



Climate-neutral industrial sites

Technological strategies for flexible, market-driven and low-carbon energy systems

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Industrial site operator for Marl and Wesseling

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Large heat-pump and energy-transition technology

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Buddenberg , Torsten, Dr.	Mitsubishi Heavy Industries EMEA Ltd.



Applied research and technology validation

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Sites such as Marl Chemical Park are key to Germany's energy transition

WHY MARL?

A highly integrated site makes the opportunity - and the complexity - visible at full industrial scale.

RESEARCH FOCUS

How can the site's energy supply be further electrified and transformed - while maintaining reliability and strengthening resilience on the path to climate neutrality?



Aerial view of Marl Chemical Park (CPM) © Evonik Industries AG

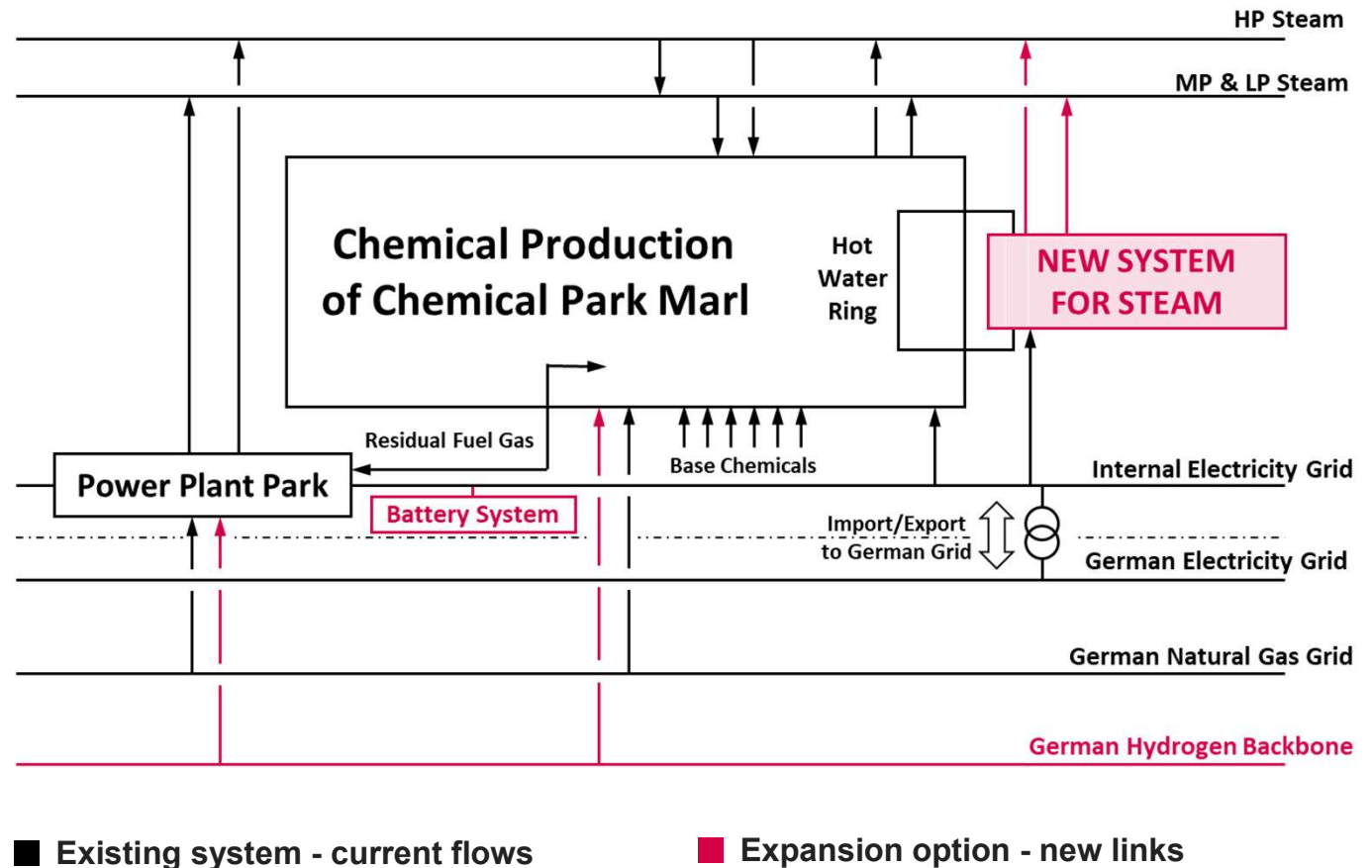
INTEGRATED SITE AT A GLANCE

12 Mt/y feedstock from Gelsenkirchen • 4 Mt/y products from Marl
≈100 production plants • 1 200 km of pipelines
4 new highly flexible CCGT units supplying steam and power

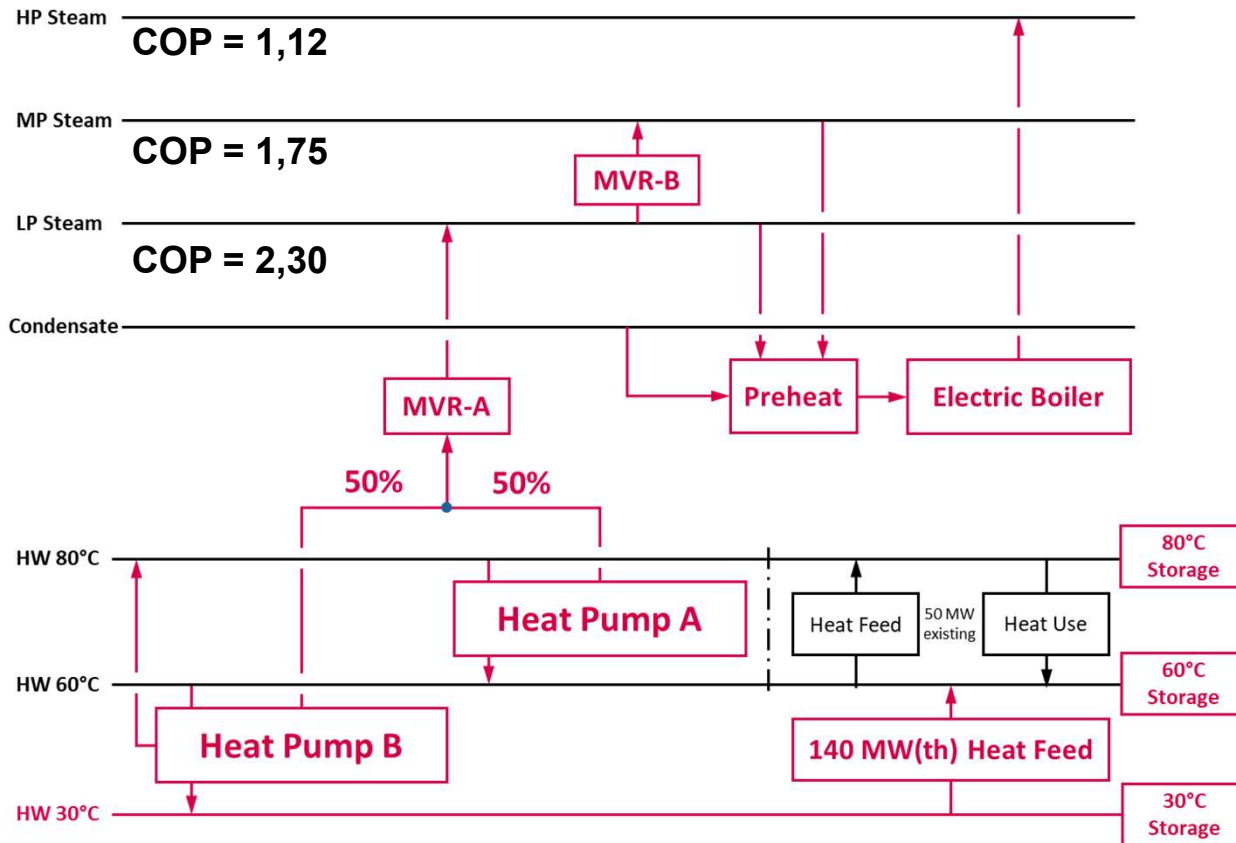
A highly integrated Verbund system requires joint system design

