Symbiotic Renewable Energy Supply for Europe

How to meet climate targets with a technology-agnostic approach

Bad Honnef, June 19th 2023

Prof. Dr. Stefan Niessen MBA

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Agenda

- Cost-minimal path to decarbonization of the EU
- Cost-minimal path to decarbonization of Germany
- Concrete examples for the decarbonization of sites
  a) SIEMENS factory at Amberg
  b) Factory for Electric Vehicles
  c) Bremerhaven Harbor

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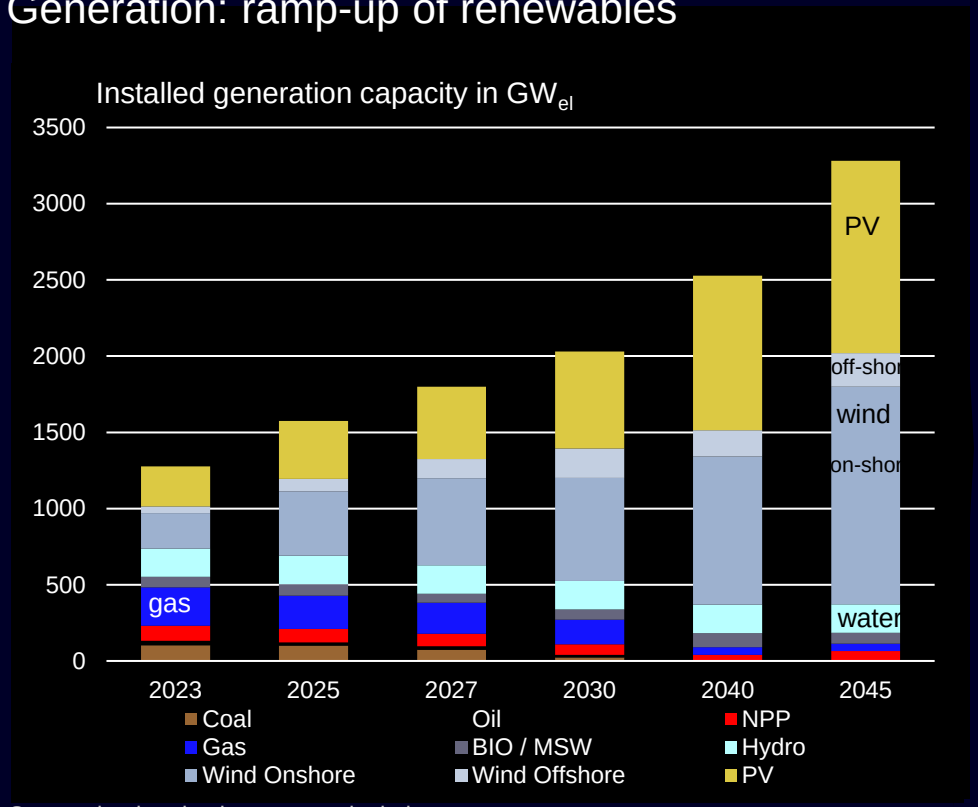
How to decarbonize the EU

EU27
+NO +CH
+UK +Balkan

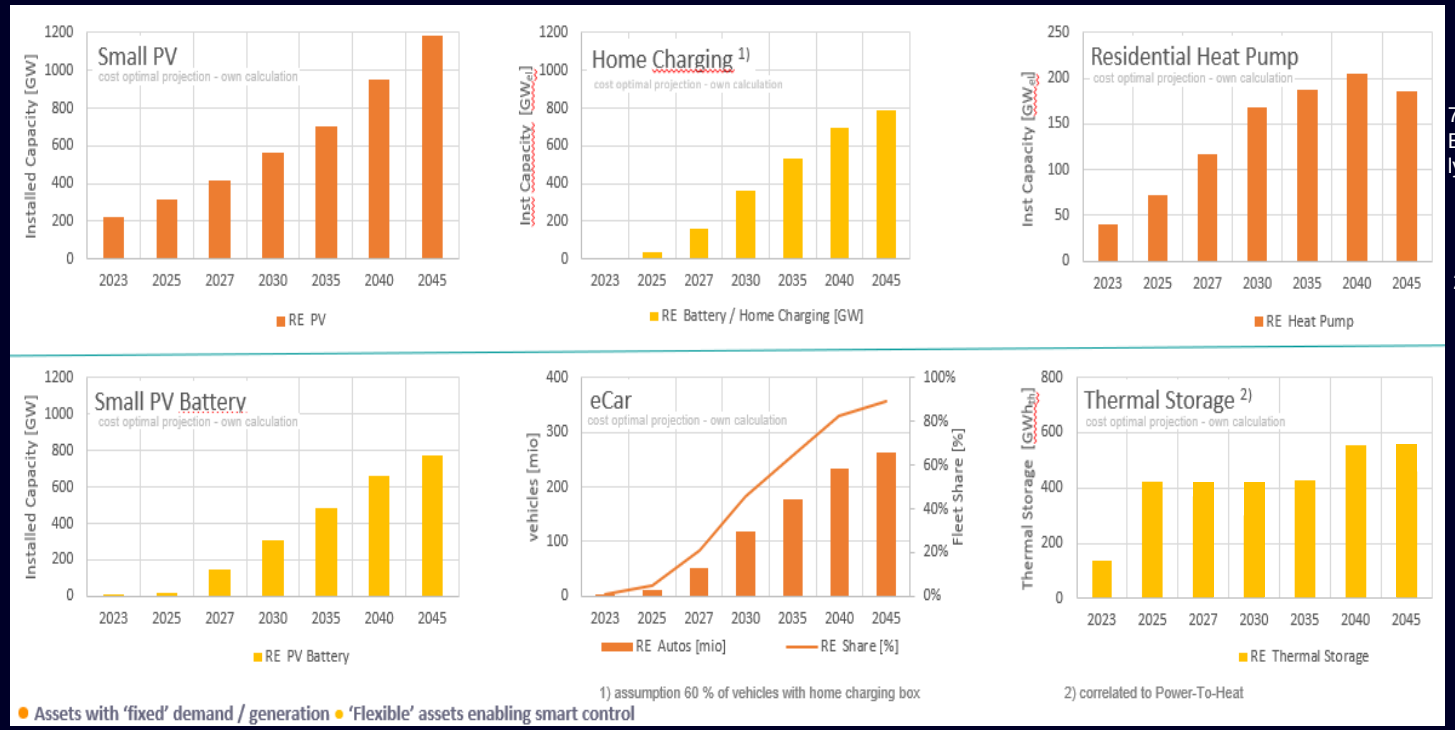
A cost-optimal implementation of the RePower EU scenario will look like this:

