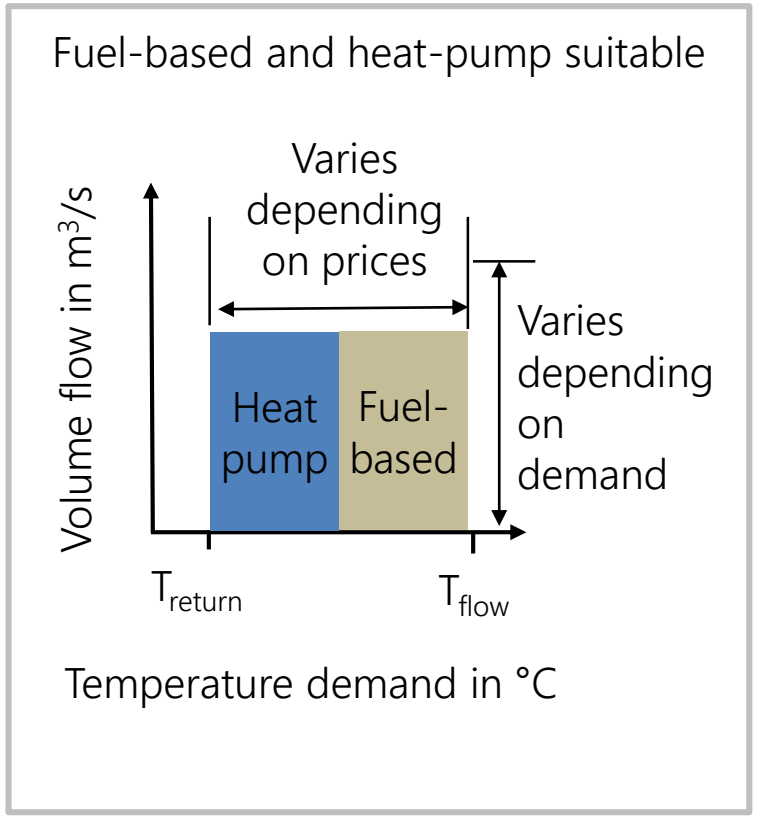


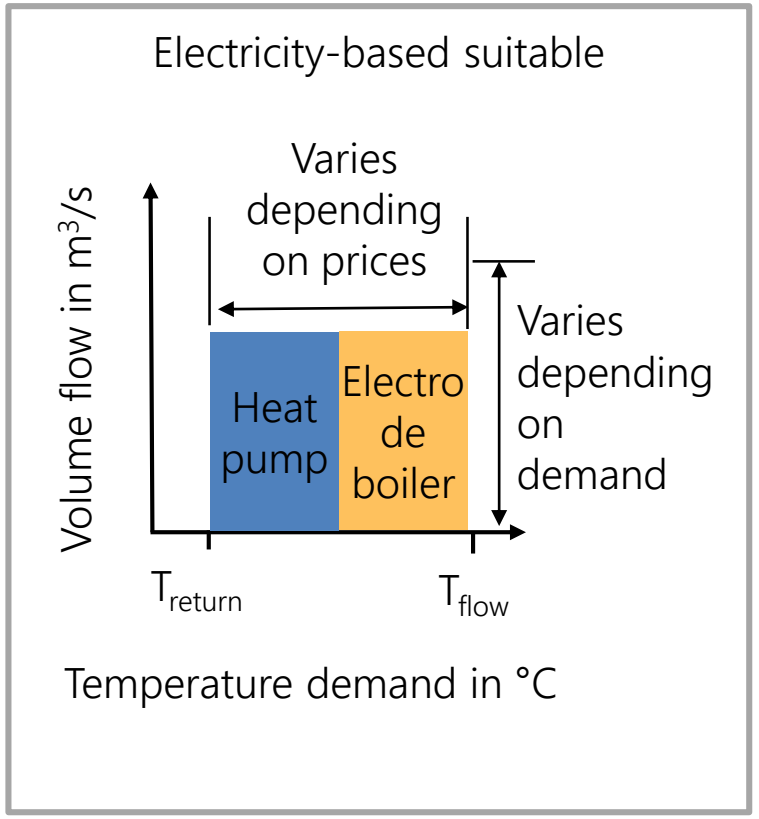
- In extreme situations prioritization is simple

