



Electrification of Industrial Heat



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March 2025

ENERGY SYSTEMS
INTEGRATION GROUP



High Temperature Industrial Heat

Problem

- Industrial heat accounts for 30% of global emissions
- Traditionally considered hard to abate, lack of good technical alternatives
- Gas is cheap

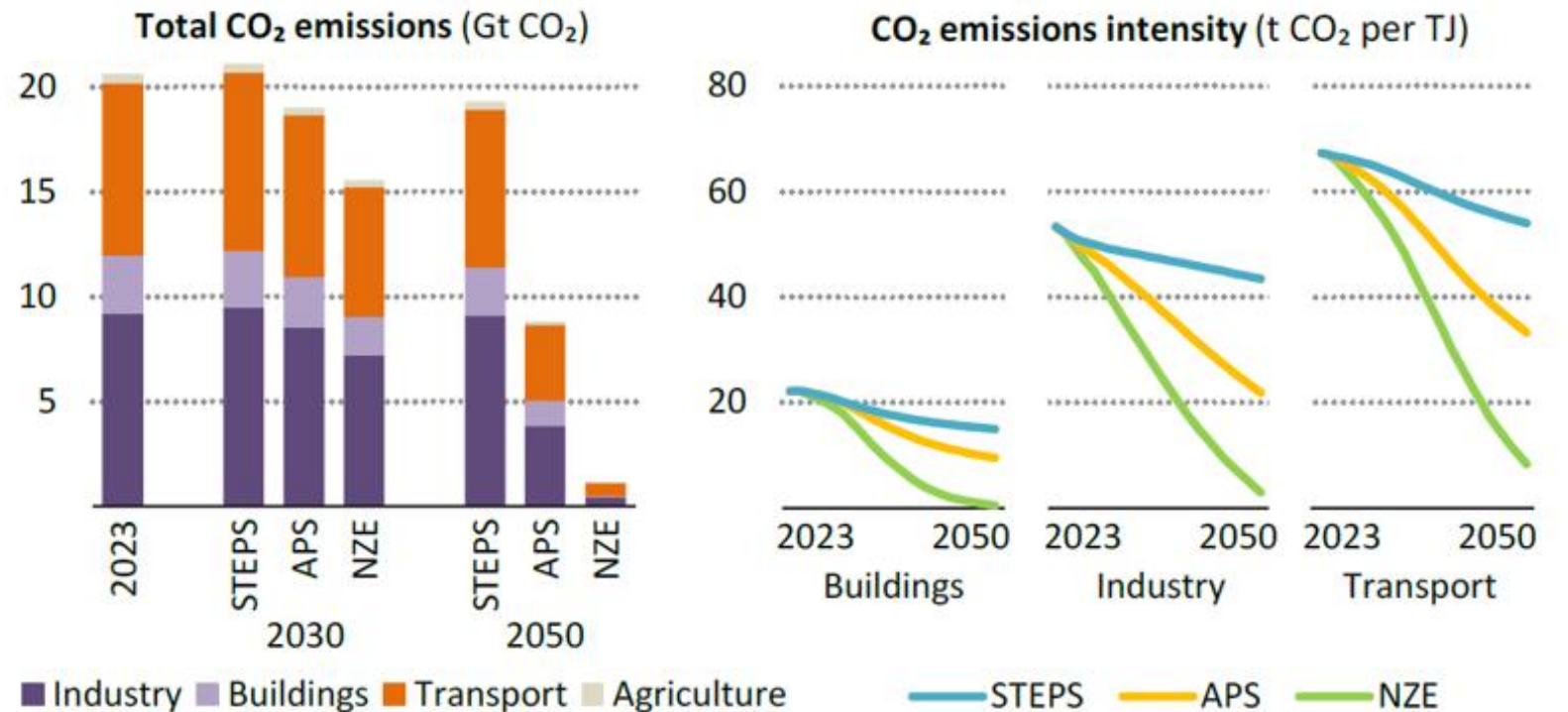


Solution

- Significant technology progress in recent years, multiple electrification solutions available
- Use surplus electricity at times of high RES generation to replace natural gas
- Remove market distortions that favor fossil fuels