Generation: ramp-up of renewables



Cost optimal projection - own calculation

Consumption: prosumer swarms -> dynamics & flexibilities



70GW Electrolyzers 2030

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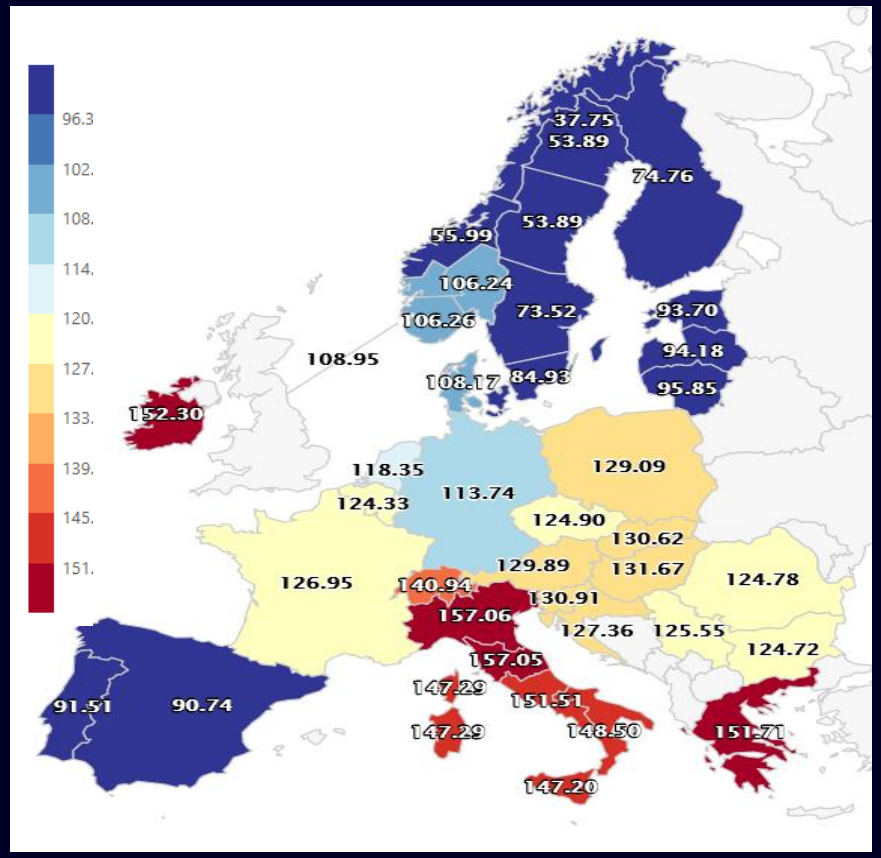
Security of supply needs to be evaluated on a European level

Germany profits from its central location

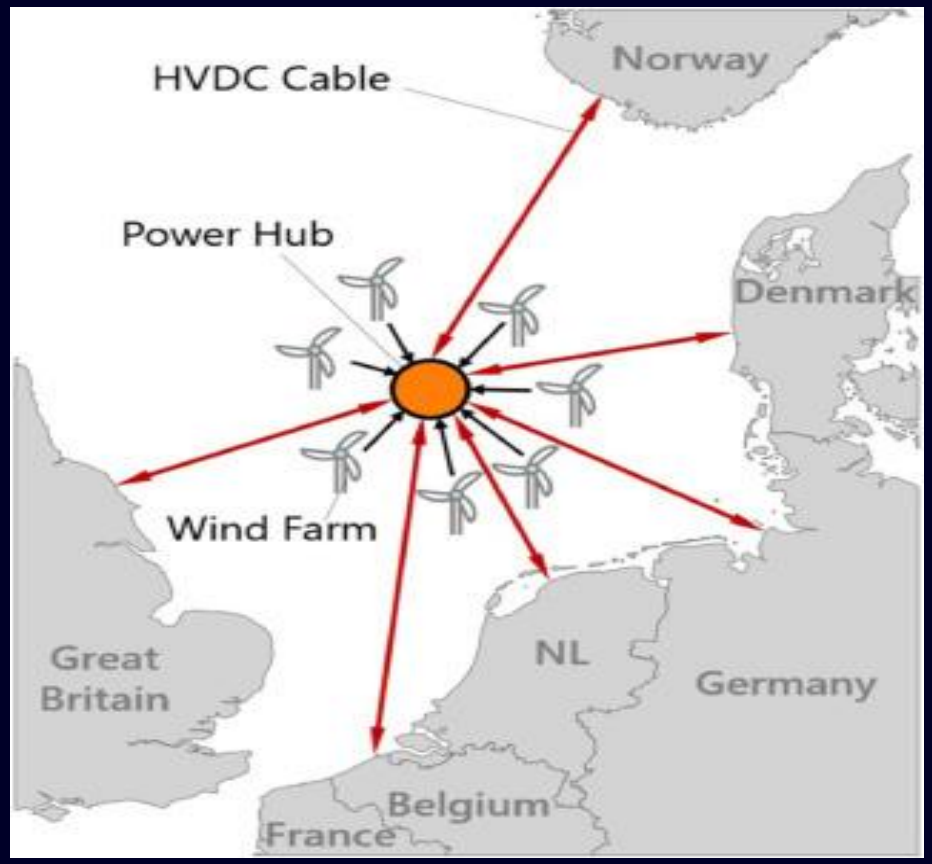
Avg. electricity price – EEX Spot Market[1)]
2023-Q1 DE:114 €/MWh



1) source [1] FhG - www.energy-charts
2) see [2] ENTSO-e TYNDP 2022 Target cross border cap +64 GW till 2030 and +132 GW till 2040

