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ENERGY RESEARCH

How big is the market potential for electrified thermal energy?

Prepared for Kyoto Group

Our analysis addresses 3 key questions regarding the market opportunity for electrified heat and thermal storage applications

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Q.1	What is the size of the market for electrified industrial heat globally?
Q.2	What is the size of other relevant heat market segments?
Q.3	What is the cumulative investment needed to electrify heat markets?

Aurora provides data-driven intelligence for the global energy transformation

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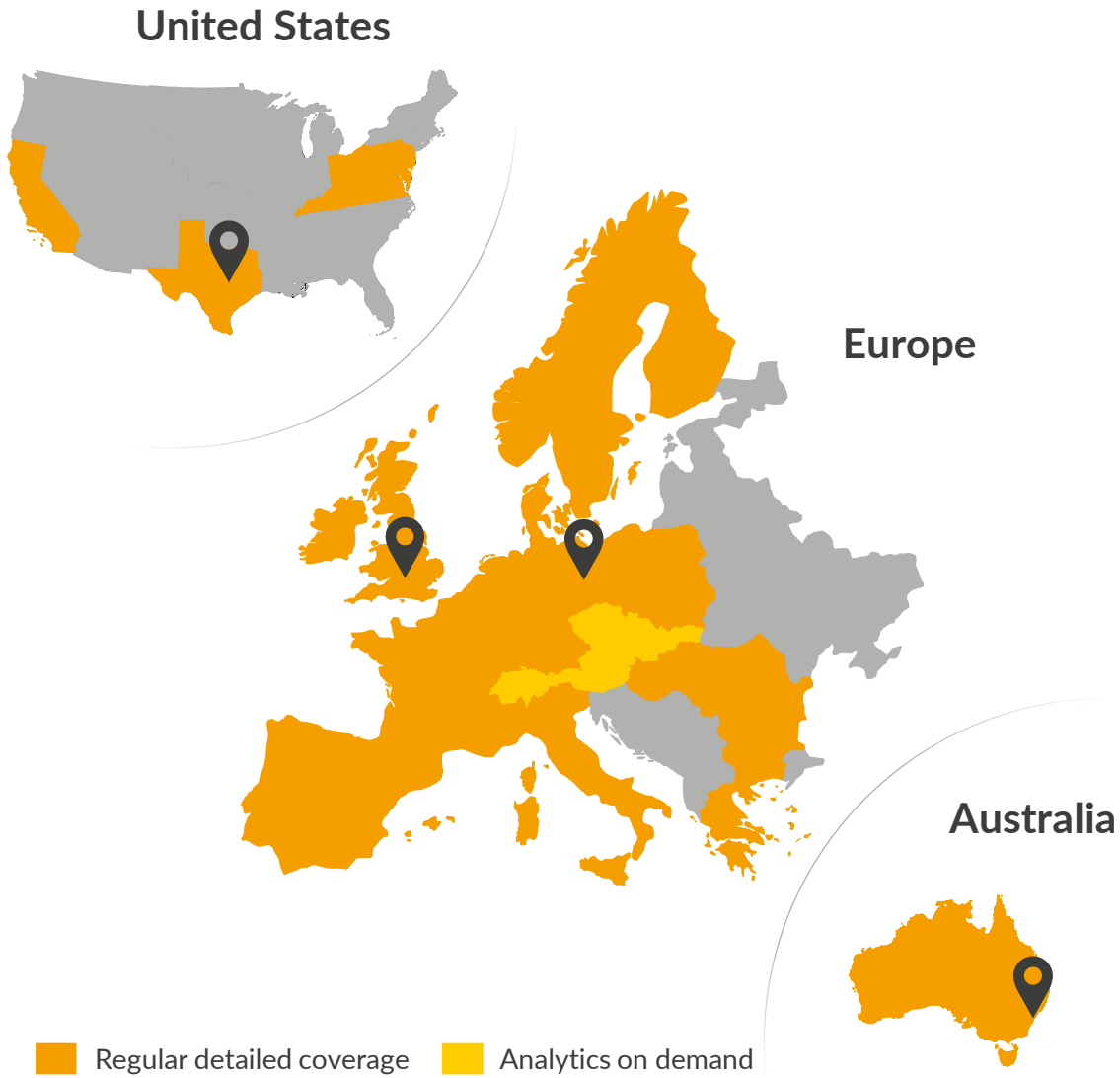
- Power markets
- Renewables
- Storage
- Electric vehicles
- Hydrogen H_2
- Carbon CO_2
- Natural gas



4 Offices
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200+
market experts

350+
subscribing companies

100+
transactions supported in 2020

Source: Aurora Energy Research

Aurora brings a sophisticated approach to the provision of analysis and insight to the energy industry

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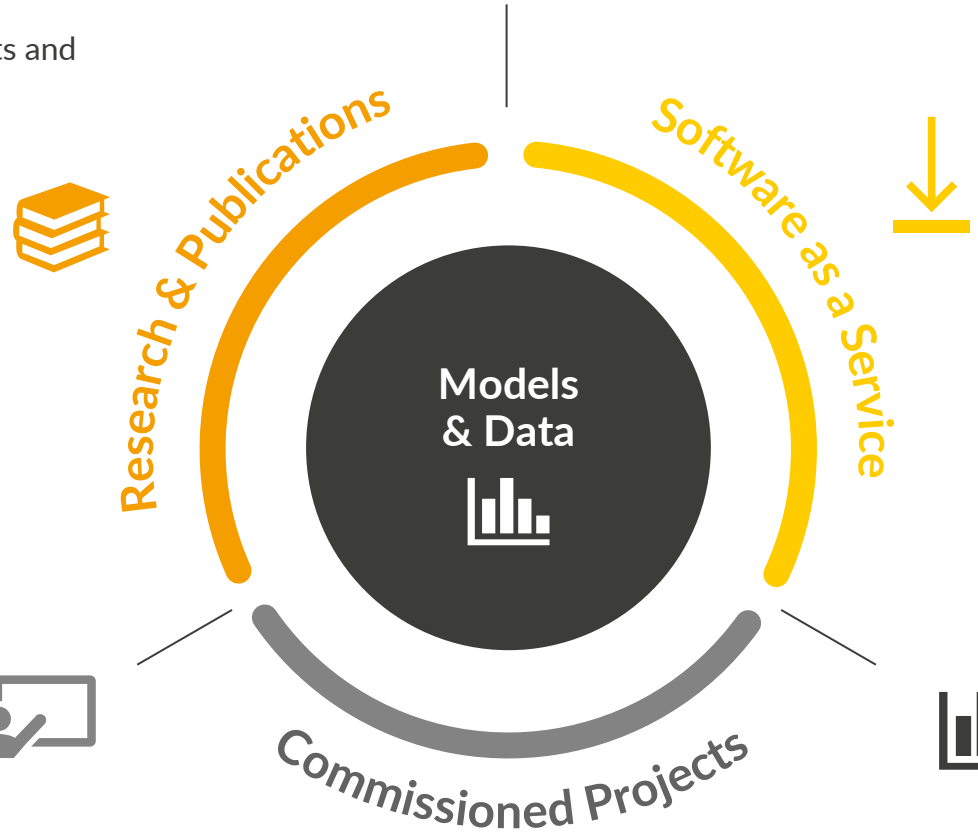
Research & Publications