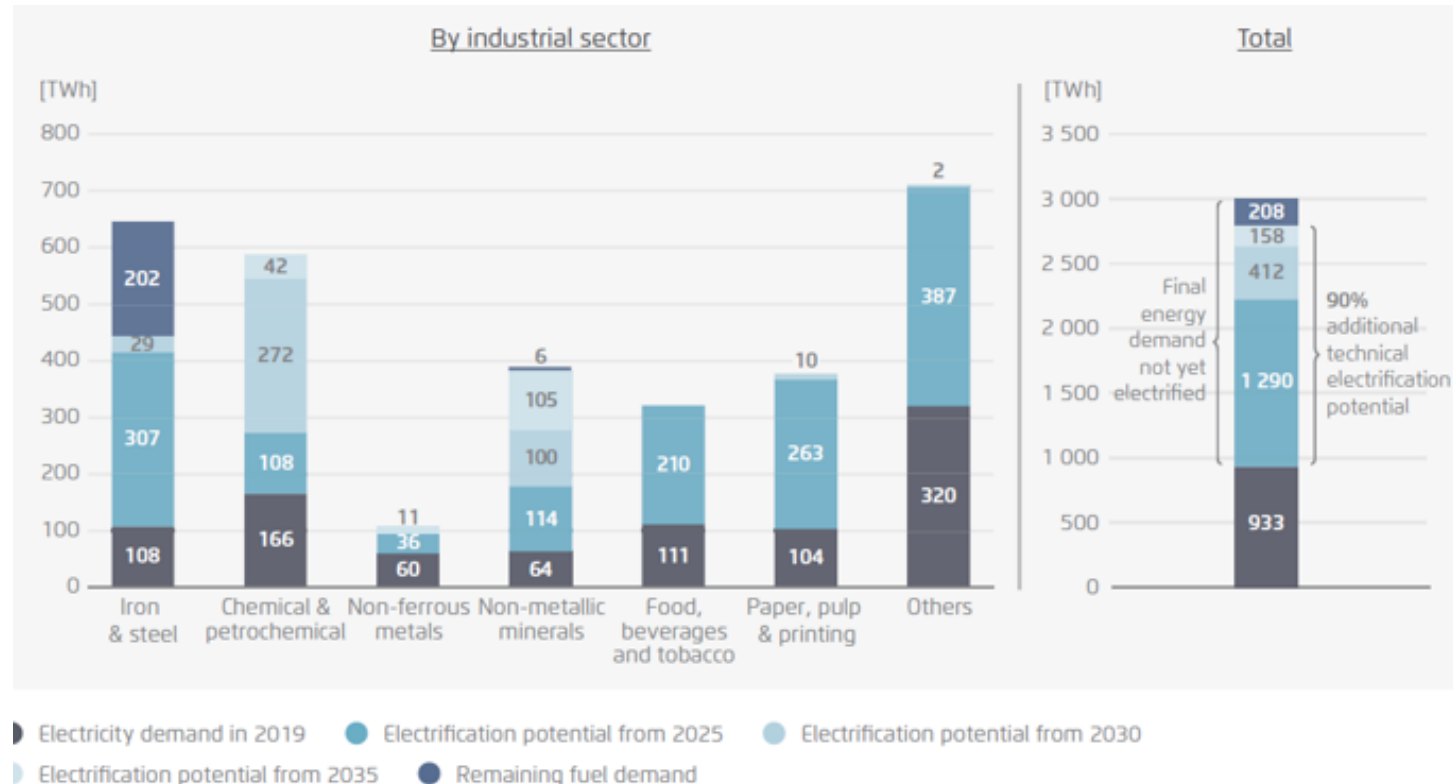
IEA: CO2 Emissions By Sectors and Scenario



IEA. CC BY 4.0.

- Industry and Transport are large sources of CO₂
- IEA anticipate faster electrification in Transport than Industry

Technical Solutions to electrify heat are available



- Technology is available to electrify industrial heat
- 60% today
- 95% by 2035
- c2,000 TWh in EU

Fraunhofer, 2024



INDUSTRIAL HEAT

- Fast charge – under 4 hours → Need < 2000 hours pa
- High Energy Density – on par with Li-Ion
- Highest Temperature – up to 1500°C delivered
- High temperature discharge can drive generators
- 95% round trip efficiency for heat, up to 55% for power
- Low Cost – material cost under \$3,000/MWh