Future wind hubs at sea

several Hubs in North & Baltic Sea are planned



3) source [3] Adv Applied Energies 2022 M.Jansen

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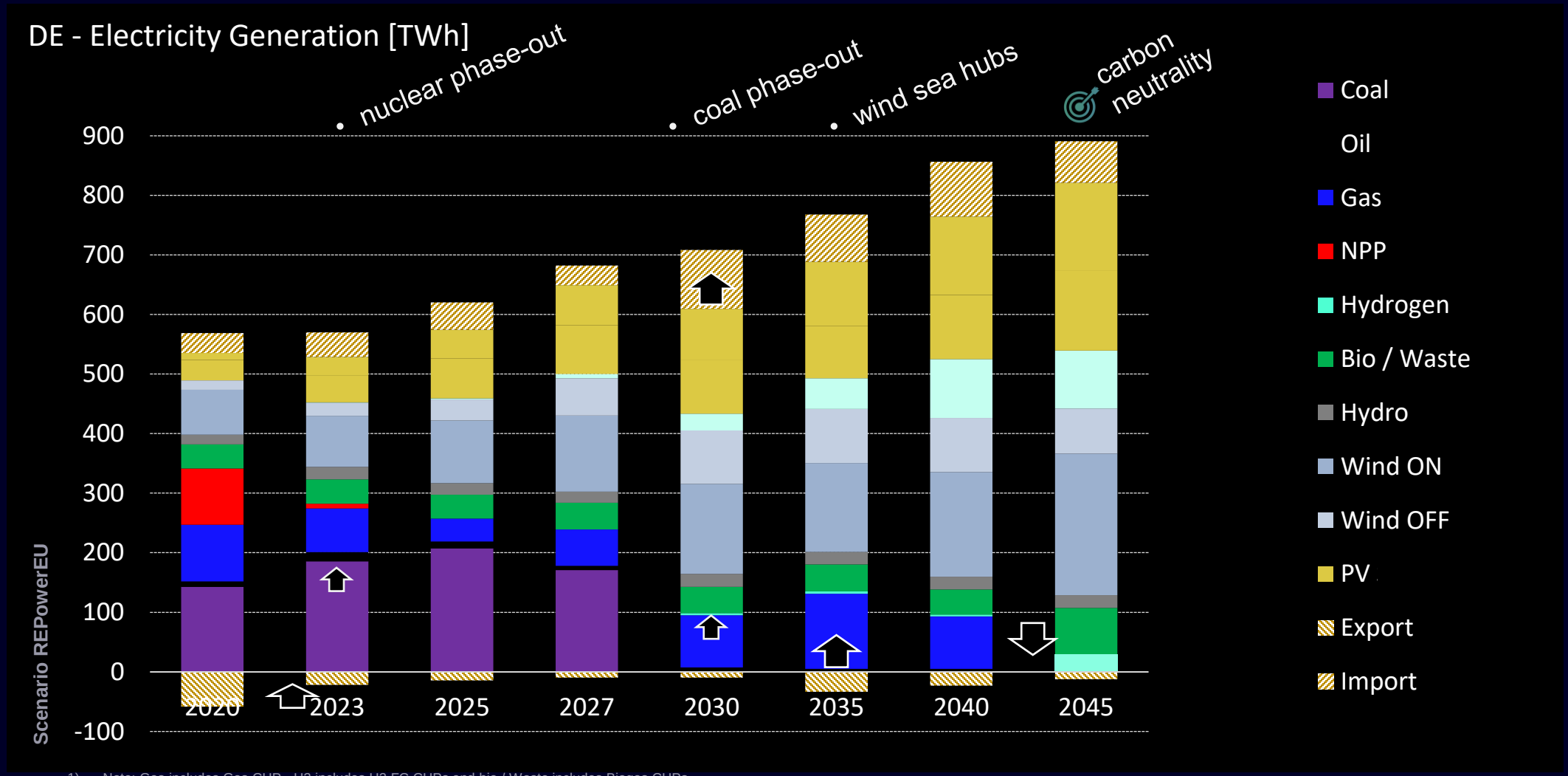
Germany: nuclear and coal phase-out require even more drastic changes



1) Note: Gas includes Gas CHP$_s$, H2 includes H2 FC CHPs and bio / Waste includes Biogas CHPs
2) RES includes Hydro, Biomass, Waste, Hydrogen, Geothermal, PV and Wind; total: sum of all generation plus net. imports

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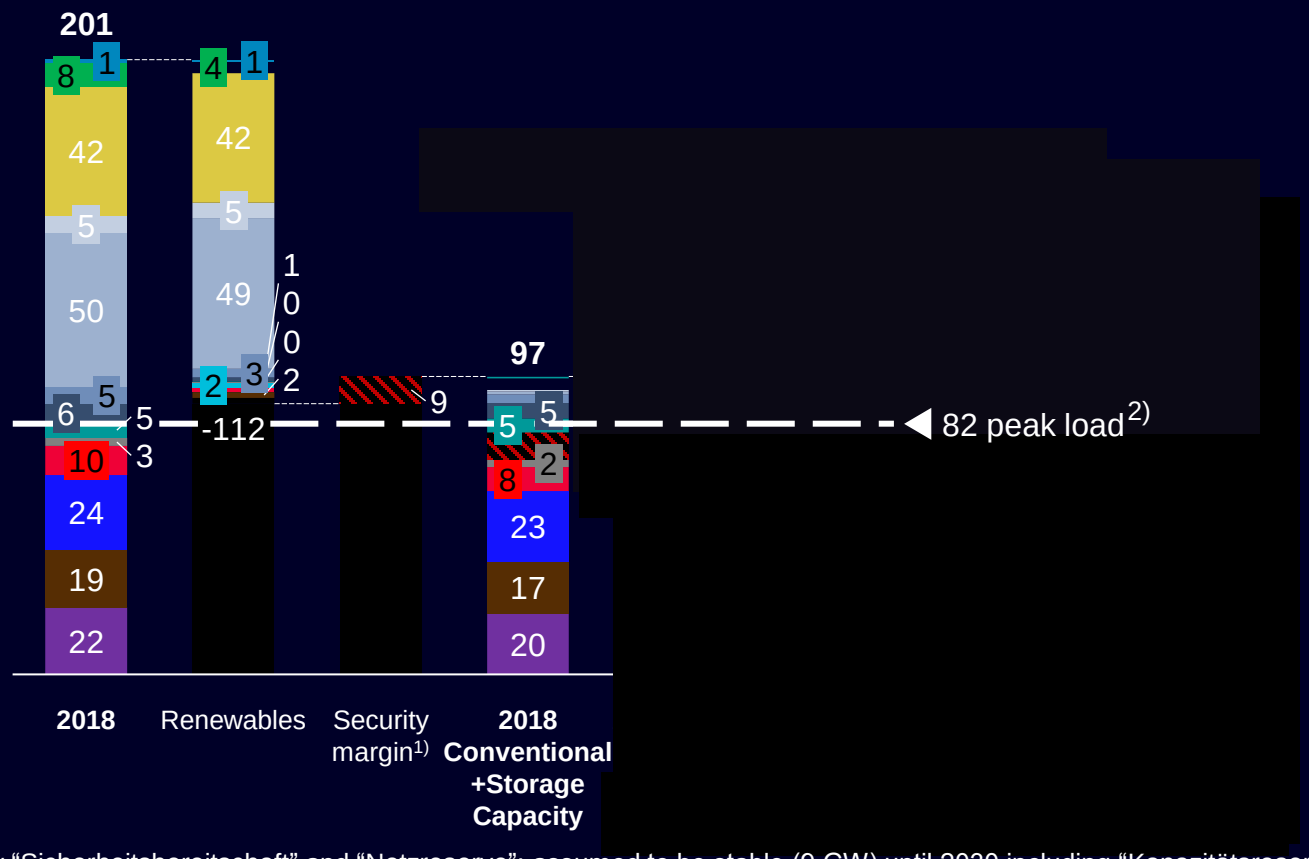
Firm capacity in Germany 2018

