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RESEARCH PROBLEM

The heterogeneity of industry hinders the achievement of the energy efficiency improvements required by the rising energy prices and the increasing environmental awareness. To keep alive strategic sectors, cross-cutting solutions for energy efficiency need to be developed, as they can contribute to improvements on a large scale. Their realization mainly consists of two methodological steps:

Identification of energy efficiency hotspots

Quantification of the potential of energy solutions

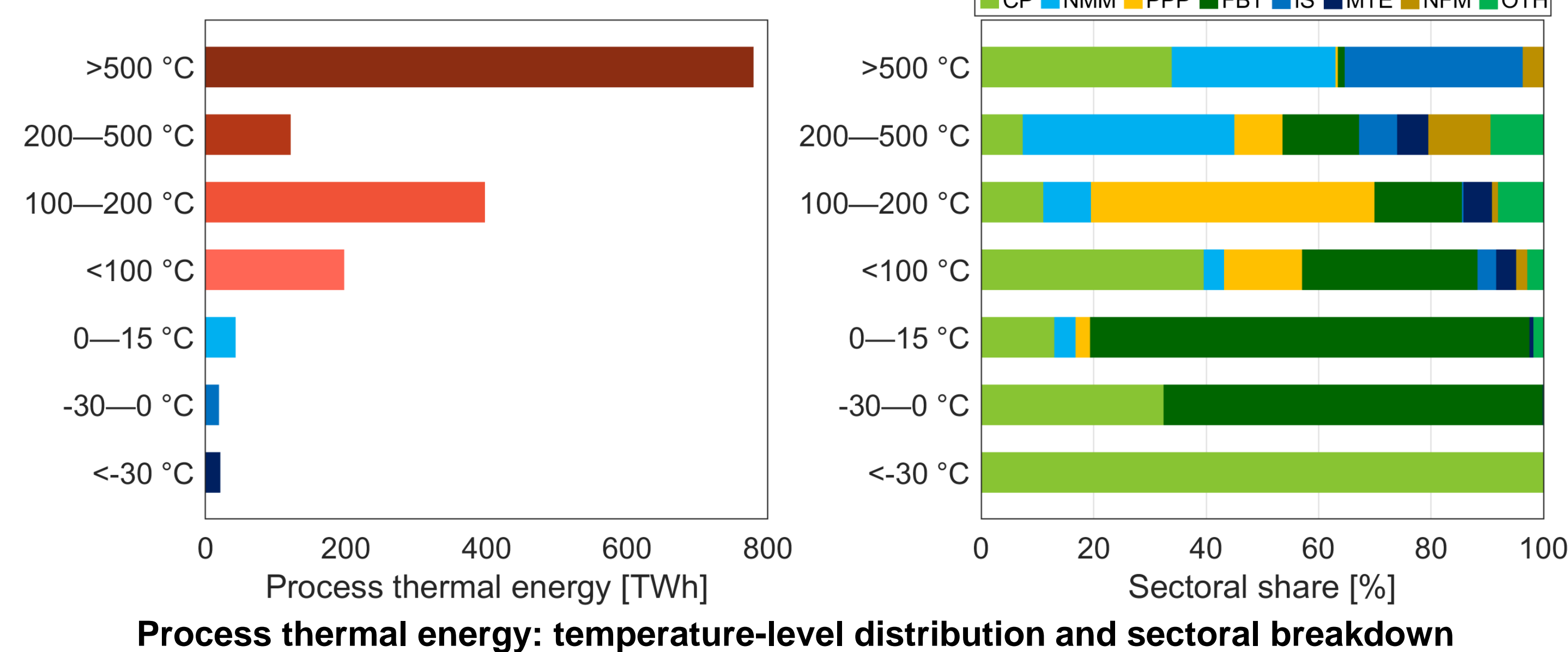
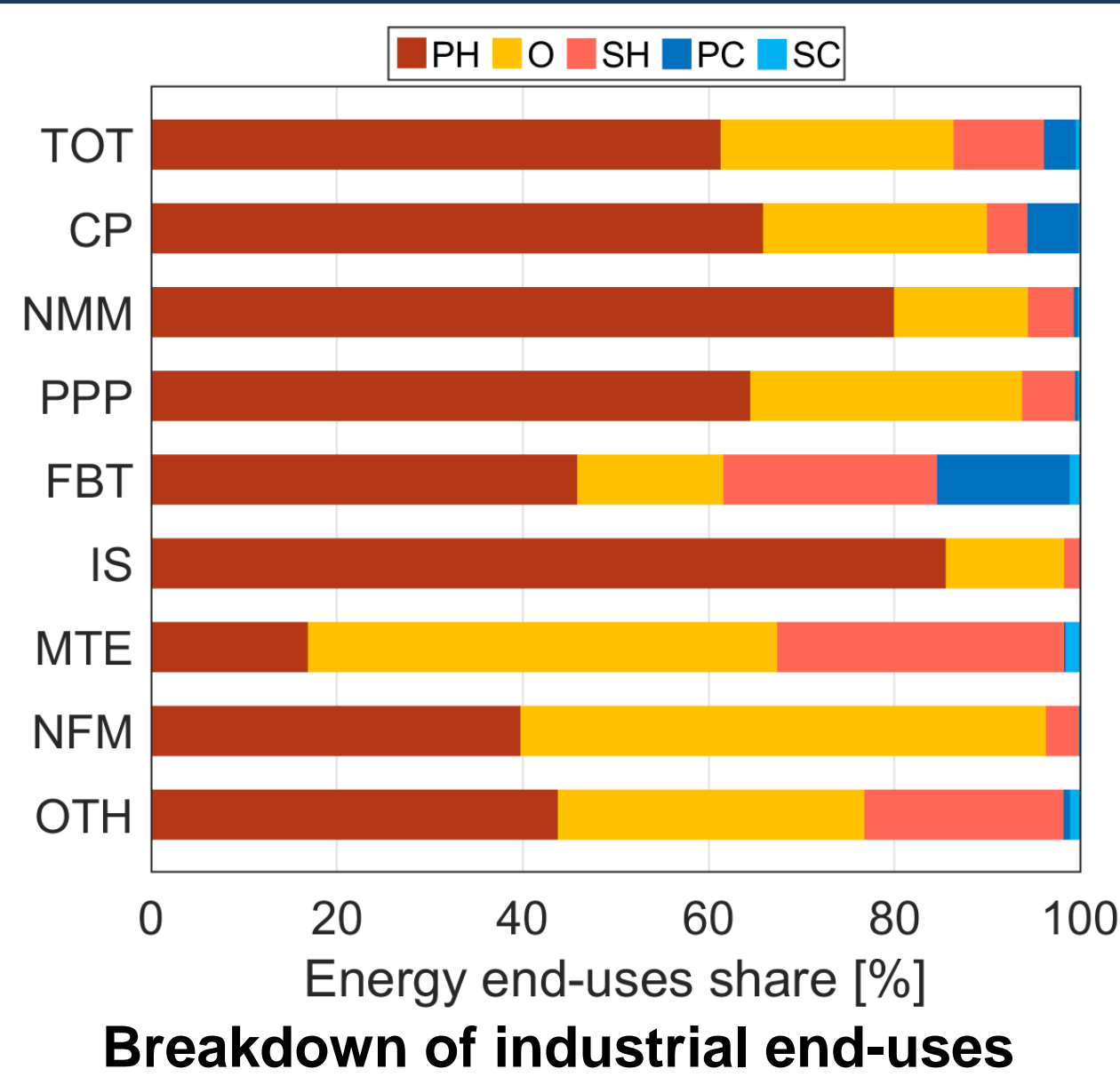