KEY FEATURES

- **Integrated Verbund**
links production, steam, power, fuels, district heating and external markets
- **Heat-led operation**
four flexible CCGTs secure electricity and multi-pressure process steam
- **System complexity**
interdependencies rule out one-for-one asset replacement
- **Joint development**
site operator, component suppliers and research partners design the transition together



Transformation concept primarily considers electrification of steam generation



SYSTEM COMPONENTS

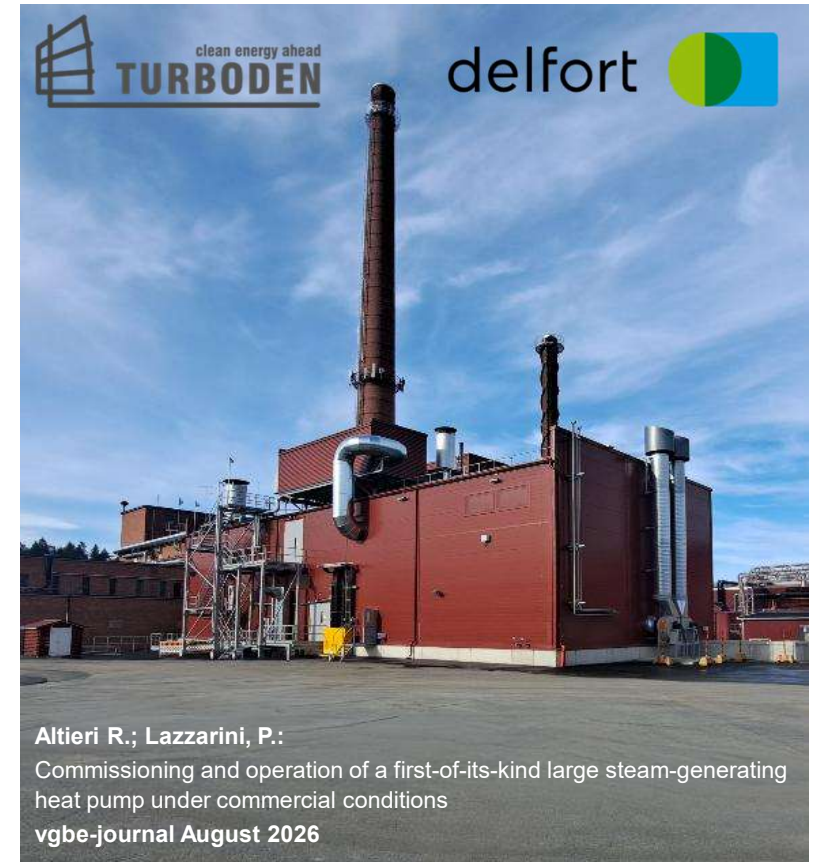
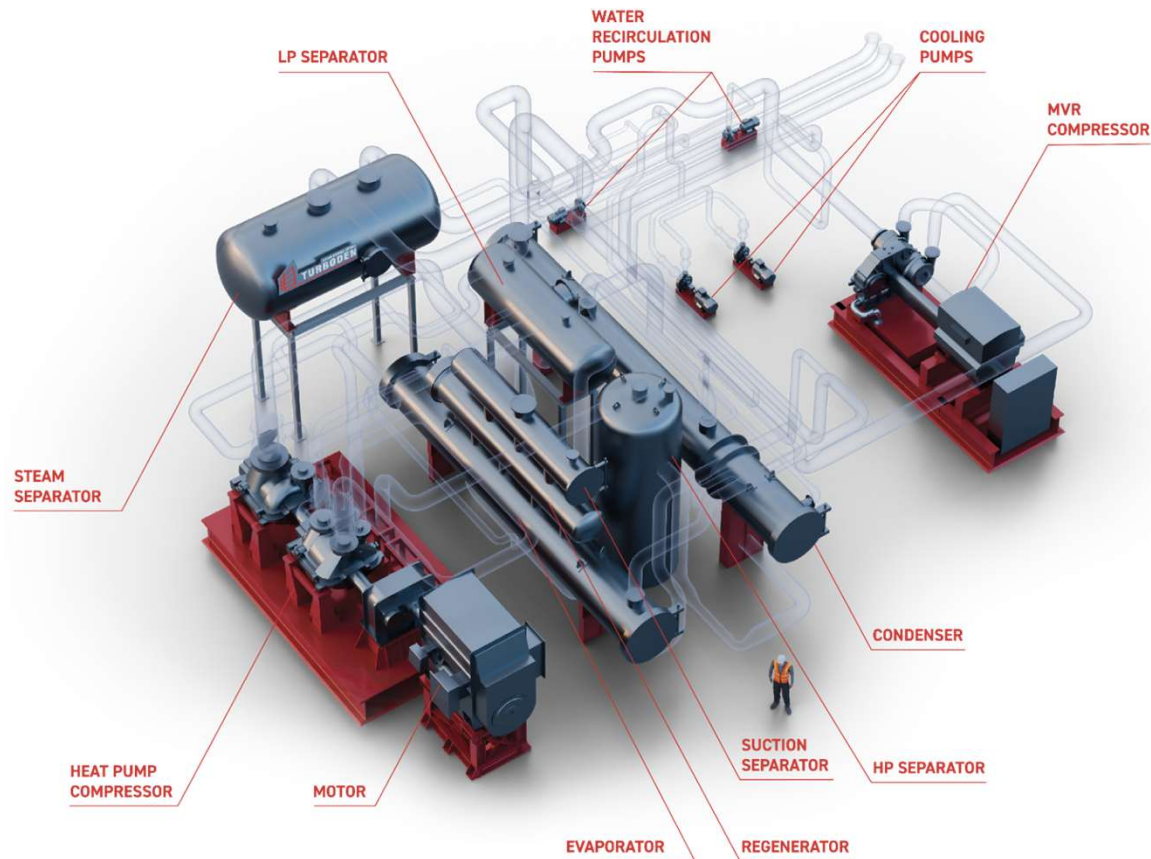
- Hot-water network - new at 30 ° C
- Electric boiler - high-pressure steam
- Heat pumps - two temperature-lift concepts
- Vapour recompression - steam upgrading