Firm capacity in GW according to Netzentwicklungsplan & Kohlekommission



1) Security margin: built by “Sicherheitsbereitschaft” and “Netzreserve”; assumed to be stable (9 GW) until 2030 including “Kapazitätsreserve” from 2019 onwards.

2) Current peak load in Germany / Peak in 2035 DEKASim.

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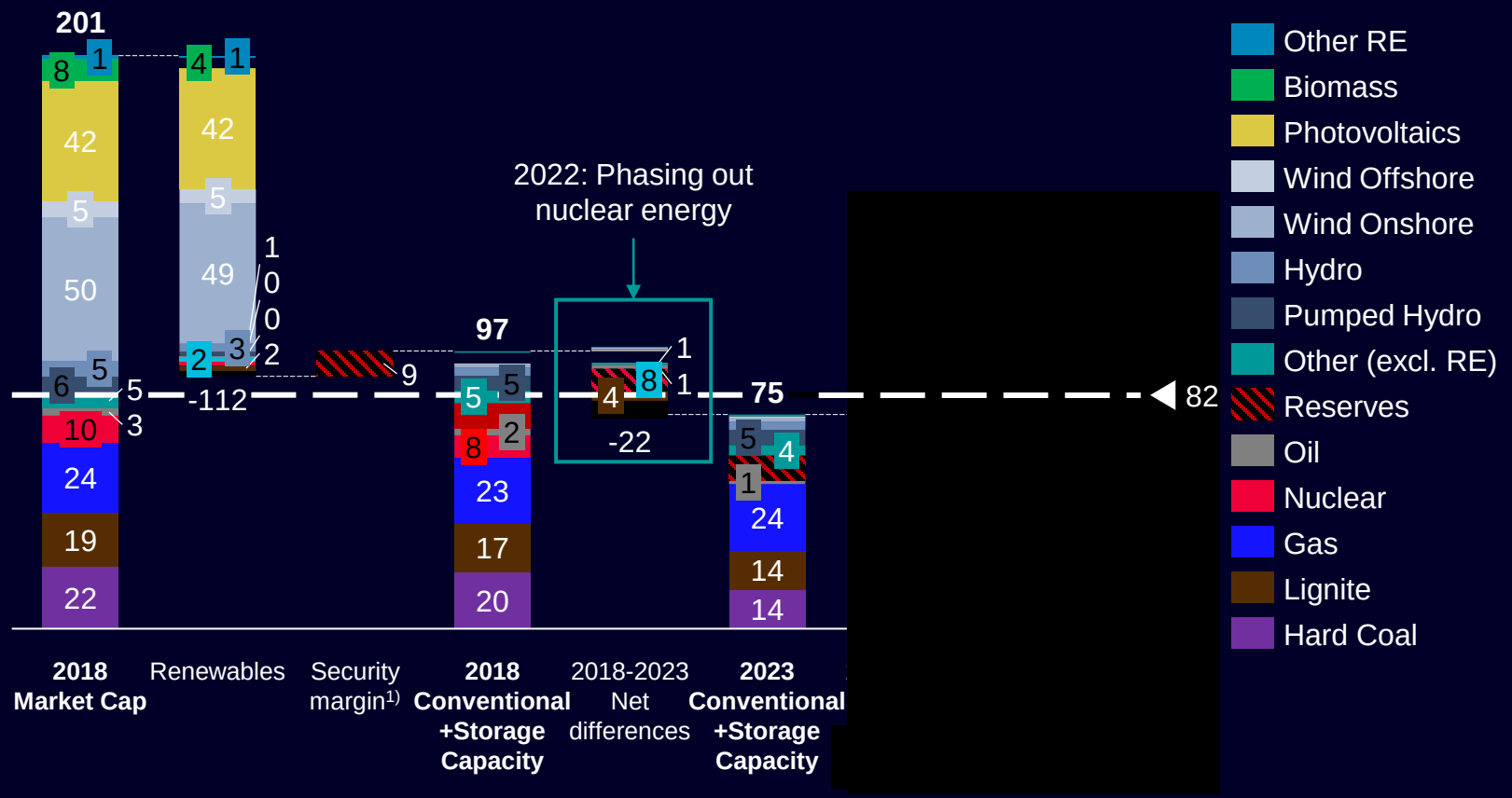
Firm capacity in Germany 2023