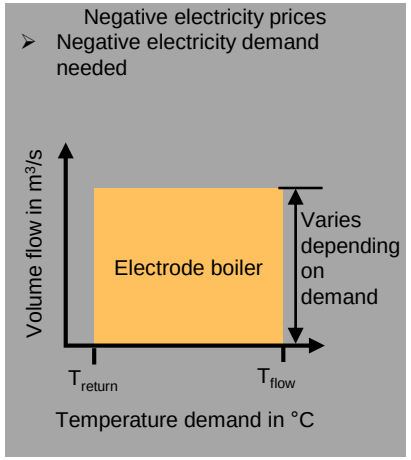
Heat pump + fuel-based technology + electrode boiler -> Medium situations

Decrease in ratio of electricity-to-fuel costs



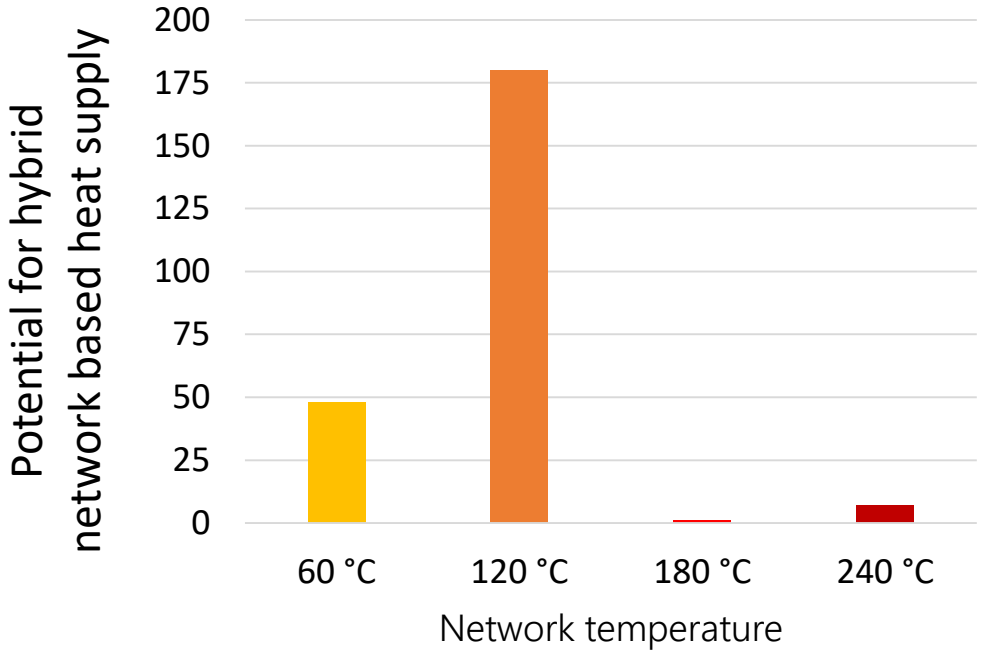


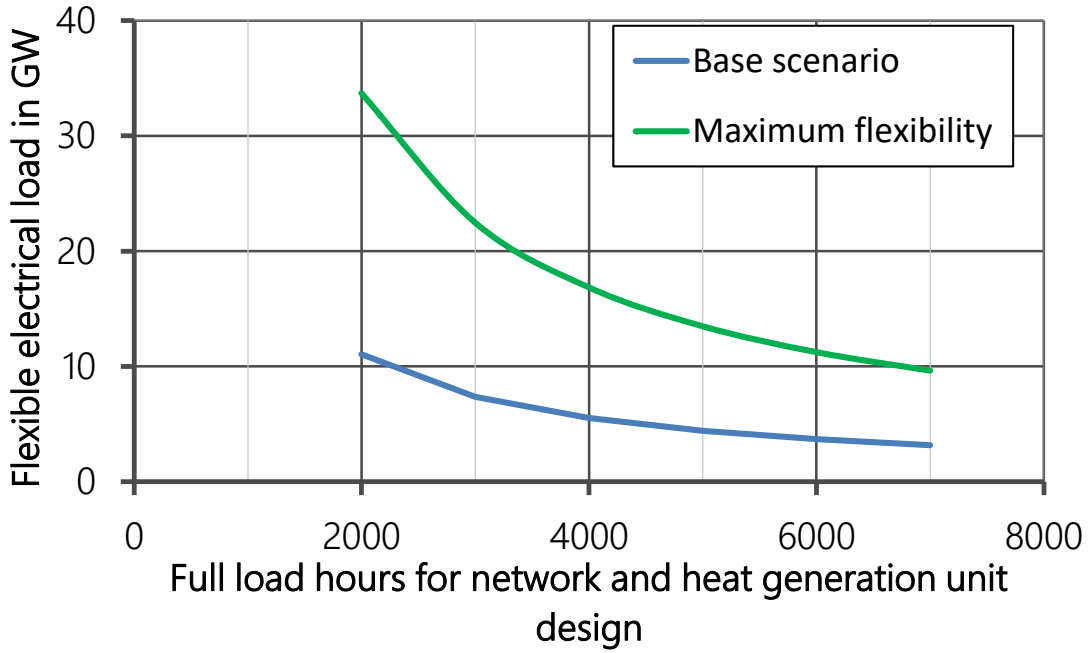




- In medium situations suitable combinations are relevant

Actual flexible load is entirely dependent on set technology and set full load hours for design





Base scenario	Heat pump E Boiler	5,5 GW
Maximum flexibility	Electrode Boiler	16,9 GW

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Evaluation of potential ways for provision of flexibility from industrial thermal networks

Hybrid system operation