2 IDENTIFICATION OF HOTSPOTS

INDUSTRY-WIDE ANALYSIS

A breakdown of energy end-uses points out similarities and differences among sectors:

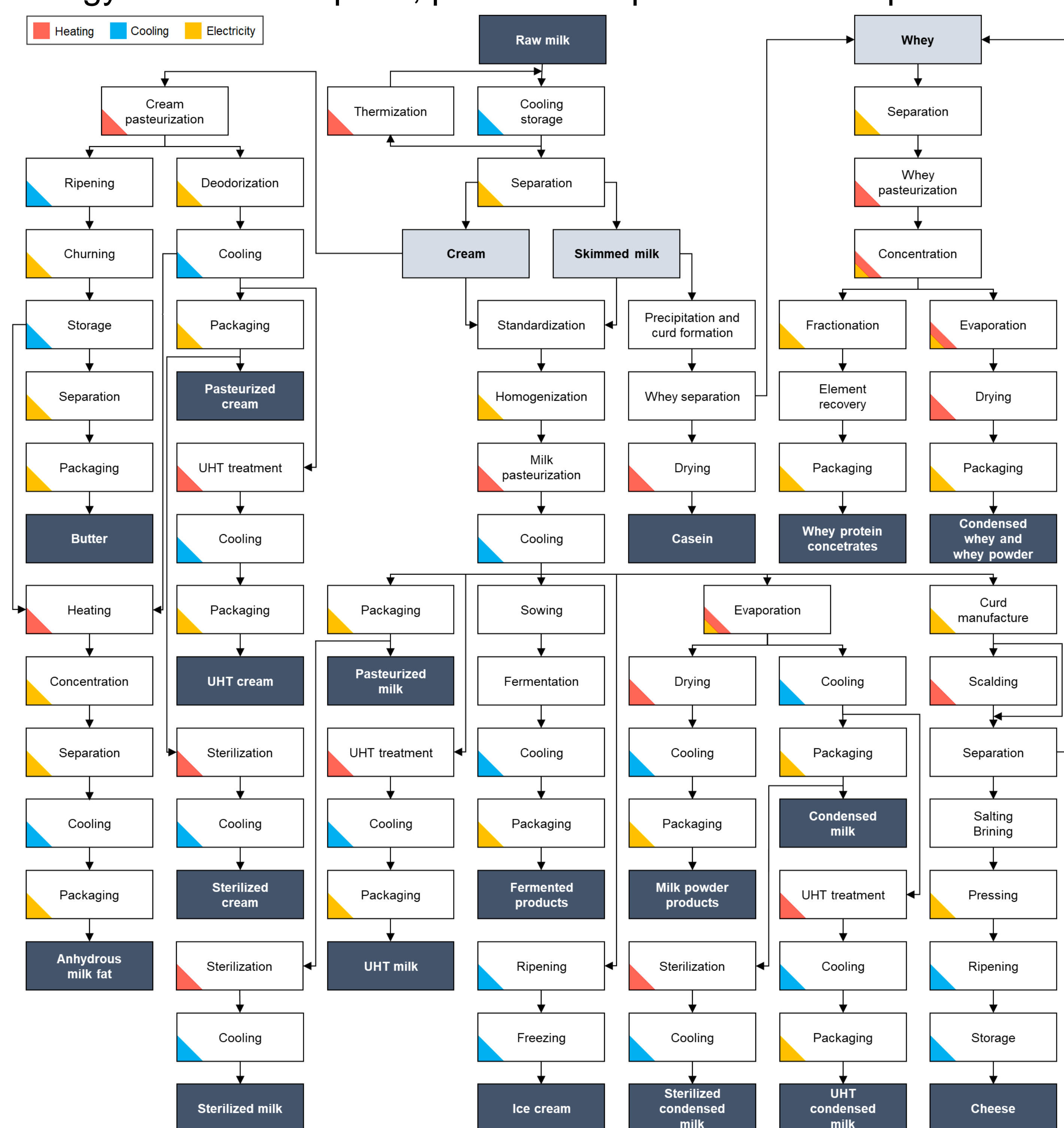
- Predominance of process heating for the most energy-consuming sectors
- Variability in the temperature-level distribution of process thermal energy demand.



Process thermal energy: temperature-level distribution and sectoral breakdown

SECTOR-WIDE ANALYSIS

The dairy industry is chosen as representative of the food industry, which is a relevant strategic sector. It consists of various products obtained from a single raw material through recurring processes. To better characterize the energy performance, establishing energy indicators at plant, product and process level is paramount.



Dairy industry: a map of products and processes

3 QUANTIFICATION OF THE POTENTIAL

SUITABLE TOOLS

Suitable tools must result from a trade-off between accuracy and power of generalization.