WHY THIS SETUP?

- Steam profile - demand across pressure levels
- Heat sources - networks and waste heat
- Grid connection - available capacity
- CCGT complement - optimised fleet fit

Total CAPEX estimate ≈ €290m - capital-intensive

Example of a steam-generating heat pump in commercial operation



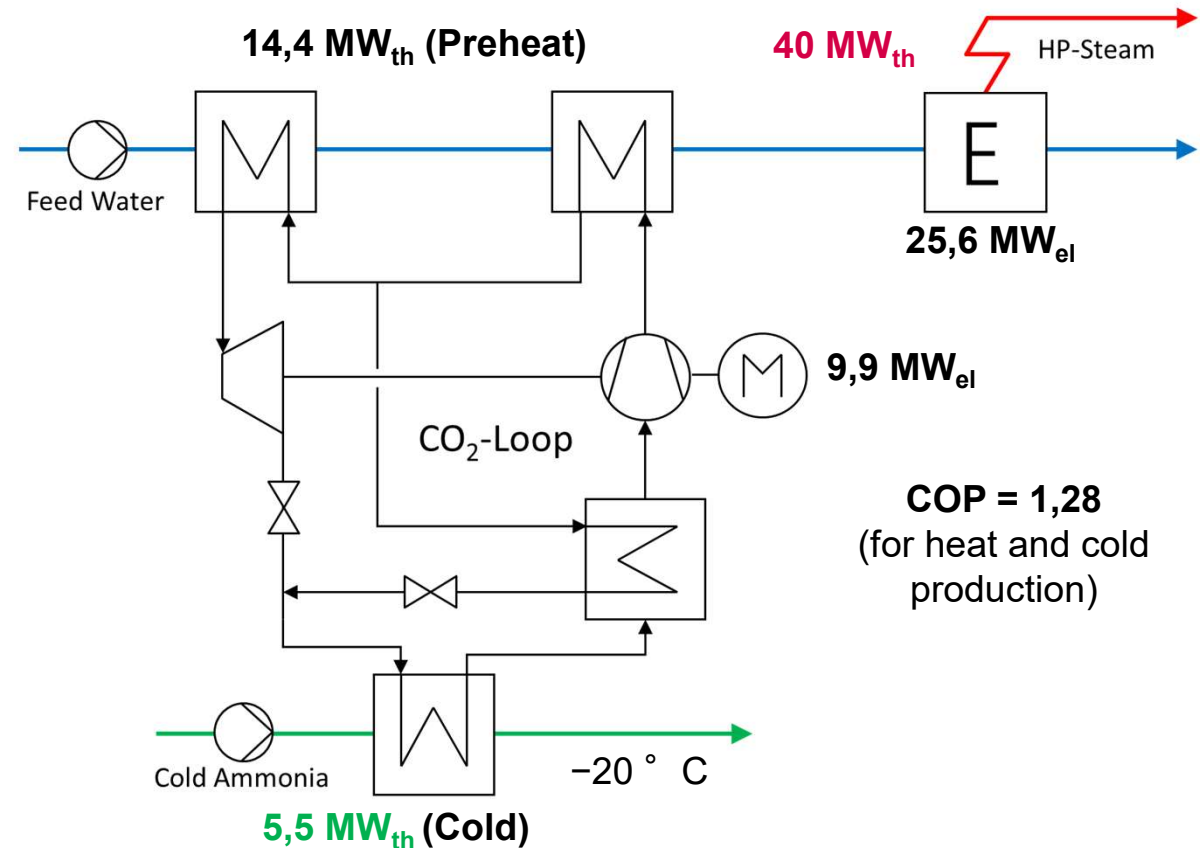
Integrating the cooling network can further increase the system COP