- Industry-standard market outlook reports and bankable price forecasts for power, gas, carbon and hydrogen markets
- Strategic insights into major policy questions and new business models
- Read and constantly challenged by 350+ subscribers from all industry sectors



Software as a Service

- Out-of-the-box SaaS solutions, combining cutting-edge sophistication with unparalleled ease of use
- *Origin* provides cloud-based access to Aurora's market model, pre-populated with our data
- *Amun* automates asset-specific wind farm valuations for over 30 leading funds, developers and utilities

Commissioned Projects

- Bespoke analysis, drawing upon our models and data
- Trusted advice for all major market participants proven in 500+ projects: transaction support, valuations, strategy & policy engagement

Models & Data

- Market-leading long-term models for power, gas, hydrogen carbon, oil and coal markets
- Continuous model improvements to reflect policy and market developments

Source: Aurora Energy Research

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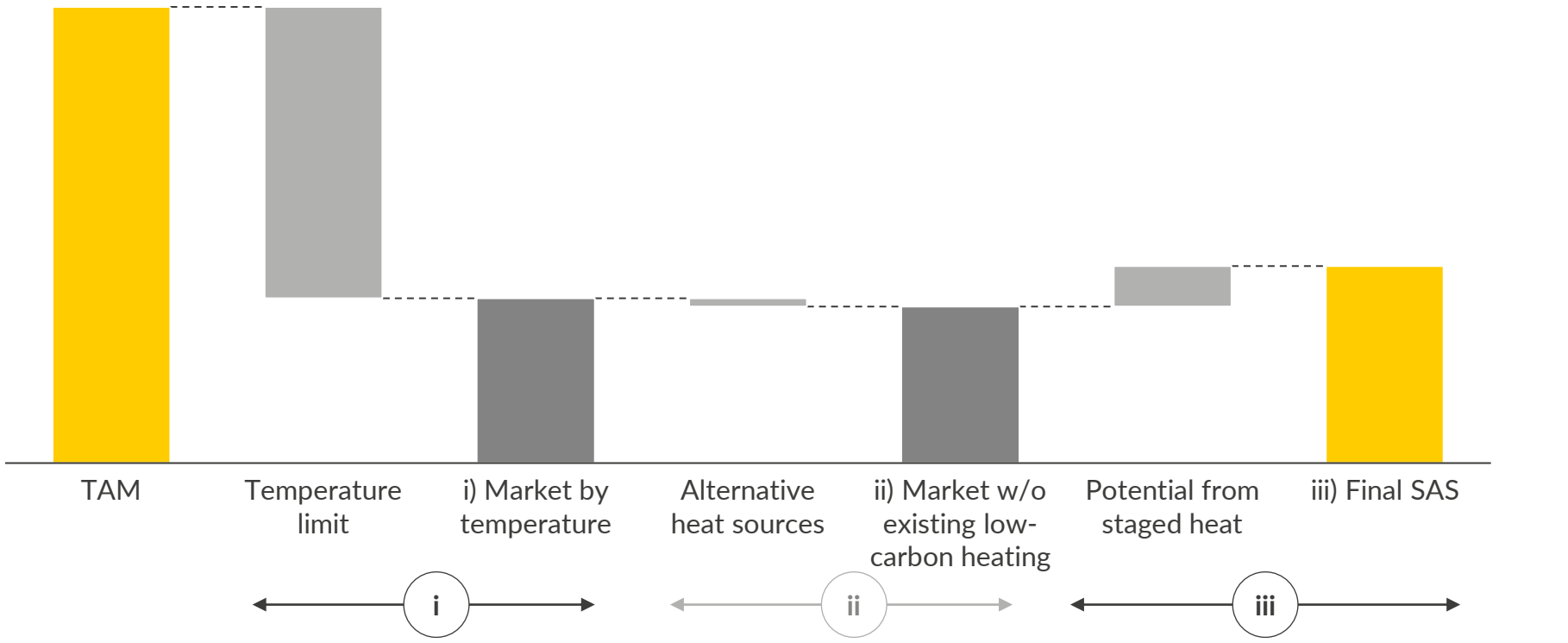
We have assessed the market size for electrified industrial heat applications in three steps

Total addressable market (TAM)

TAM =
Global heat demand ⊖ heat demand outside industry

Serviceable addressable segments (SAS)

SAS =
TAM ⊖ Heat demand outside relevant temperature range ⊖ existing low-carbon heat ⊕ heat demand for pre-heating