Key Performance Indicators (KPIs) are very useful, as they allow to characterize the performance in a synthetic manner and promote technological transfer.

PROMISING SOLUTIONS

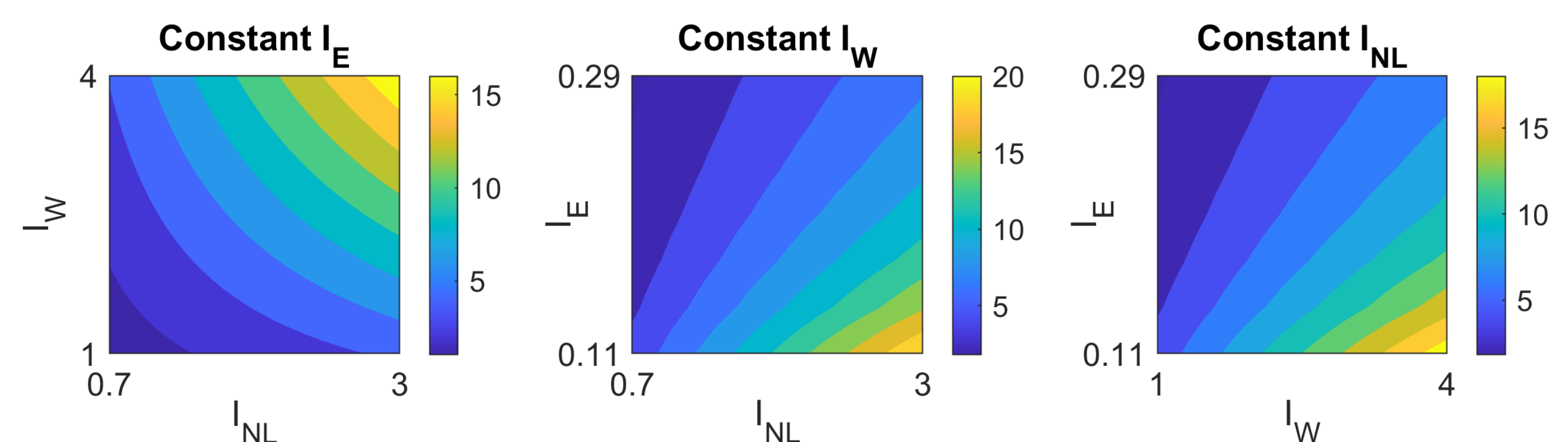
The dairy industry is characterized by a large production of wastewaters that are harmful for the environment.

The enhancement of dairy wastewaters for biogas production represents a promising solution to foster the sustainability of the dairy industry.

The potential of this solution can be quantified in terms of the KPIs for nutrient loss, water consumption, and energy consumption:

|               | Wastewater BOD <sub>5</sub> [g/l] | COD [g/l] |
|---------------|-----------------------------------|-----------|
| <b>Cheese</b> | 0.4-5.7                           | 0.2-7.6   |
| <b>Milk</b>   | -                                 | 0.7-1.4   |
| <b>Yogurt</b> | -                                 | 4.66      |
| <b>Cream</b>  | 1.2-4.0                           | 2.0-6.0   |
| <b>Butter</b> | 1.3-1.5                           | 1.9-2.5   |
| <b>Whey</b>   | 35                                | 68        |

$$Pot_{biogas} = r_{CH_4} \cdot LHV_{CH_4} \cdot \frac{I_{NL} \cdot I_W}{I_E}$$



Maps of biogas potential from dairy wastewaters

4 FUTURE WORK

- Development of energy indicators for the characterization of the energy performance at various levels
- Development of KPI-based tools for the quantification of the potential of energy efficiency solutions
- Analysis of promising solutions in the dairy processing industry and other relevant sectors

PUBLICATIONS

- A. Franco, L. Miserocchi, D. Testi. Energy efficiency in shared buildings: quantification of the potential at multiple scales. Energy Reports (1<sup>st</sup> round of revision)
- A. Franco, L. Miserocchi, D. Testi. Energy indicators for enabling the energy transition in industry (submitted to Energies)

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