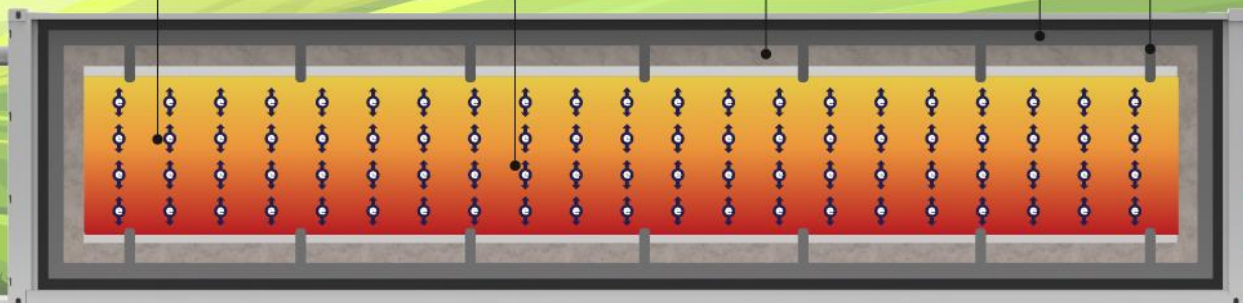
INTERMITTENT
POWER



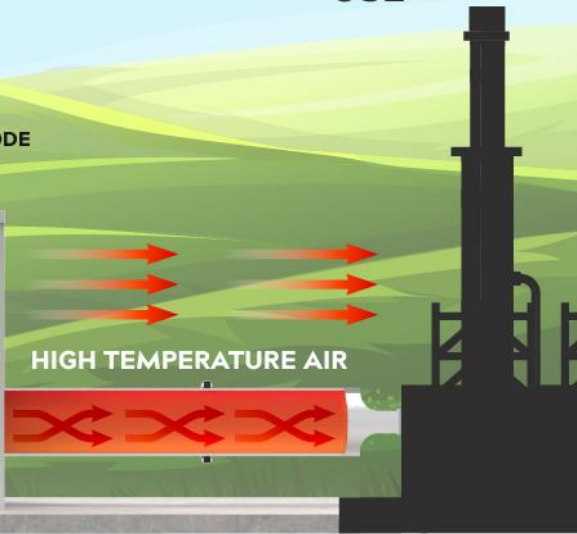
FRESH
AIR INTAKE



ELECTRON FLOW STORAGE MATERIAL REFRACTORY HIGH TEMPERATURE INSULATION ELECTRODE



INDUSTRIAL
USE



INDUSTRIAL HEAT

ELECTRICITY



HEAT



STORE

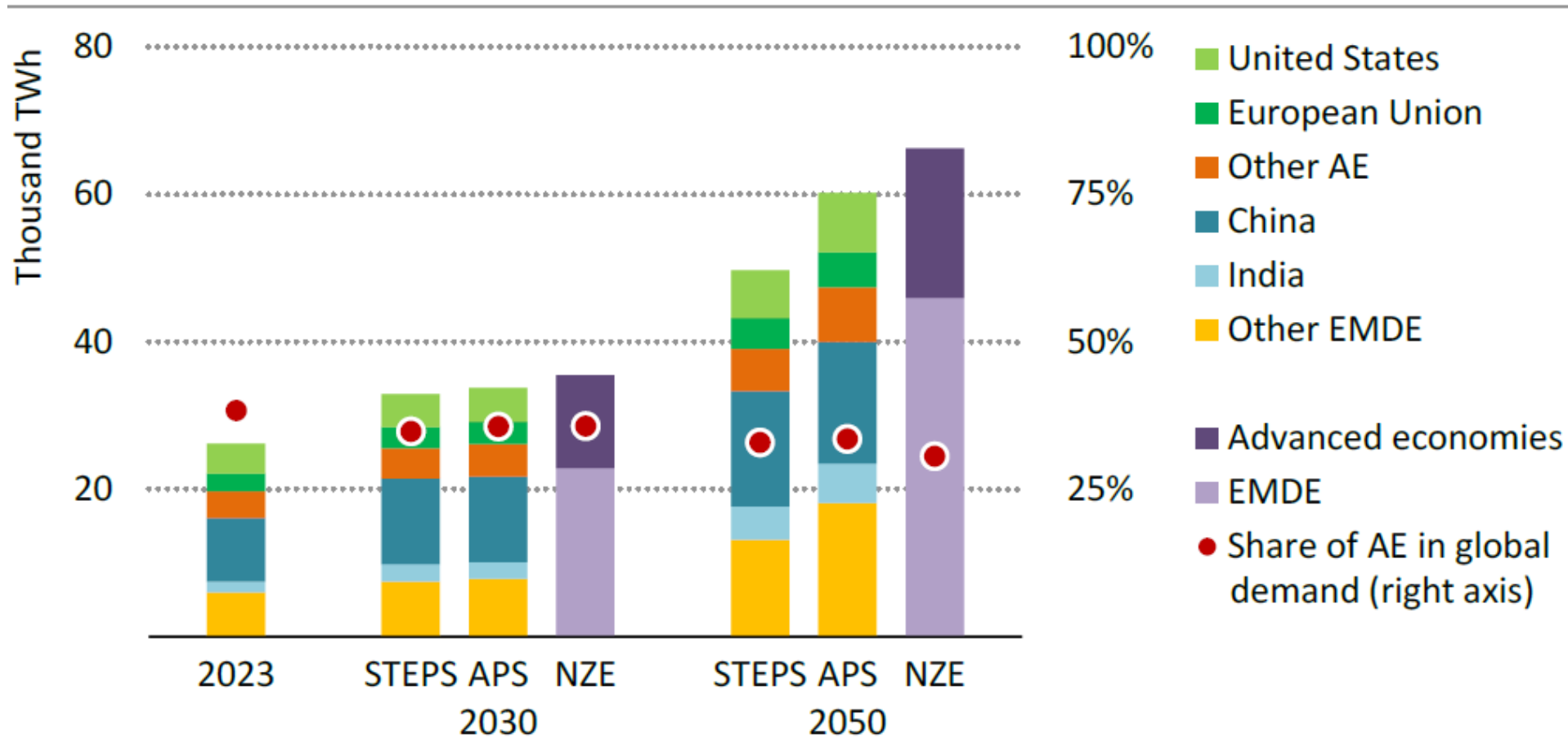


HEAT



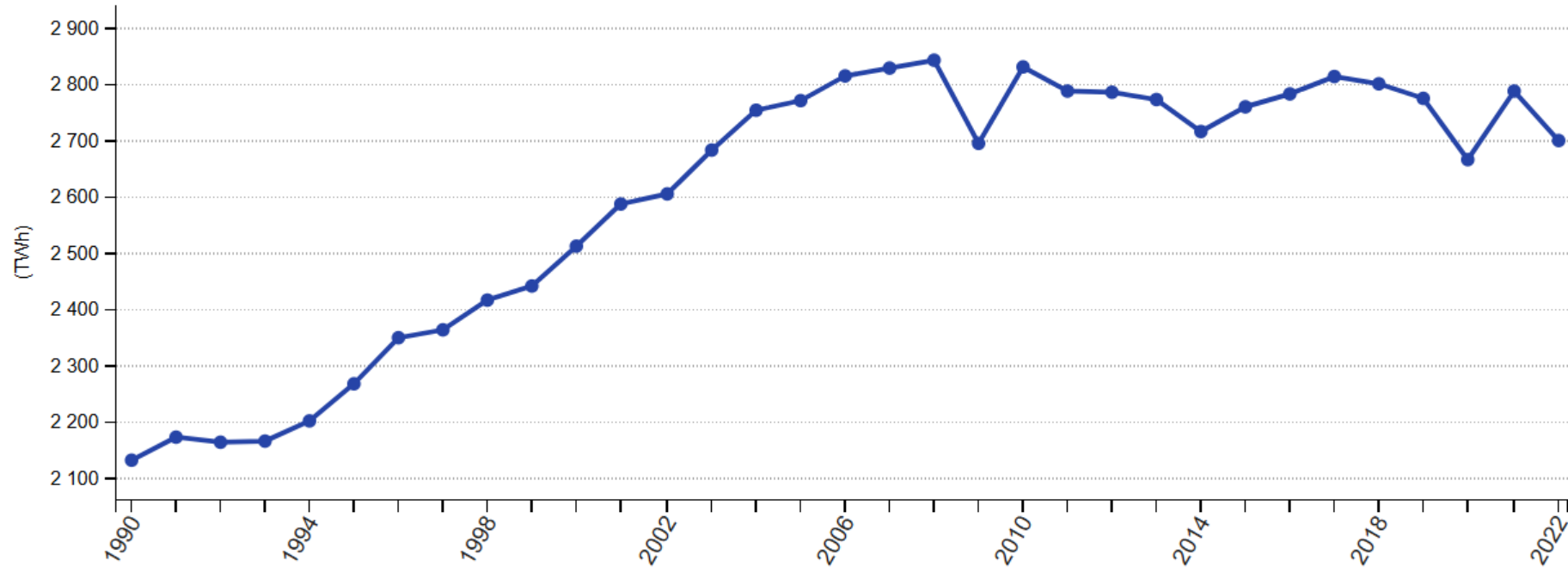