Source: Aurora Energy Research

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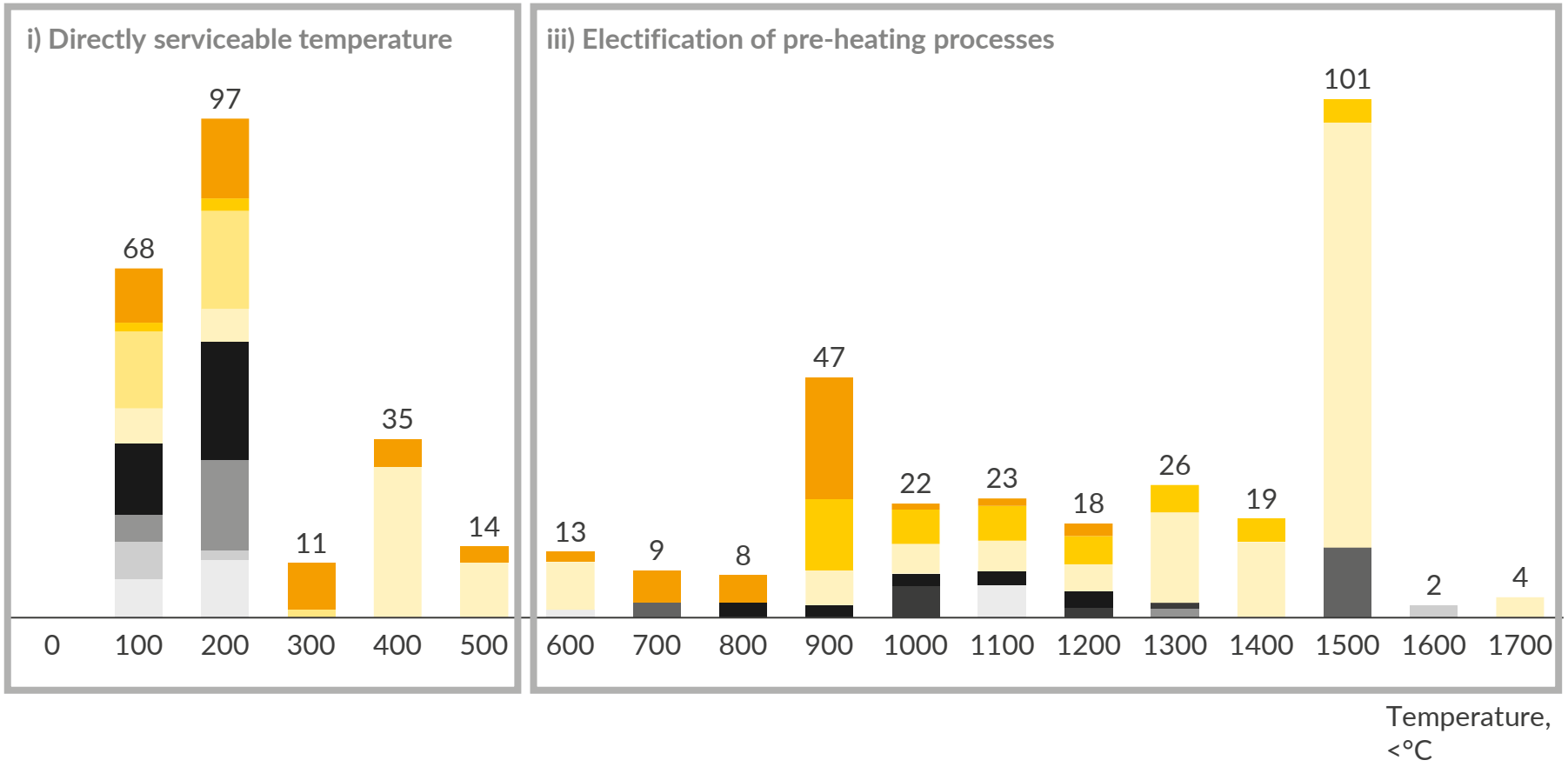
Method

- We estimated the heat market size based on UN data
- To determine SAS, we applied three steps:
  i. Limits by directly serviceable temperature range
  ii. Discount to consider existing alternative low-carbon heating technologies
  iii. Upside from staged heat in high-temperature industry processes

The market size of different industrial heat segments is determined by the temperature requirements of each segment

Heat demand per temperature and industry segment in Germany
TWh



Sources: Aurora Energy Research, dena (2016)

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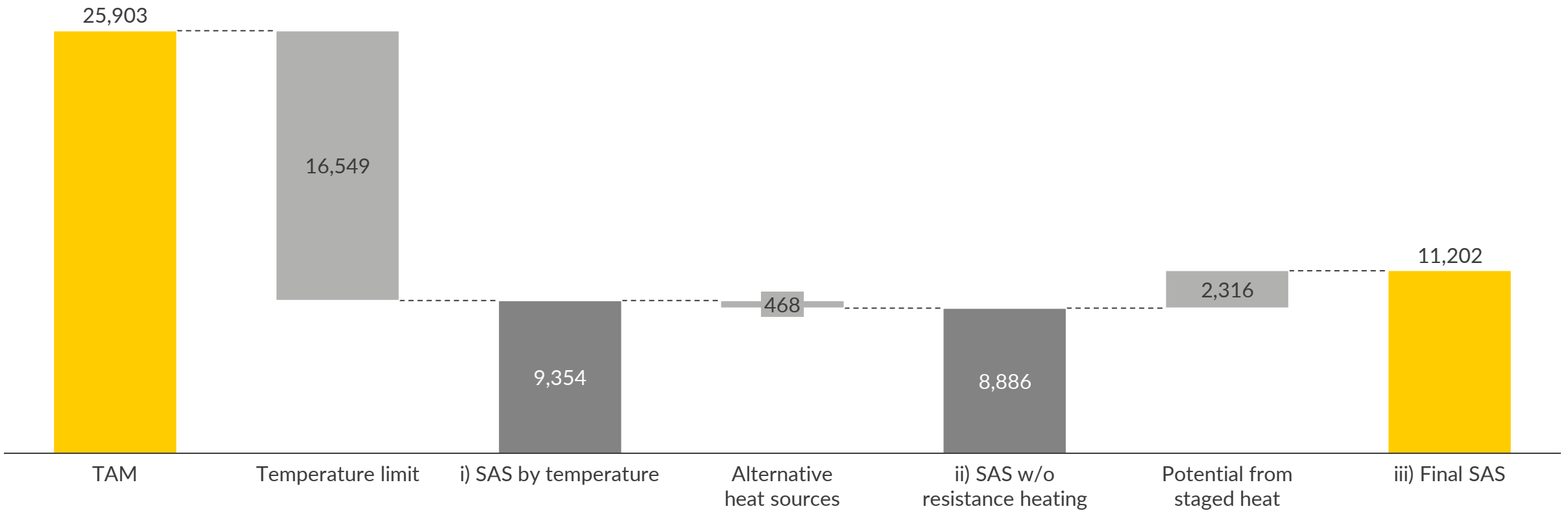
Methodological notes

- A significant proportion of industrial heat is required at temperatures above 500°C
- Iron and Steel makes up a significant proportion of total industrial heat demand, largely above 1000°C
- This is the key factor leading to a lower Serviceable market than the Total market for electrified heating applications
- Staged heating leads to potential for accessing higher temperature demands – although a share of pre-heating is already provided via waste heat
- c. 5% resistance-based heating in industry process heat could be deducted from SAS

Focusing on the directly applicable temperature range and the potential for staged heating leads to a SAS of c. 11,200 TWh

Market size globally,
TWh/year



Source: Aurora Energy Research

An electrified system that can deliver heat up to 500°C can serve c. 45% of all industrial heat demand

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Total addressable heat market (TAM)