- Network based heat supply
  - Backups needed
  - Large potential

➢ Network based heat suitable for hybrid systems

Usage of thermal storages

- Currently mainly used for
  - provision of supply security
  - Maximize heat generation unit efficiency

➢ Vast potential

Usage of network overheating

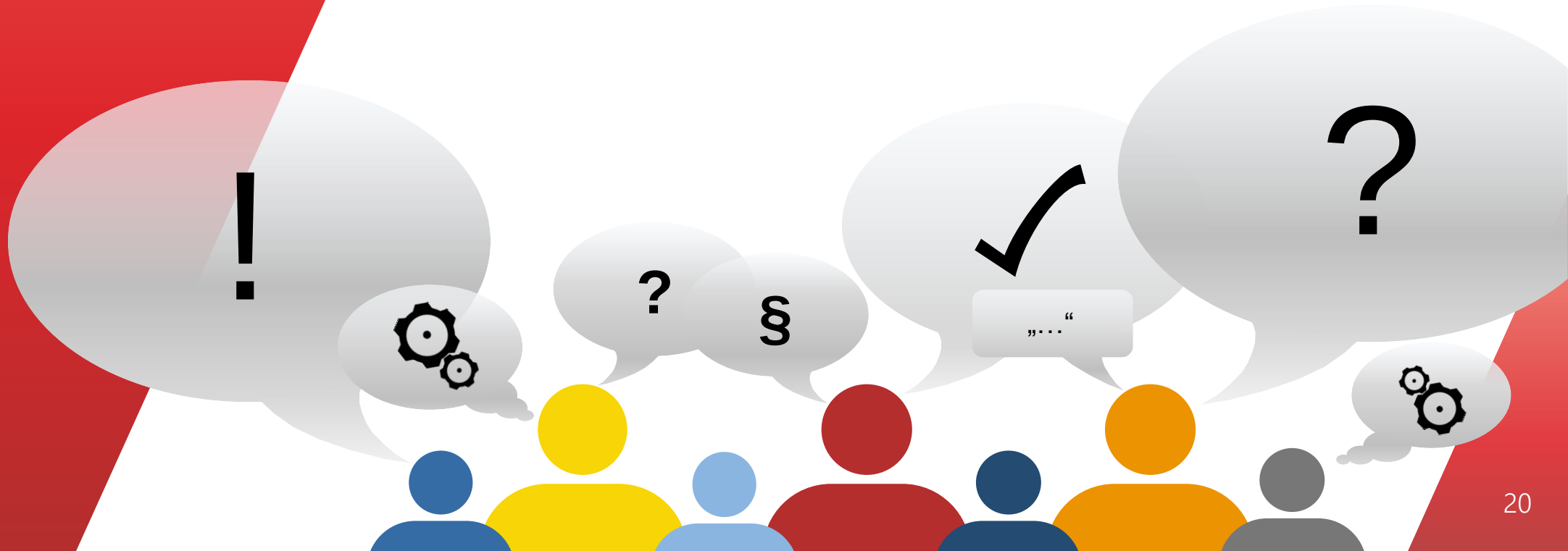
- Limited by
  - Missing heat exchangers for decoupling of supply and demand

➢ Low short time potential in networks with primary and secondary network

➢ Vast potentials exist, databases must be enlarged for realistic estimations

Diskussion

Fragen? Anregungen?
Weiteres Vorgehen?



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