EFFICIENT

Global Electricity Demand: IEA



IEA. CC BY 4.0.

EU Net Electricity Generation, 1990-2022

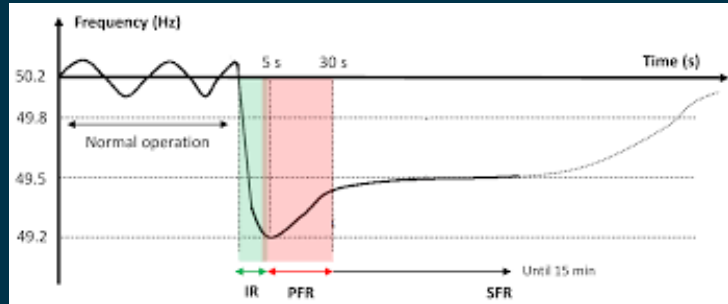


Total EU
Electricity
Generation in
2022

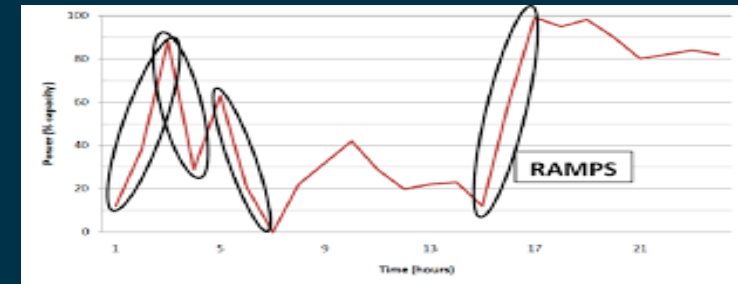
2,701 TWh

Eurostat

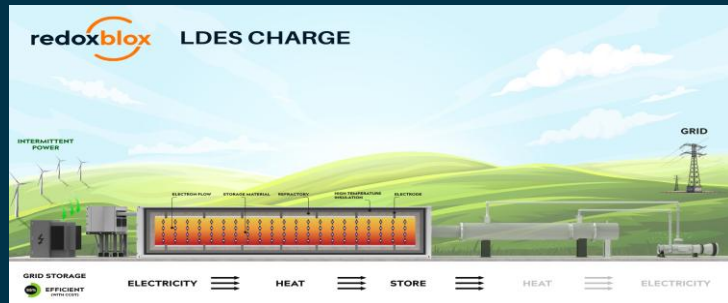
Technical Characteristics of Industrial Electrification