Firm capacity in GW according to Netzentwicklungsplan & Kohlekommission



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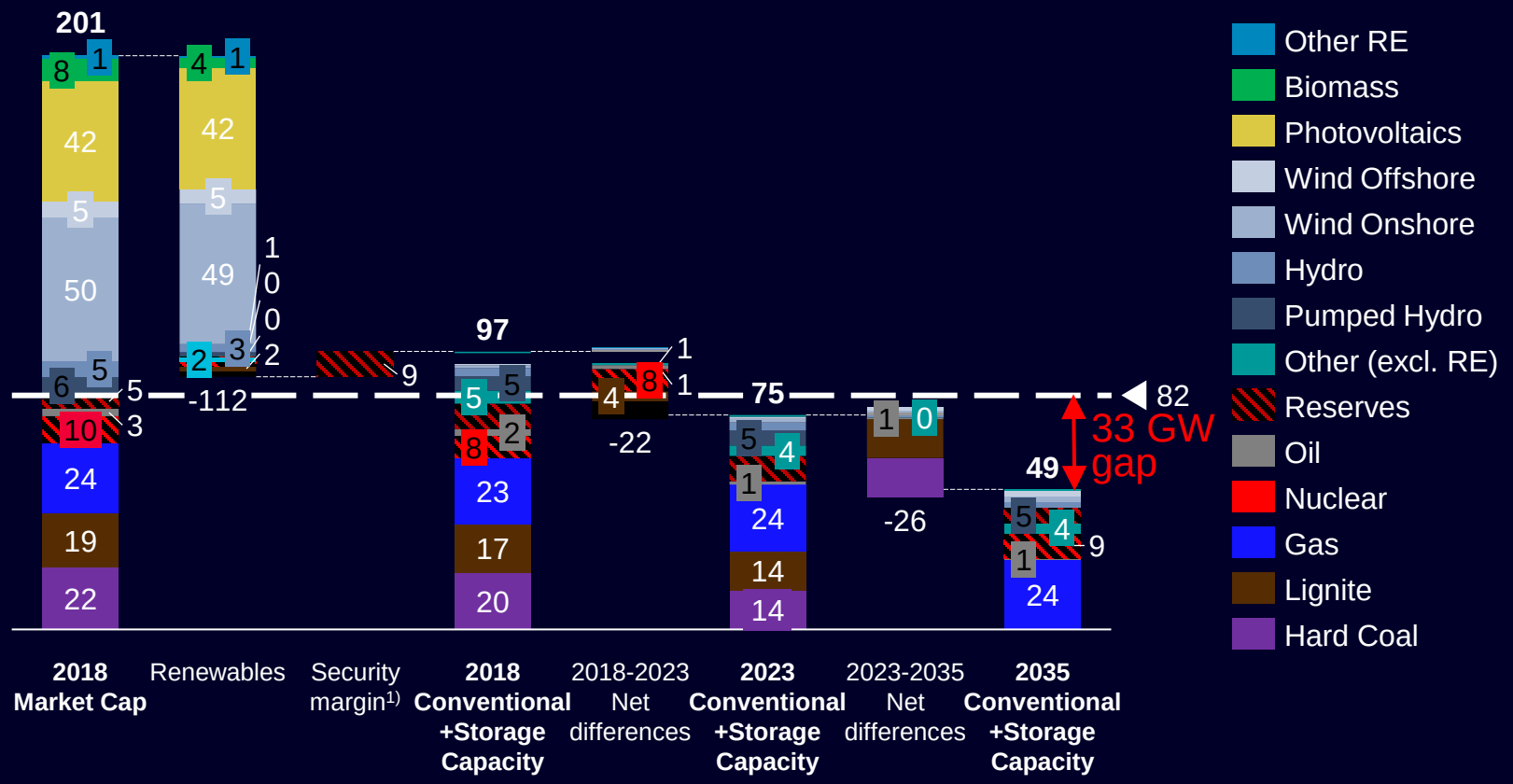
Firm capacity in Germany 2035 - or already 2030

Firm capacity in GW according to Netzentwicklungsplan & Kohlekommission



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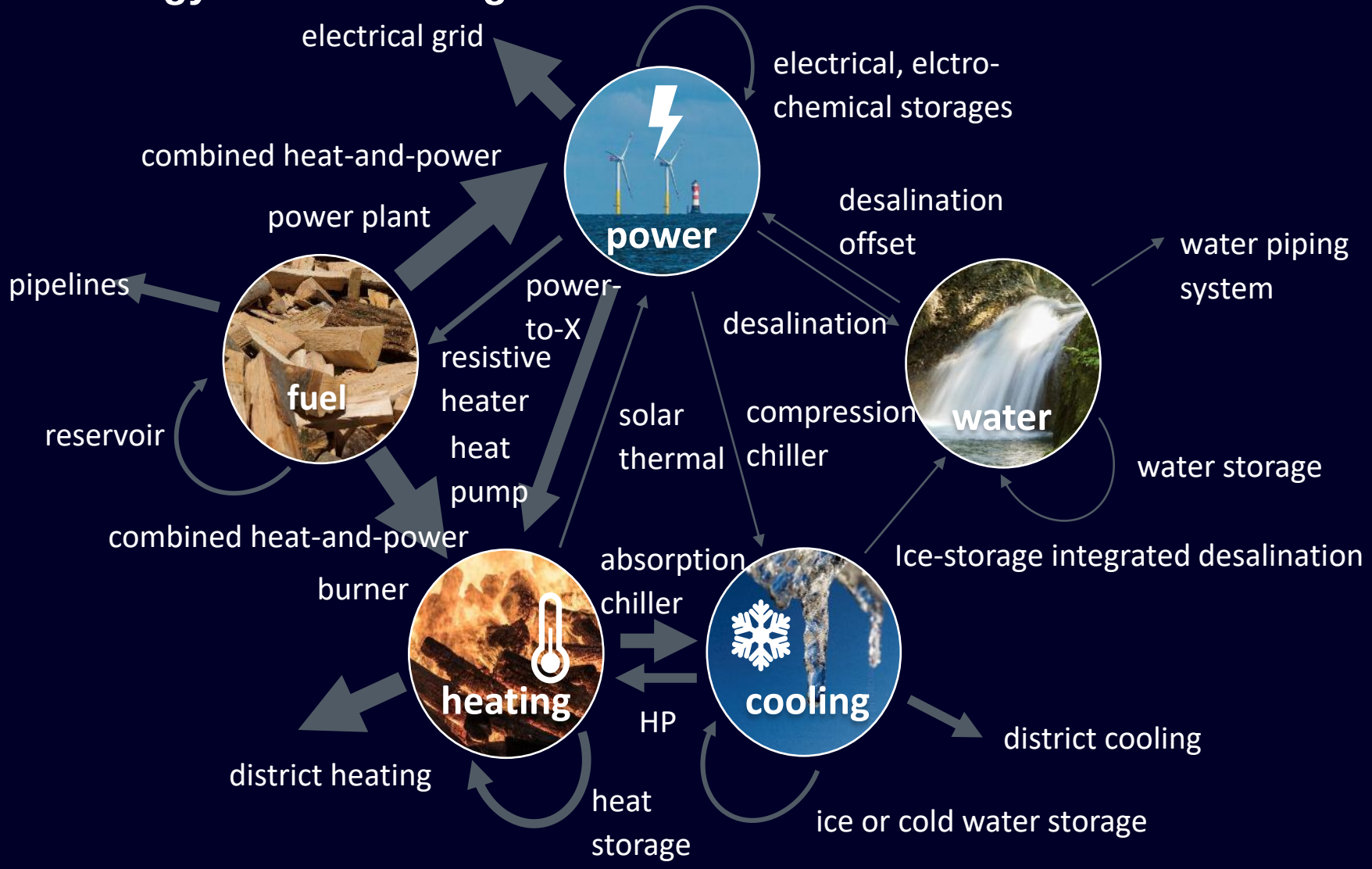
Different modes of energy and technologies for conversion