FROM COMPONENT TO SYSTEM

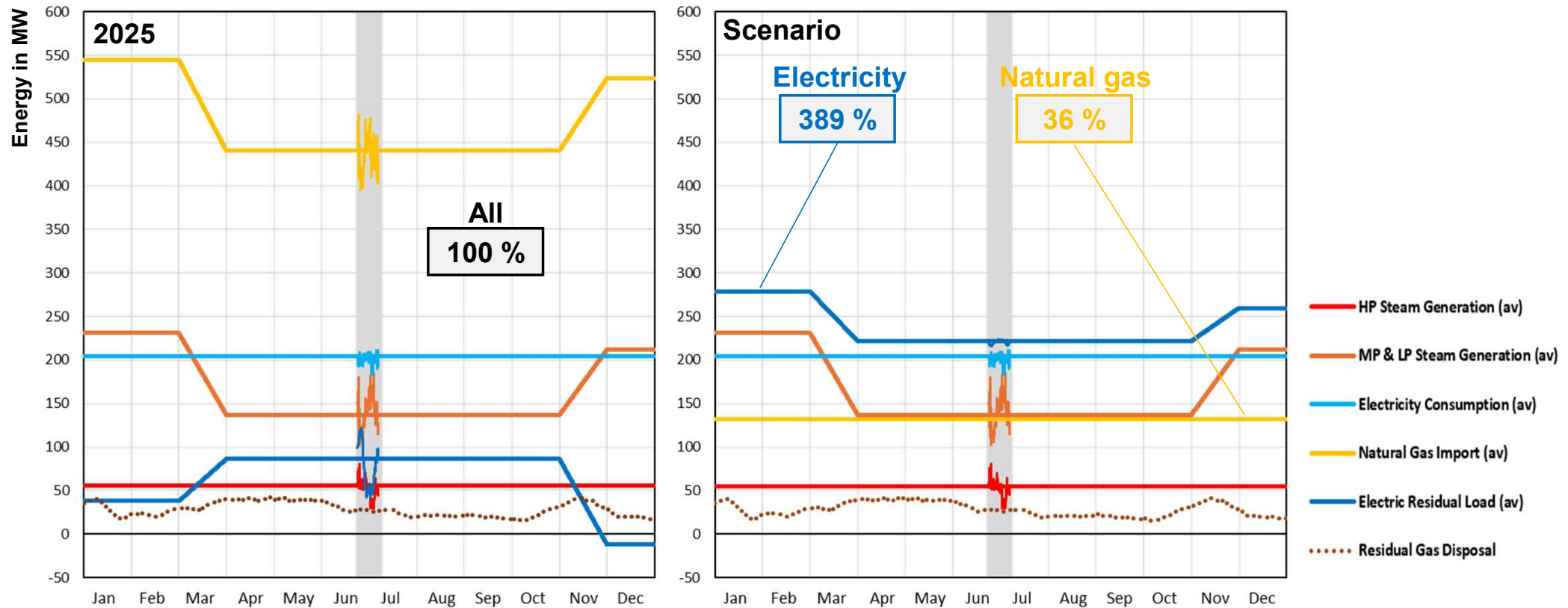
A transcritical CO₂ heat pump can match the near-linear temperature profile required for high-pressure boiler-feedwater preheating.

ADDITIONAL LEVER

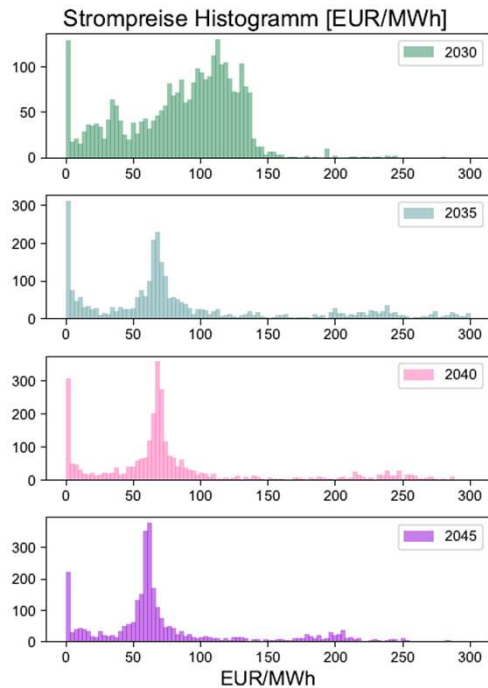
- **Cooling integration** - use the cold side as a valuable product rather than as rejected energy.
- **Joint utilisation** - heat and cold use can raise system COP beyond a heat-only assessment.
- **Further optimisation** - temperatures, loads and integration can unlock added efficiency.