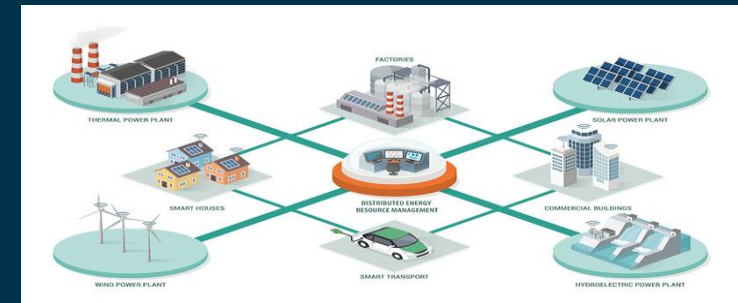
Fast Frequency Response, 50 ms



Very High Controllable Ramping



Long Duration Energy Storage



Real time network controllable

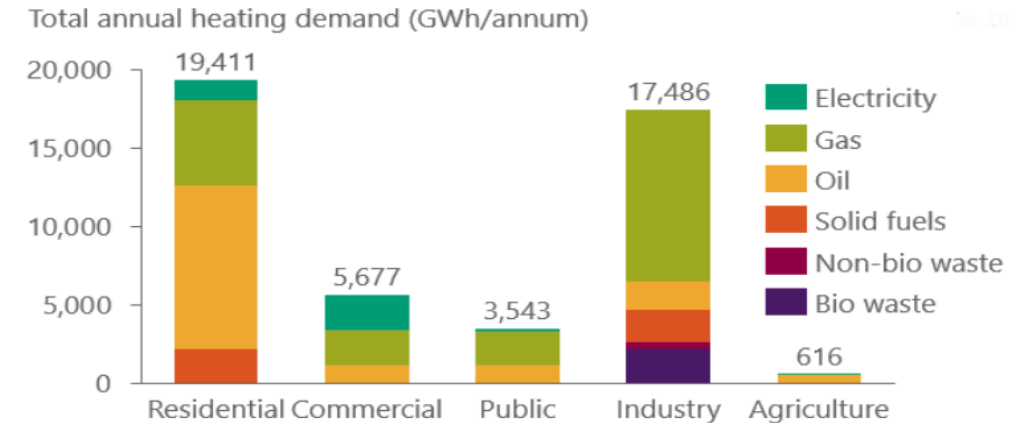
Deep Dive Ireland RES Curtailment and Industrial Heat



Figure 18: Summation of surplus renewable generation for each hour in 2030

13 TWh of expected RES constraint in 2030

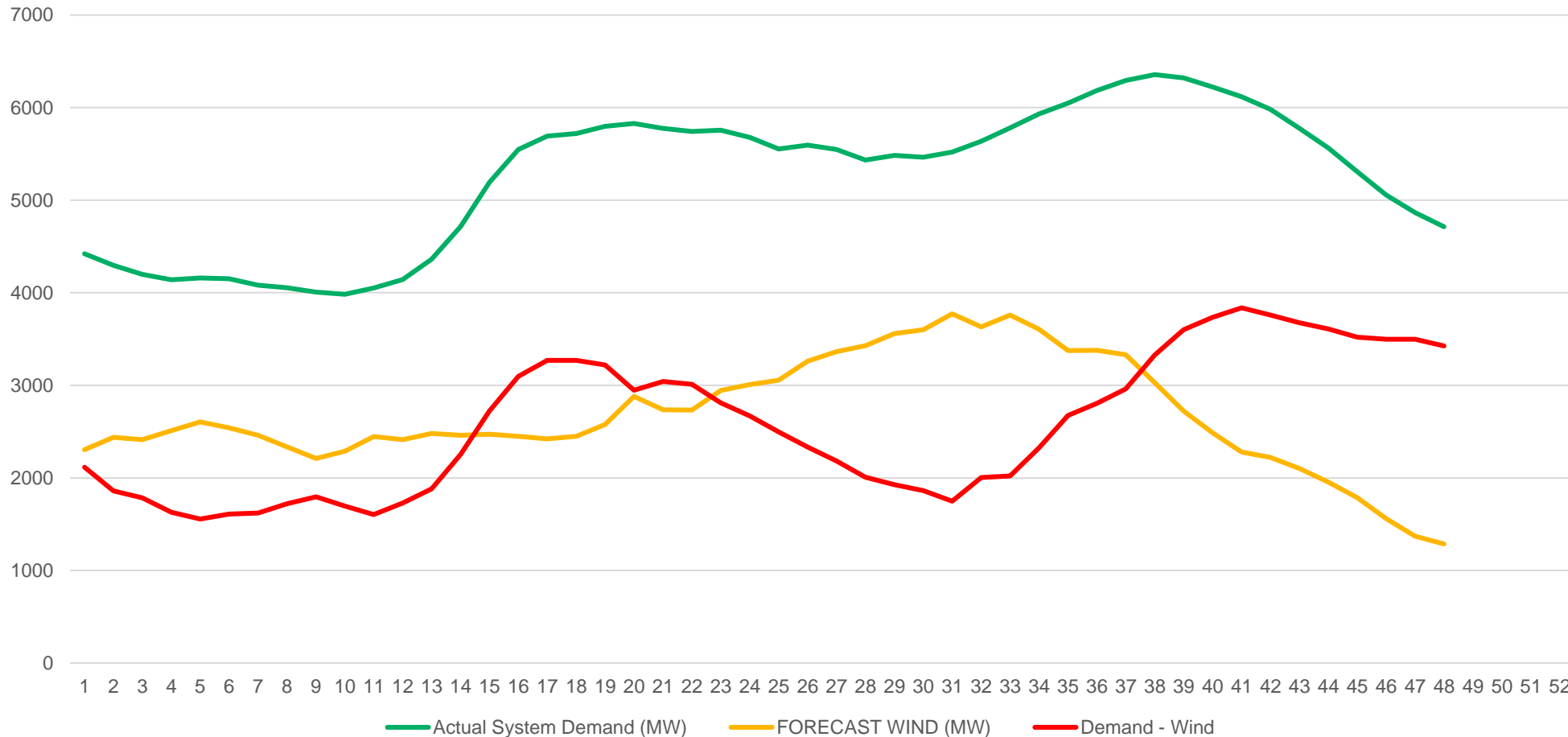
Figure 5: Total annual heating demand (GWh/annum), by sector