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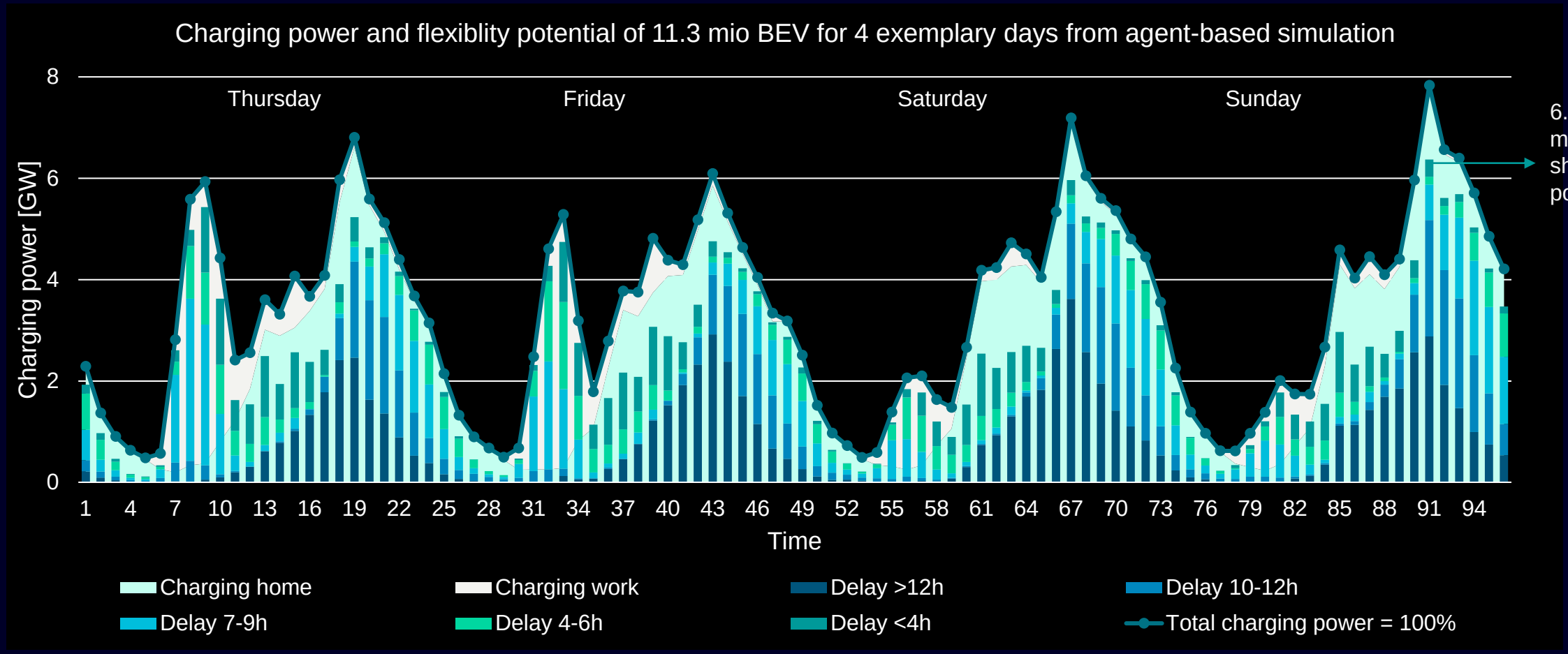
Example: flexibility from battery electric vehicles



Source: *The Contribution of Carbon-Optimized Battery Electric Vehicle Charging to the Decarbonization of a Multi-Modal Energy System*
D. Husarek, S. Paulus, M. Huber, M. Metzger, S. Niessen
4th E-Mobility Power System Integration Symposium, 3 November 2020 https://mobilityintegrationsymposium.org/downloads/

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example: flexible Industrial processes
Siemensstadt Berlin

peak load

SIEMENS Gasturbinenwerk	12,89 MW
SIEMENS Schaltwerk	6,93 MW
SIEMENS Meßgerätewerk	0,03 MW
SIEMENS Dynamowerk	1,64 MW