Scenario: power consumption rises as natural gas consumption falls

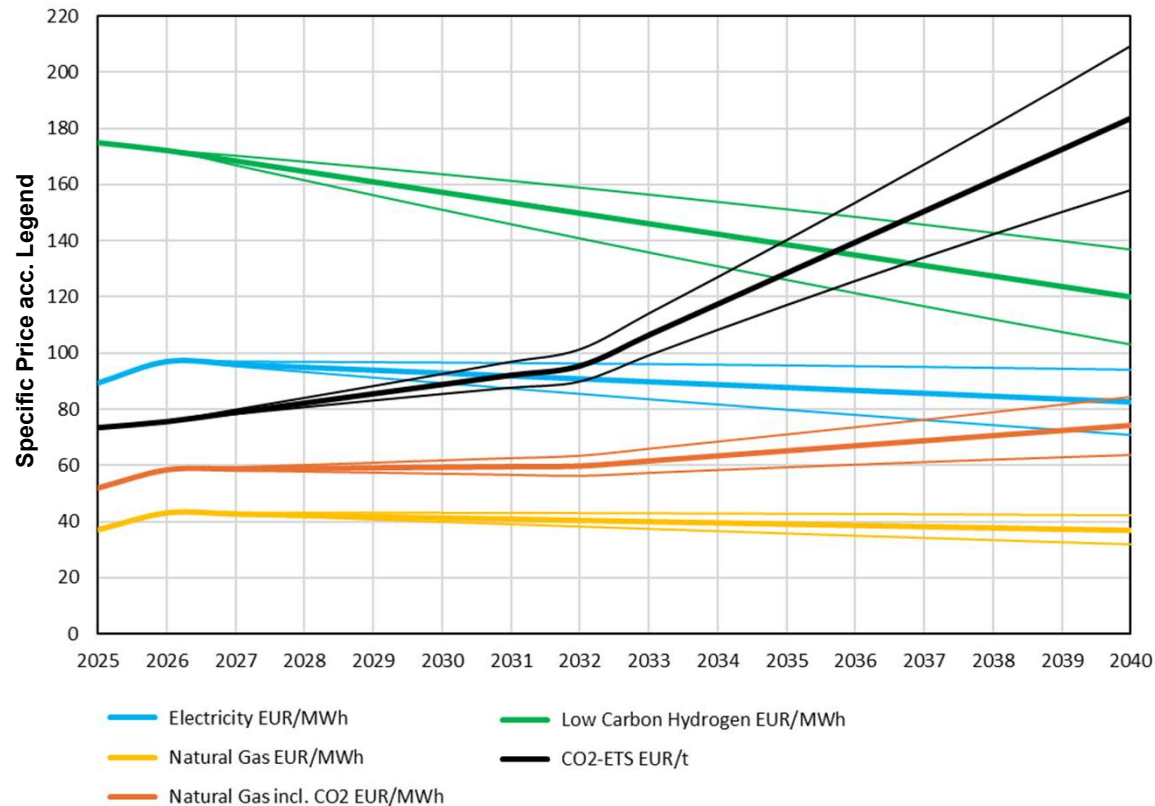


Different study-based energy price scenarios show similar trends until 2040



Source: Ariadne-Report
Die Energiewende kosteneffizient gestalten:
Szenarien zur Klimaneutralität 2045