15 TWh Industrial heat powered by fossil fuels

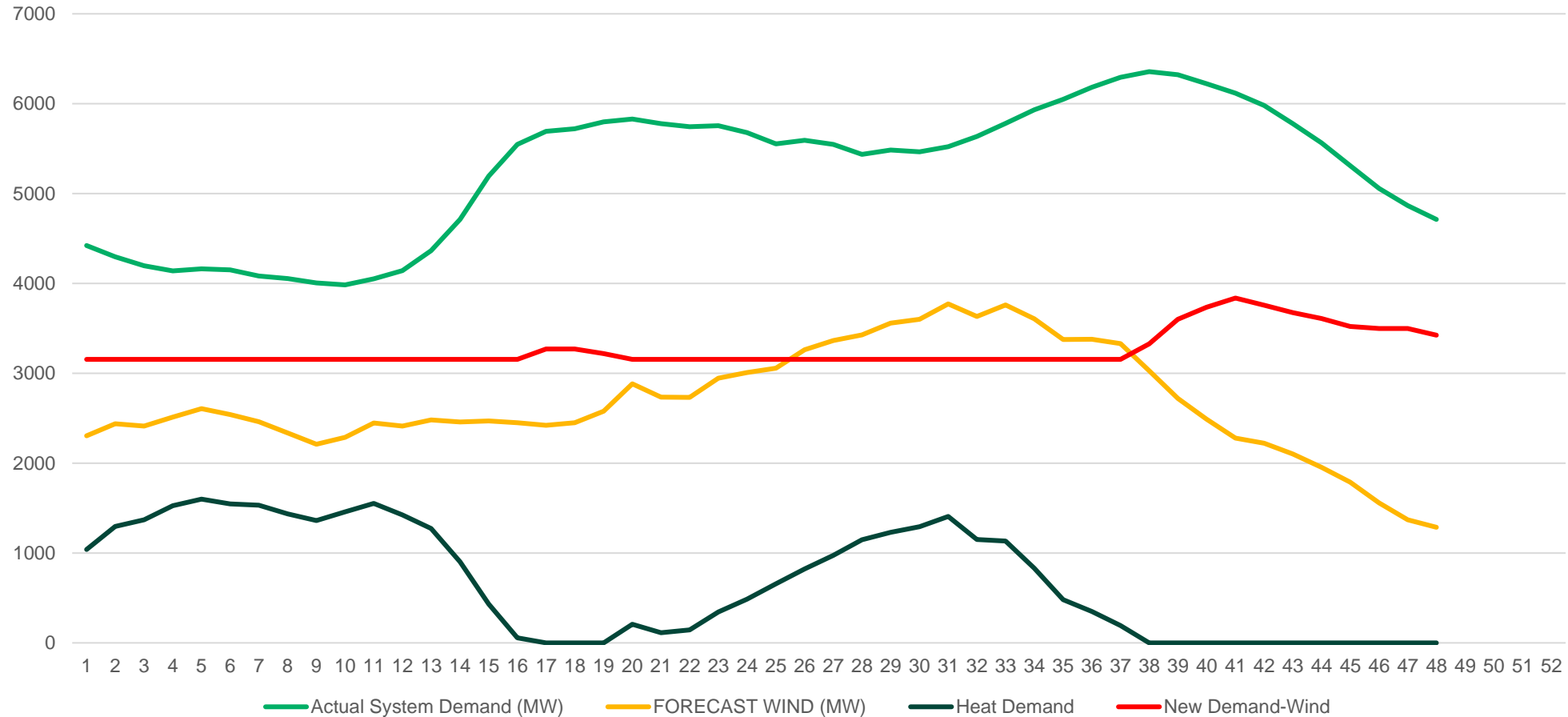
Impact of 50% Electrification of Industrial Heat