Balancing machine for gas turbines

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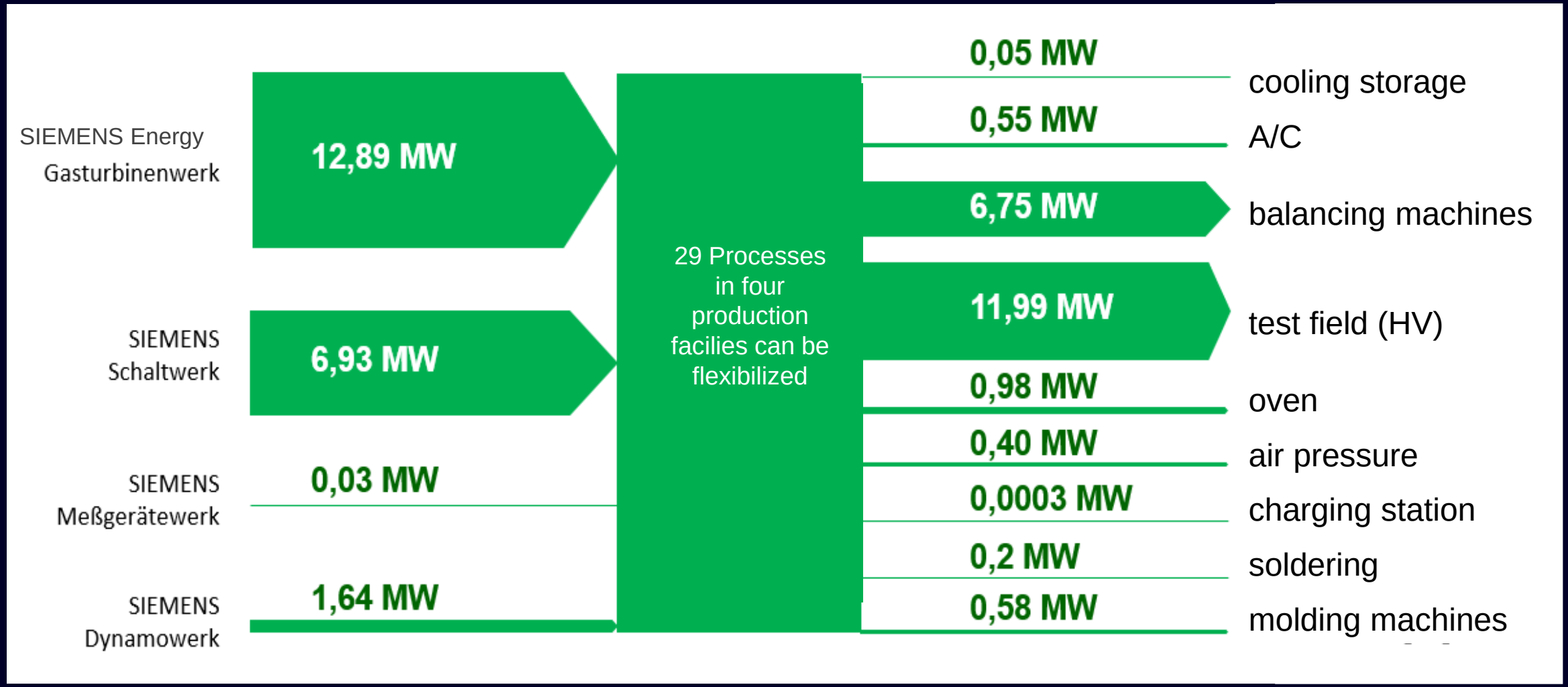
example: flexible Industrial processes
Siemensstadt Berlin



Balancing machine for gas turbines

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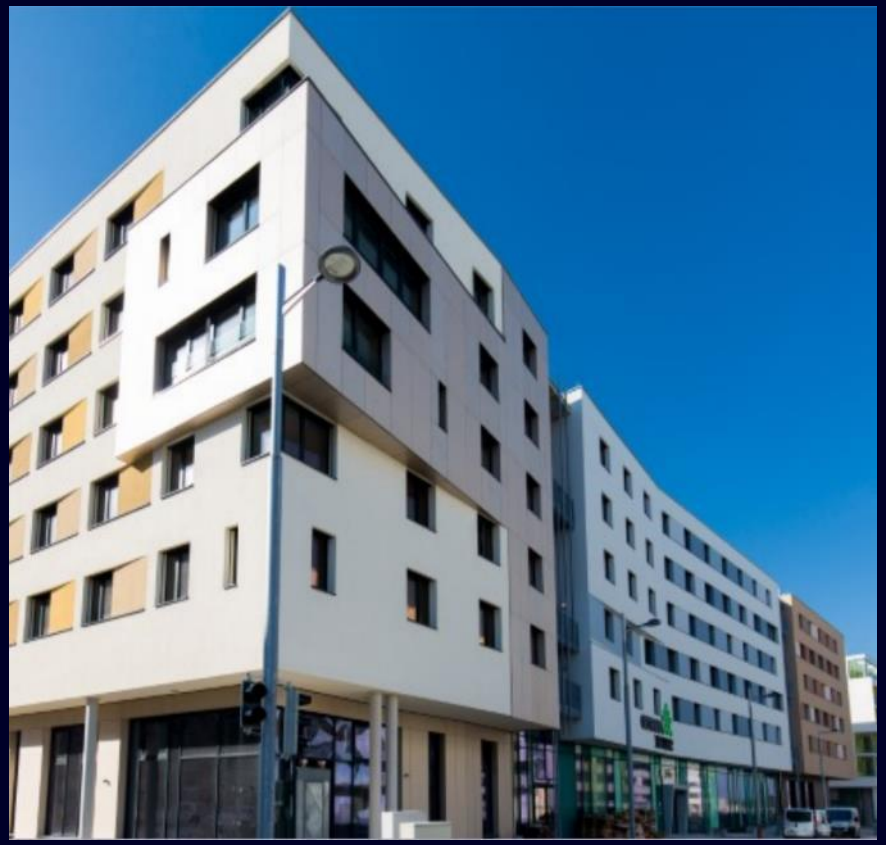
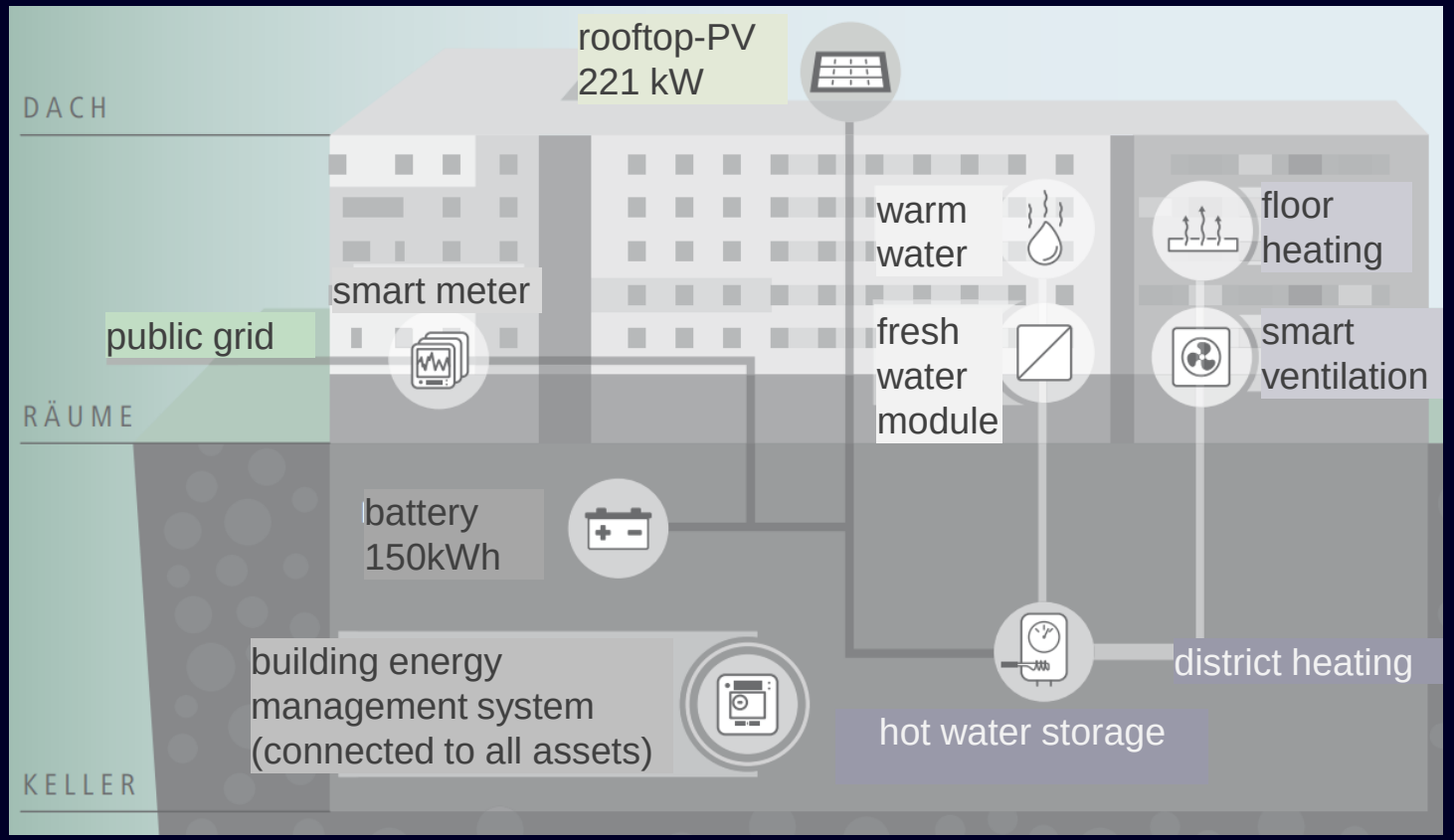
example: flexibility from building heating
student residency in Wien Aspern