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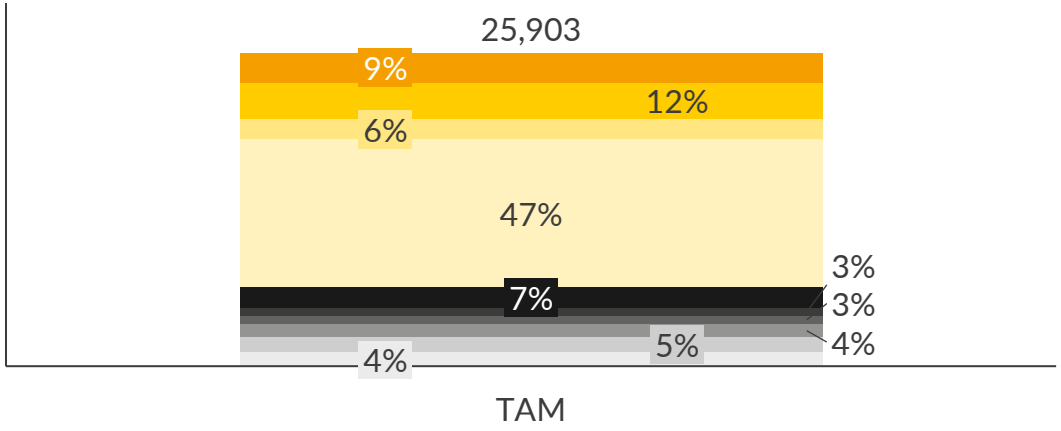
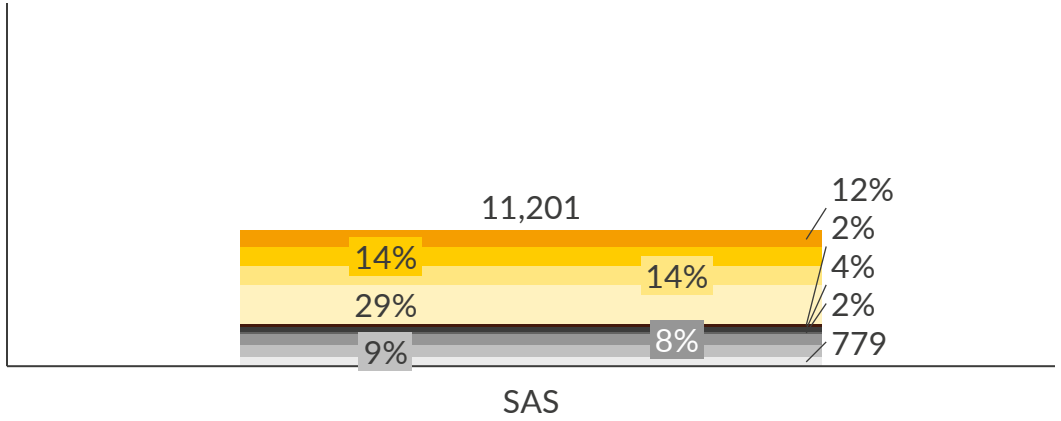
Heat demand,
TWh/year



Heat demand,
TWh/year



Chemical and petrochemical
Construction
Food and tobacco
Iron and steel
Machinery
Non-ferrous metals
Non-metallic minerals
Paper, pulp and print
Textile and leather
Not elsewhere specified

Source: Aurora Energy Research

Germany is by far the highest source of industrial heat demand in Europe

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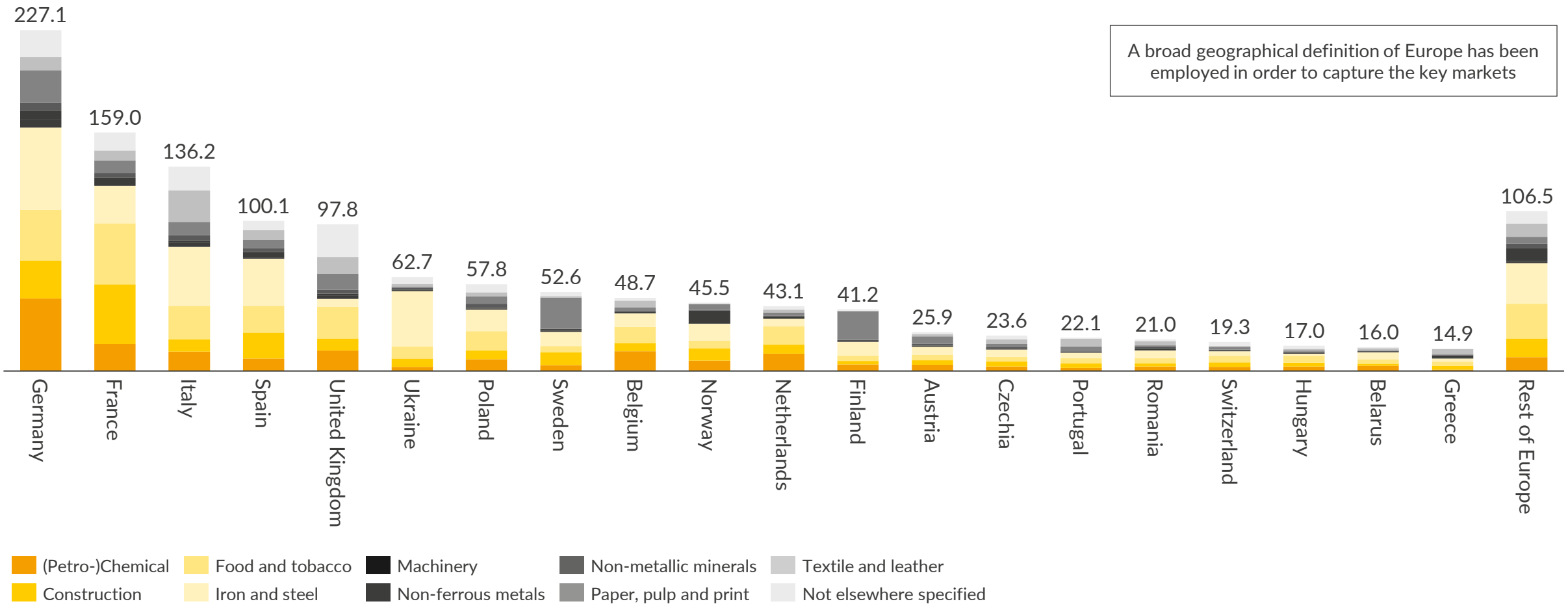
European SAS break down
TWh/year



Sources: Aurora Energy Research, Papapetrou et al.