26 February 2025



Impact of 50% Electrification of Industrial Heat

New 26 February 2025



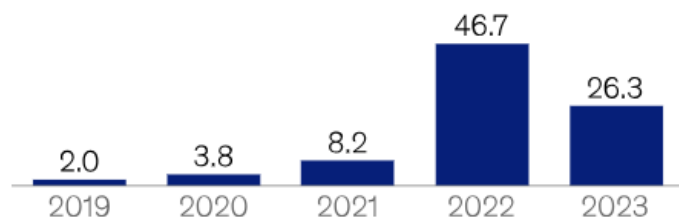
6 TWh annual electricity added
Av. 685 MW/hr

And the pricing at wholesale level is improving...

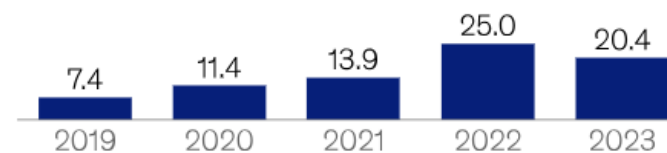
Day-ahead electricity prices are falling below the costs of gas and CO₂.

Share of hours with electricity prices below gas and CO₂, %

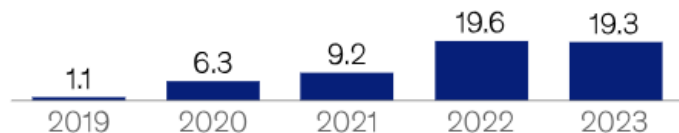
Spain



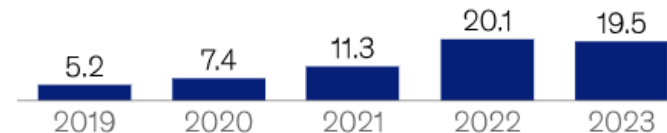
Germany



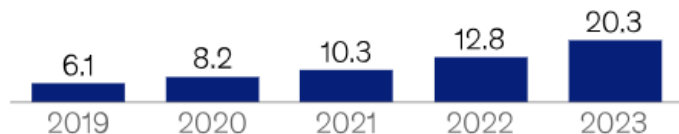
The Netherlands



Belgium



France

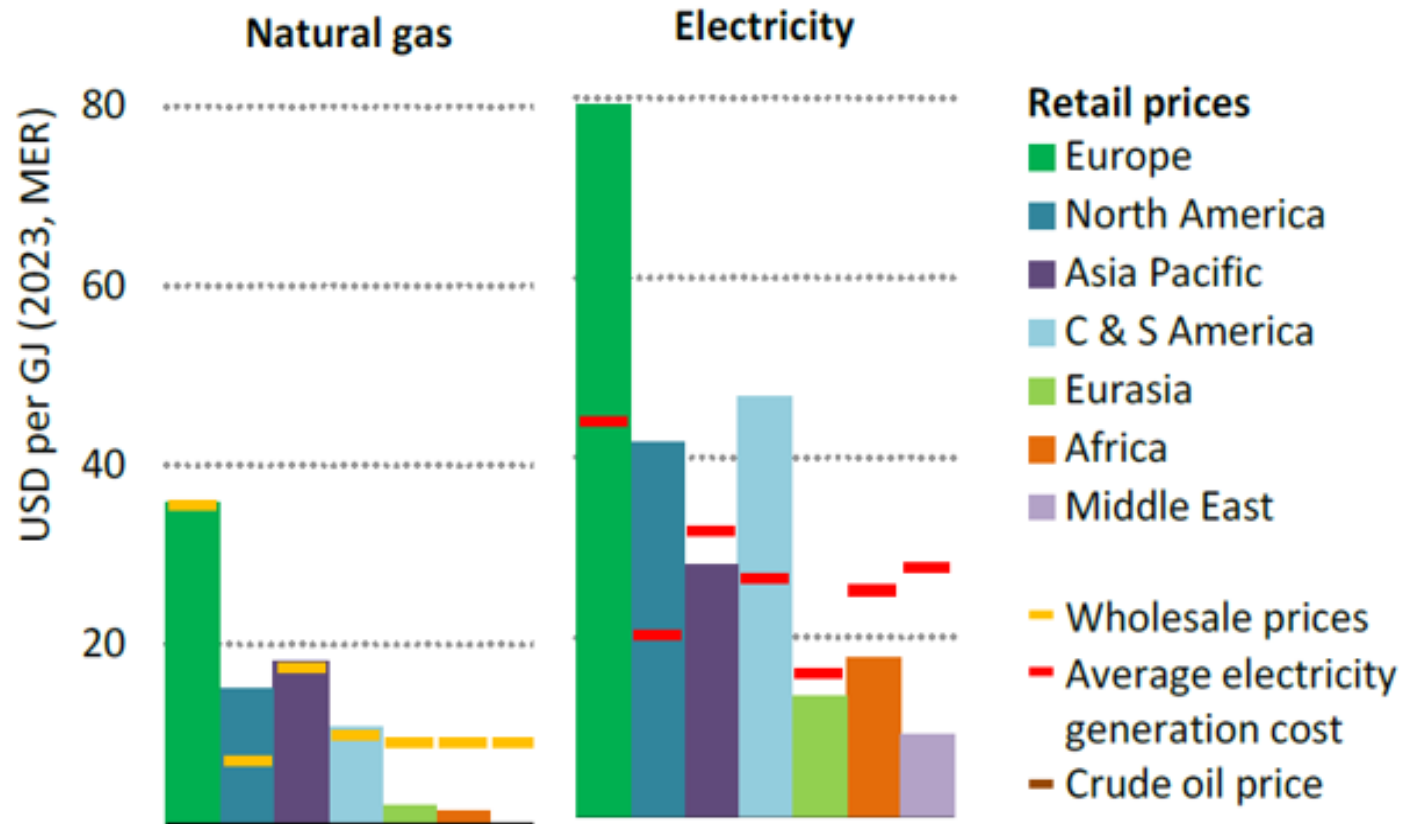


Italy



Source: ENTSO-E; International Carbon Action Partnership; Investing.com

Natural Gas Versus Electricity Prices



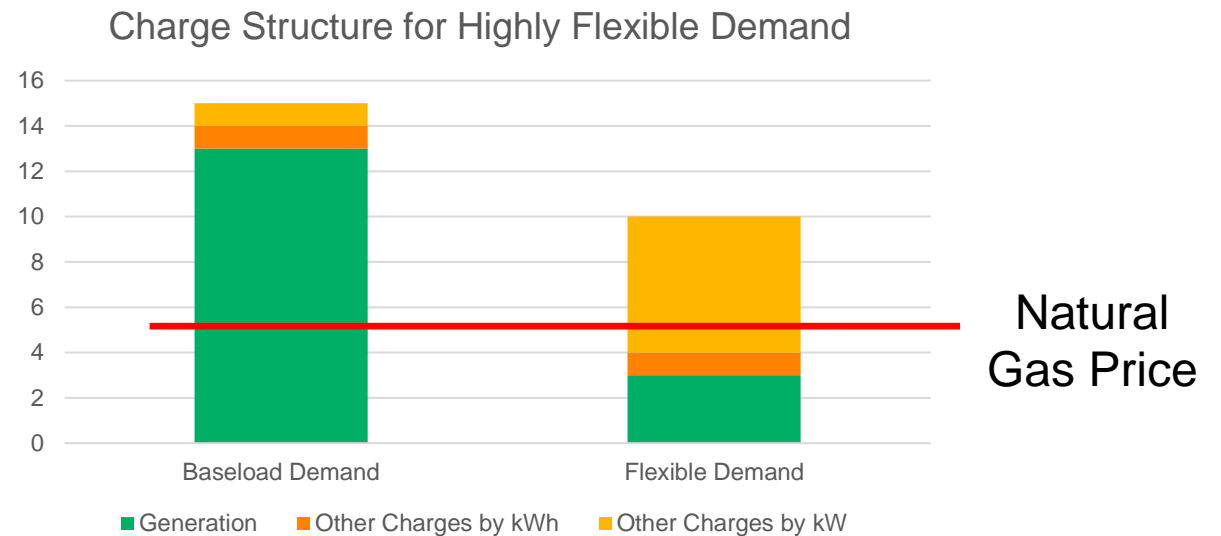
IEA. CC BY 4.0.

- Generation Costs comparable to Natural Gas in many markets
- More than enough hours of low cost wholesale electricity in many markets
- But legacy tariff and tax policy distort the economics for “new” demand

Impact of legacy Tariff structures

- Network charging designed to incentivize baseload/ flat consumption to maximise load factors on systems with low levels of variable generation
- They actively discourage demand flexibility
- Need to consider how flexible demand drives network costs

Element	Cost cents
Average Energy generation costs	13 /kWh
Average Energy Generation cost lowest 4 hours	3 /kWh
Natural Gas Industrial price	5 /kWh
Other Electricity Charges	1 /kWh
Other Electricity Charges	24 /kW day



Conclusions

1. Recent technical progress means electrification of industrial heat is imminent
2. Significant opportunity to reduce CO2 and deliver flexibility to the electricity system to balance RES
3. A 50% electrification strategy retaining gas capability in sites delivers long term energy security
4. Wholesale markets and flexibility pricing provide efficient signals to consume when RES is abundant
5. Legacy network tariff structures and other cost recovery mechanisms distort and dominate economics of consumption at times of high RES



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