KOPERNIKUS
Ariadne >> PROJEKTE
Die Zukunft unserer Energie



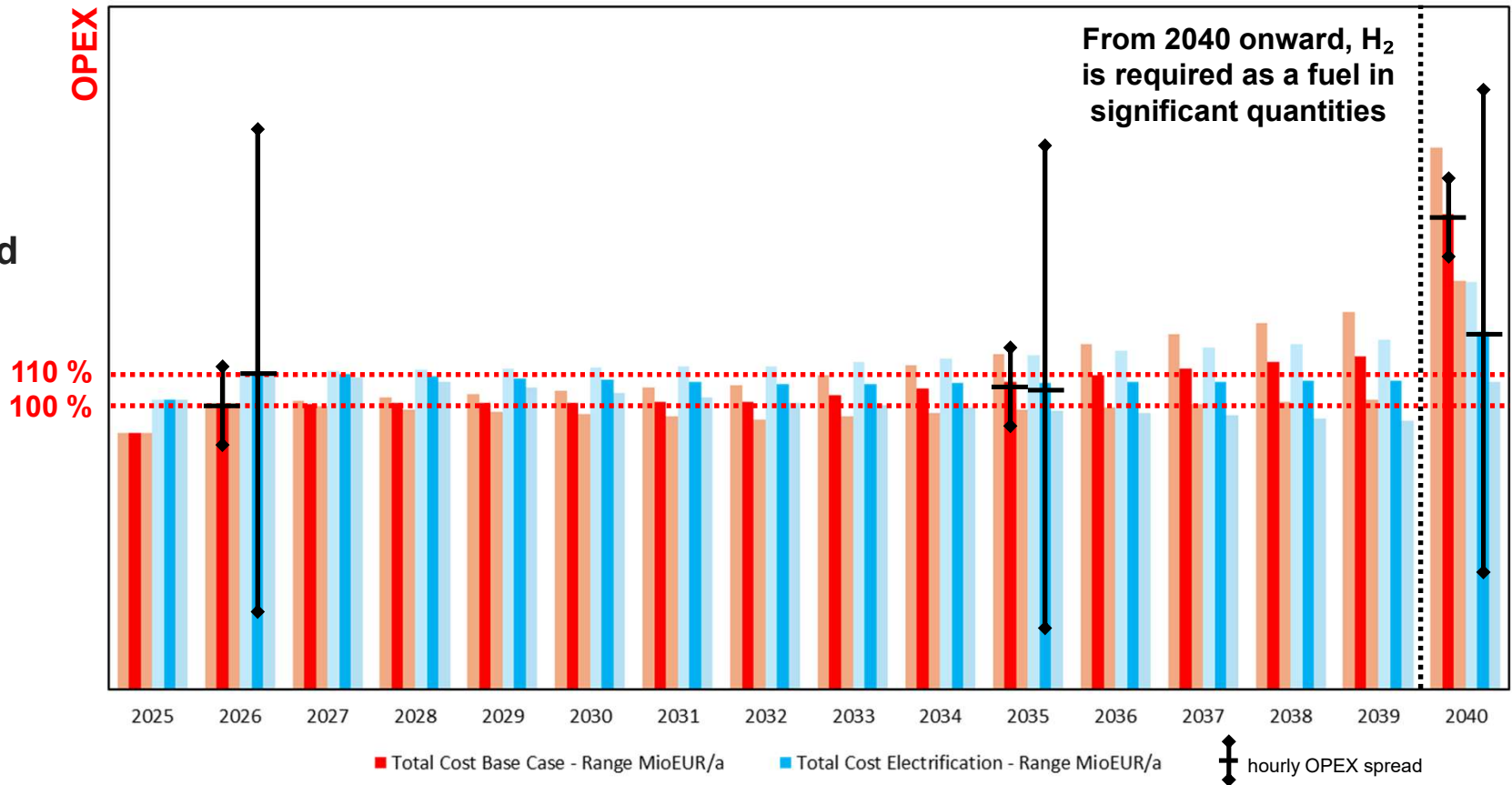
KEY INSIGHTS

- **Electricity volatility**
narrows as prices trend lower
- **CO₂ pricing**
is a key driver of the projected increase
- **Hydrogen costs**
decline but remain above natural gas through 2040

H₂-requirement impacts OPEX as of 2024 - need to start transformation now

KEY TAKEAWAYS

- **Until 2035**
electrification has higher OPEX
- **From 2040 onward**
H₂ fuel requirements significantly raise costs in both cases
- **Electrification**
is less exposed to the H₂ fuel-switch scenario



Summary and outlook

- **Defossilisation**
transforms the entire energy system
- **Commercial technologies**
enable action today
- **Site-specific pathways**
must be compared and refined
- **Phased investment**
makes implementation economically viable



Aerial view of Marl Chemical Park (CPM) © Evonik Industries AG

KEY MESSAGE

Climate-neutral industrial sites are achievable with available technologies — if system design and investment decisions are coordinated and timed correctly.

RRP guiding idea

Achieving together in the network what no one can accomplish alone

Thank you for listening

Questions & discussion

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