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Heat storage systems could be used to recover c. 2,500 TWh of waste heat globally

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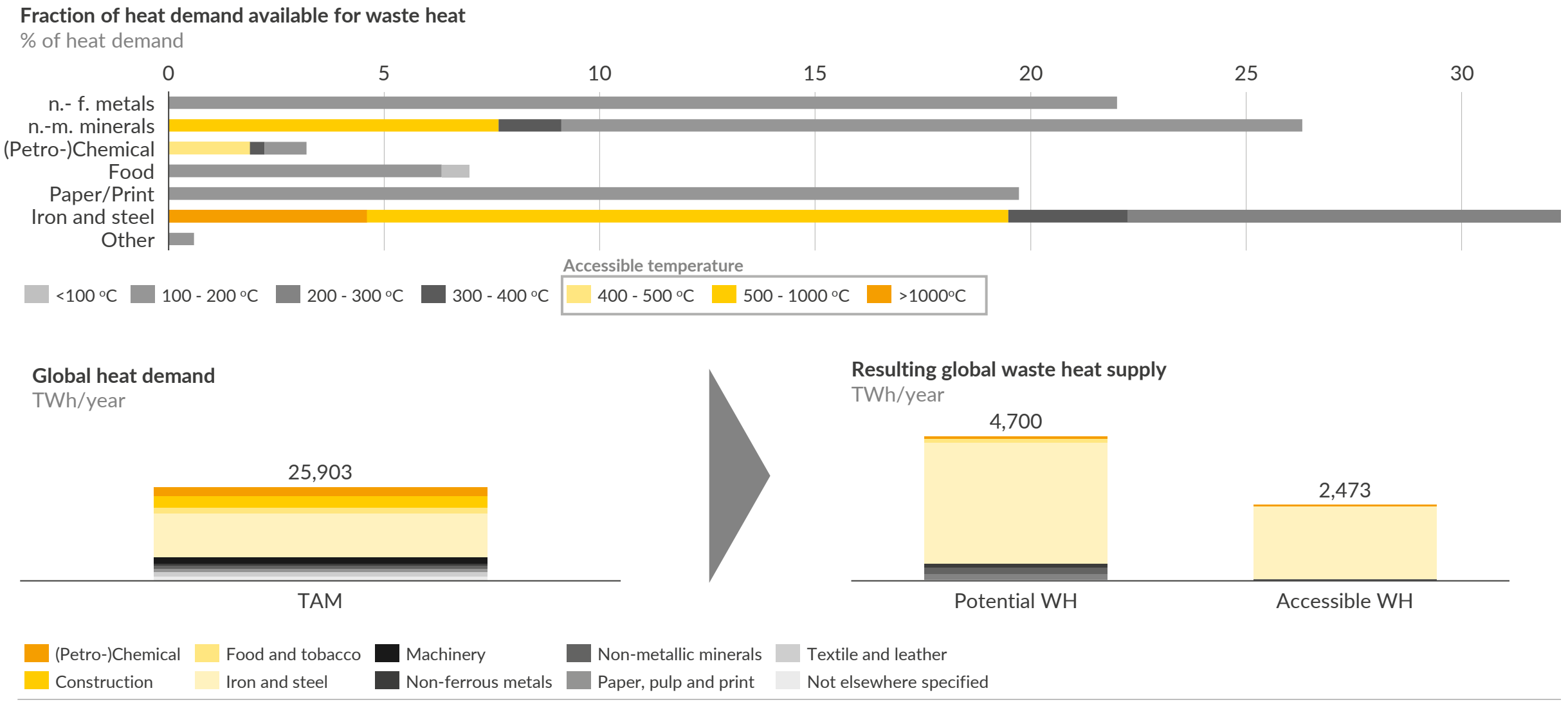

Sources: Aurora Energy Research, Papapetrou et al.

Germany is by far the highest source of waste heat in Europe

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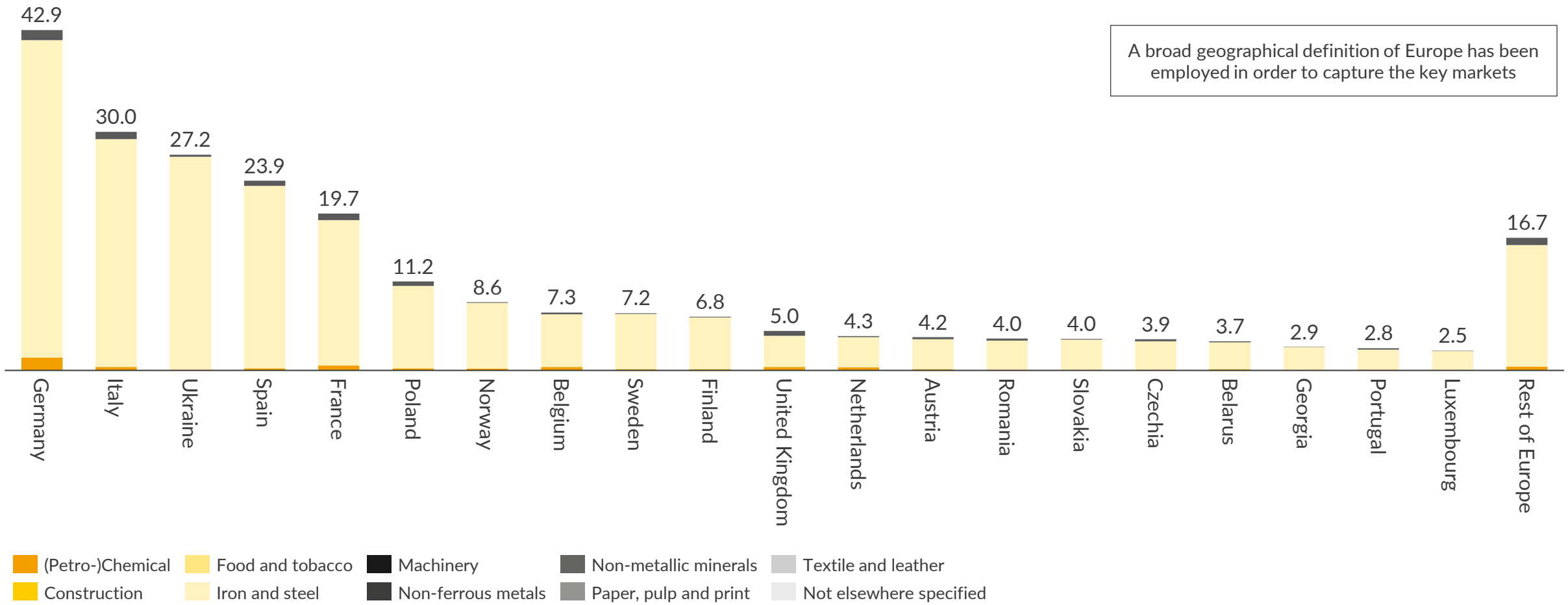
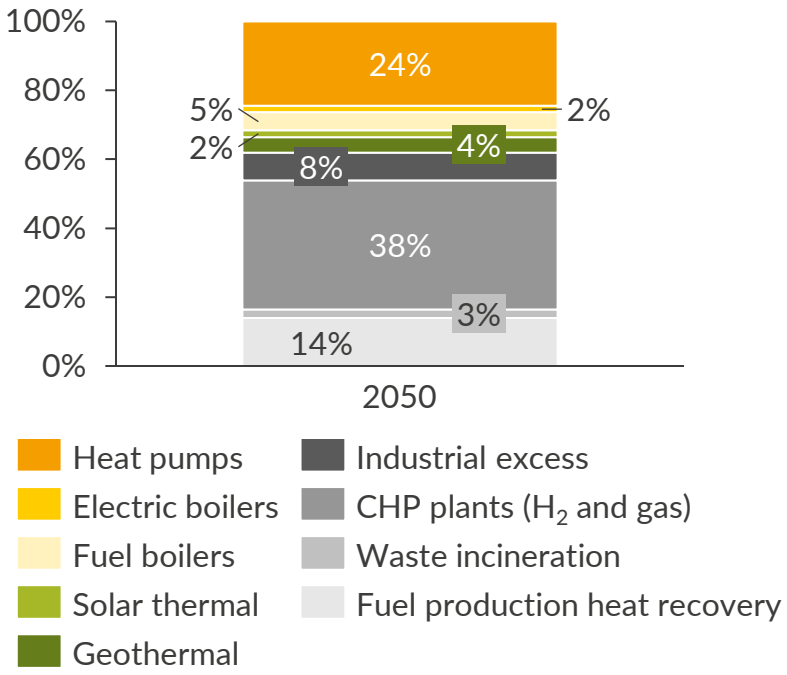
Resulting European waste heat potential
TWh/year



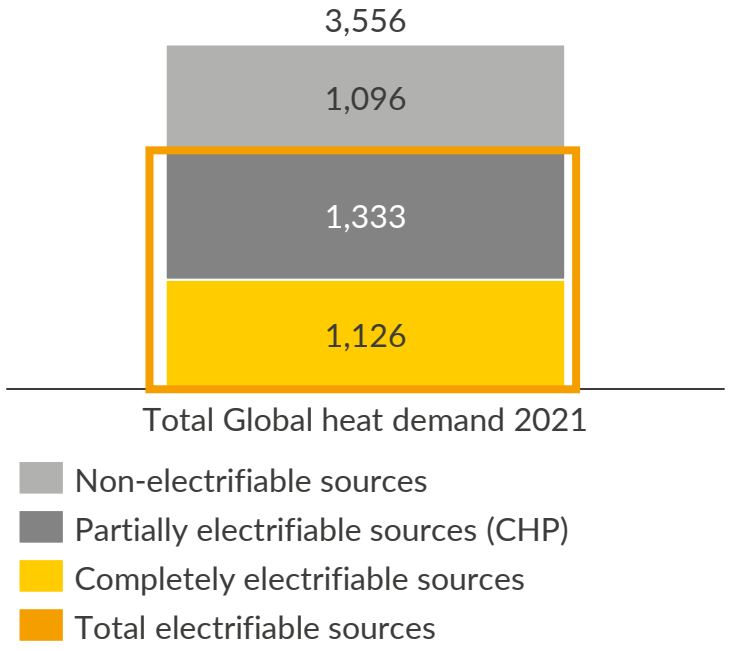
Sources: Aurora Energy Research, Papapetrou et al.

Up to 69% of global district heating demand could be electrified, reflecting a market of c. 2,460TWh

European district heating demand by source
%



Global district heating demand
TWh



District heating can be electrified up to 31 + 38 % by 2050

- 31% of the district heating demand in Europe in 2050 would be either already electrified (Heat pumps and electric boilers) or electrifiable (fuel boilers)
- An additional 38% of CHP could be electrified

The size of the current market that can be electrified is between 1 and 2.5 PWh

- The analysis presented here represents an upper bound of the size of the district heating market
- Overall demand growth for district heating may stagnate due to efficiency improvements, but Heat Roadmap Europe sees the potential for district heating to increase from 12% to 50% in terms of the proportion of total heat delivered
- The total market for low-carbon DH is up to 2.5 PWh, which is addressable by electric applications and CHP plants
- Key uncertainties moving forward are regarding the role of large scale heat pumps, combined heat and power (CHP) from gas and coal with carbon capture and storage (CCS) and hydrogen.

Sources: Heat Roadmap Europe, Aurora Energy Research

Demand for district heating comes mainly from Russia and China, with China being the main growth area

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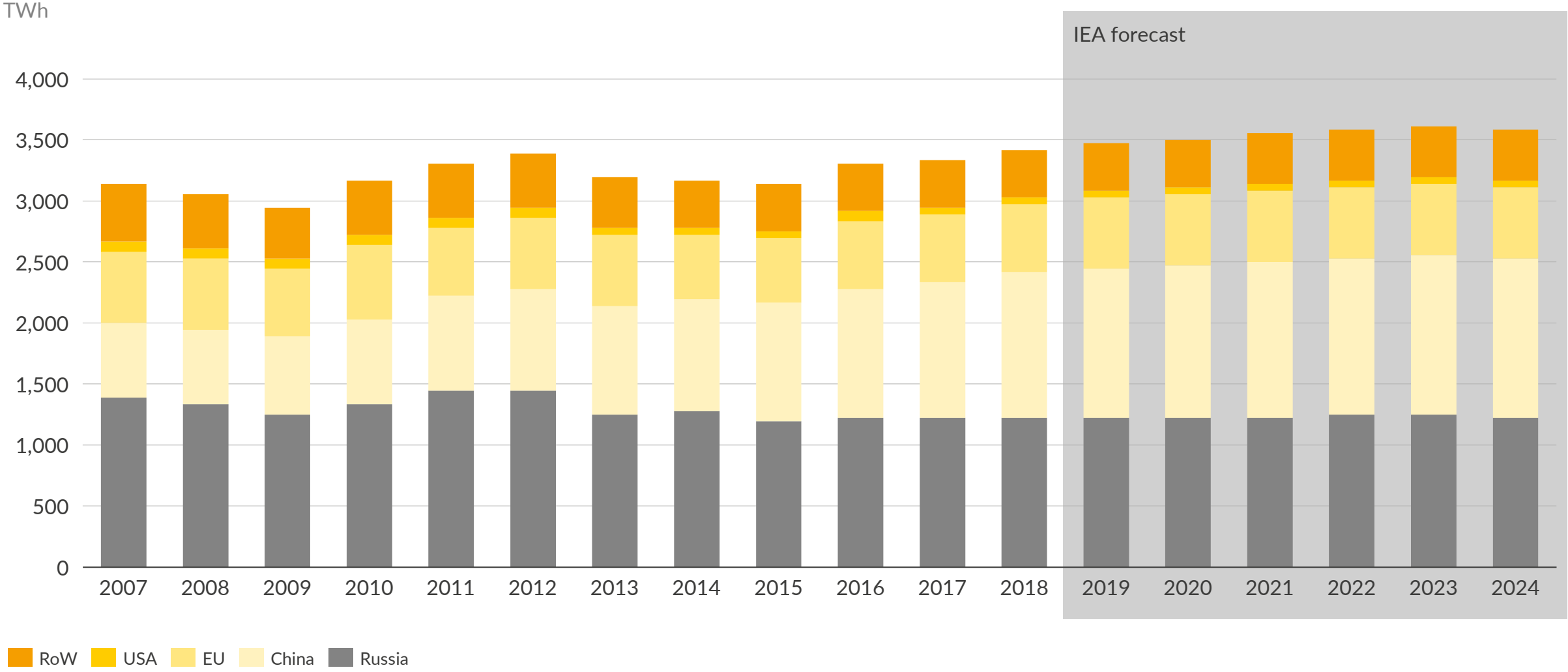
Heat demand from district heating

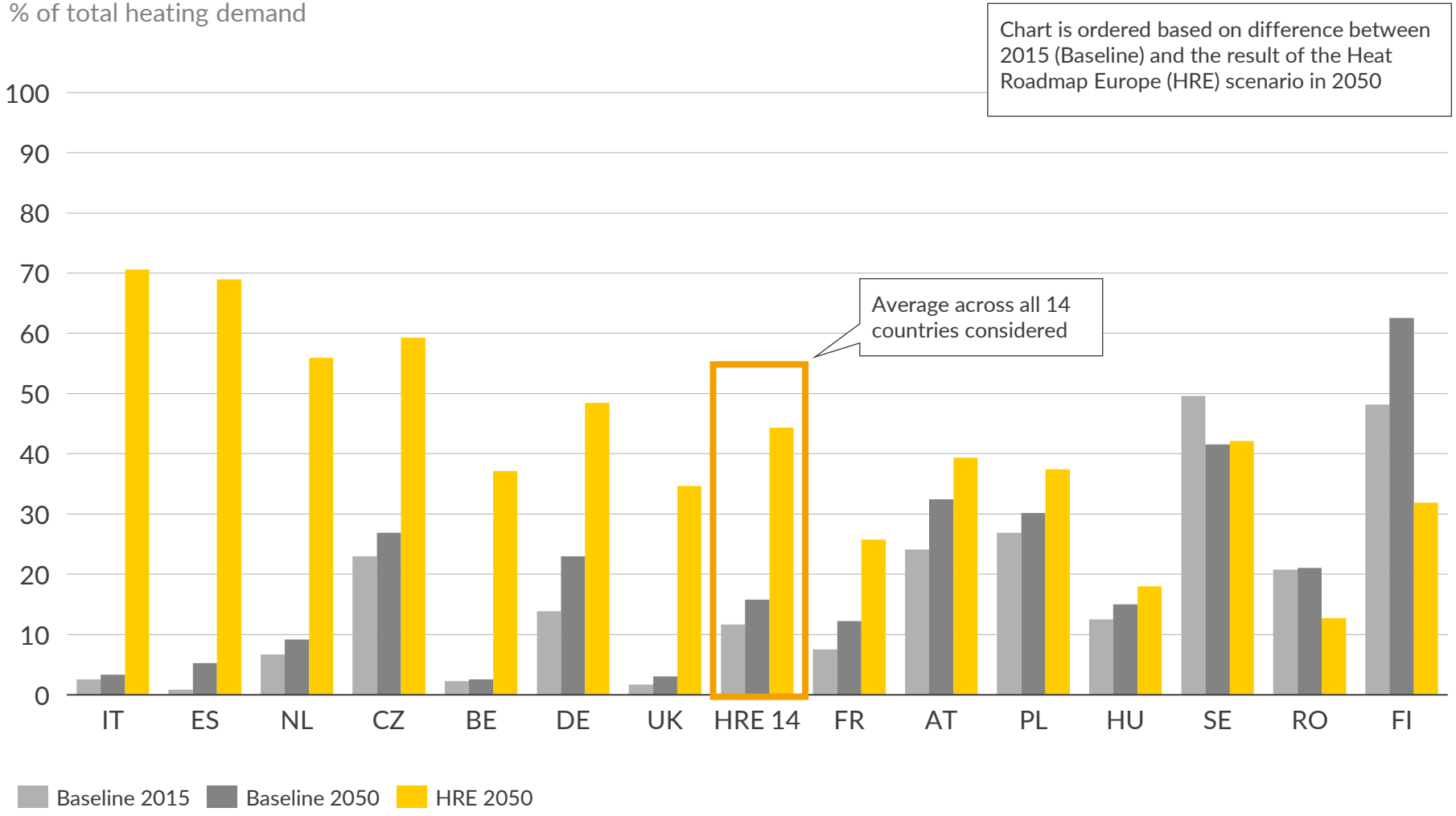
TWh



Sources: Aurora Energy Research, IEA (2019)

There is great potential for expansion of district heating networks, however it will only be realised if there is a significant policy shift

Modelled heat demand from district heating
% of total heating demand



- Baseline 2015 represents historical data from 2015
- Baseline 2050 represents the proportion of district heating demand if no change in policy is enacted
- HRE 2050 represents the proportion of district heating that could be expanded in order to remain in line with Paris targets
- The chart shown here indicates that the countries that exhibit the biggest growth potential are Italy, Spain, the Netherlands, the Czech Republic, Belgium, Germany, and the UK
- In some countries (such as Romania or Finland) the penetration of district heating is lower in the HRE scenario, due to economic reasons

Sources: Aurora Energy Research, Heat Roadmap Europe (2019)

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Cumulative investment to electrify industrial heat is c.€1tn, with iron and steel representing about 29% of the total

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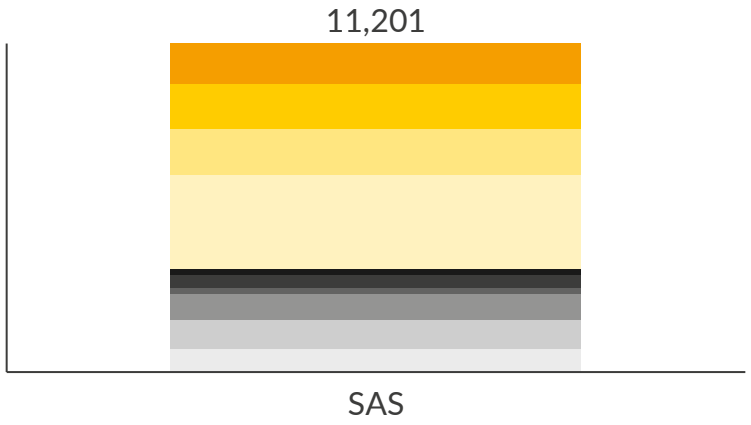
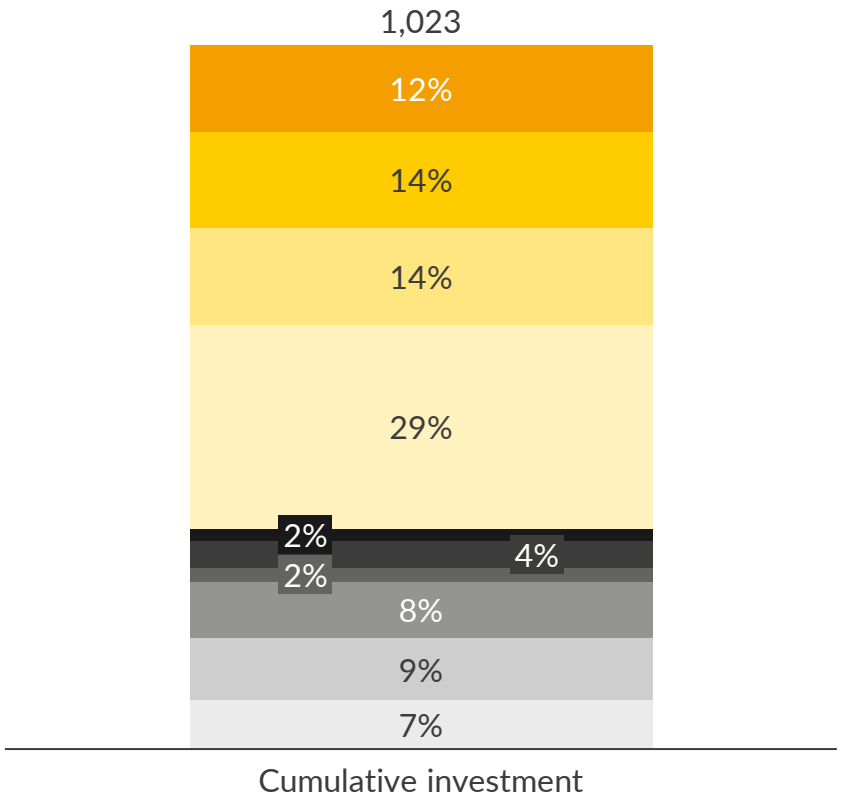
Technology Assumptions

Unit capacity	12 MW charge; 5 MW discharge
Storage capacity	60 MWh
CAPEX	2 mEUR
=> Annual heat output	**21.9 GWh**

Global heat demand
TWh/year



Cumulative investment to electrify SAS
bn EUR



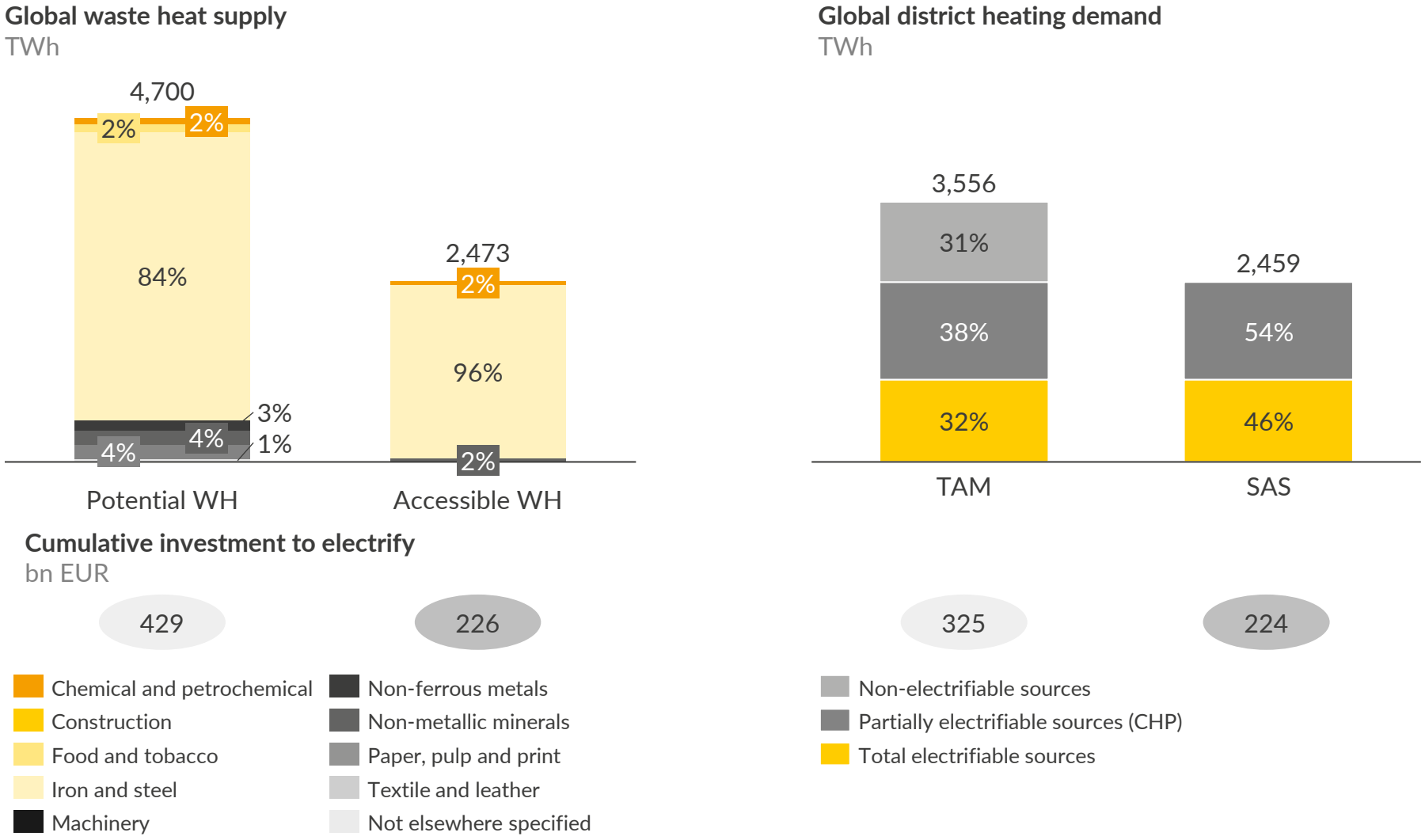
Chemical and petrochemical
Construction
Food and tobacco
Iron and steel
Machinery
Non-ferrous metals
Non-metallic minerals
Paper, pulp and print
Textile and leather
Not elsewhere specified

Sources: Aurora Energy Research, Kyoto Group

Comments

- We assume that Heatcube is cycled once per day – leading to a total of 21.9 GWh of heat output per 60 MWh unit
- CAPEX is assumed to be consistent over countries and industry applications
- Cumulative investment represents the market at saturation.

Electrification of other heat markets could imply additional cumulative investment of €450bn globally



- Accessible waste heat supply is c. 2.5PWh, with iron and steel industry being the dominant sector
- Up to 70% of the district heating demand could be satisfied by electrical sources, which could be an additional 2.5PWh market globally for electrified heat applications

Sources: Aurora Energy Research, Kyoto Group

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