Student dormitory

Multimodally coupled energy system

Reference: https://www.ascr.at/wp-content/uploads/2017/11/ASCR_Folder_2017_OK_deutsch_low.compressed.pdf
http://sk.porr-group.com/uploads/tx_mmc_porr_references/pdf/11177_de.pdf

example: flexibility from building heating
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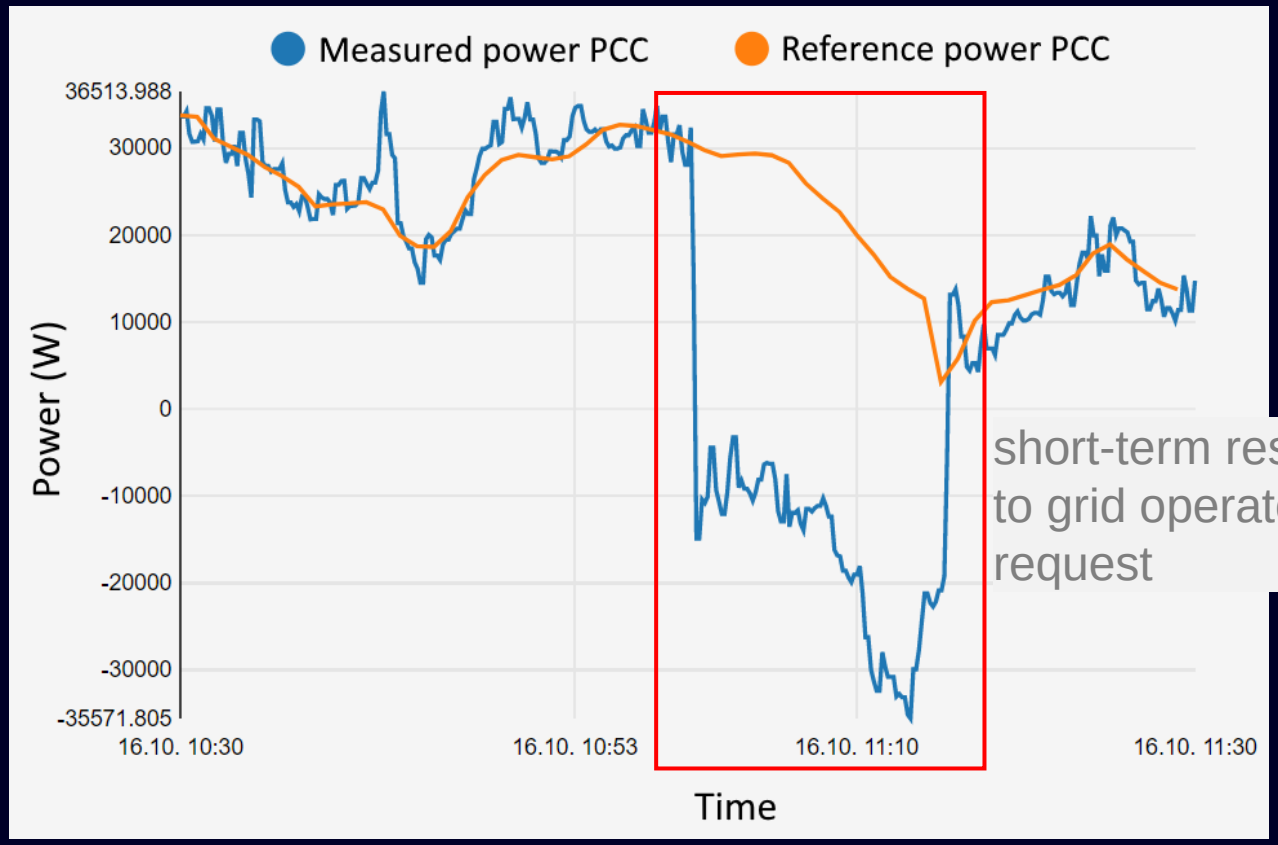

Student dormitory

Automated reaction to short-term requests from dispatch center

PCC: point of common coupling

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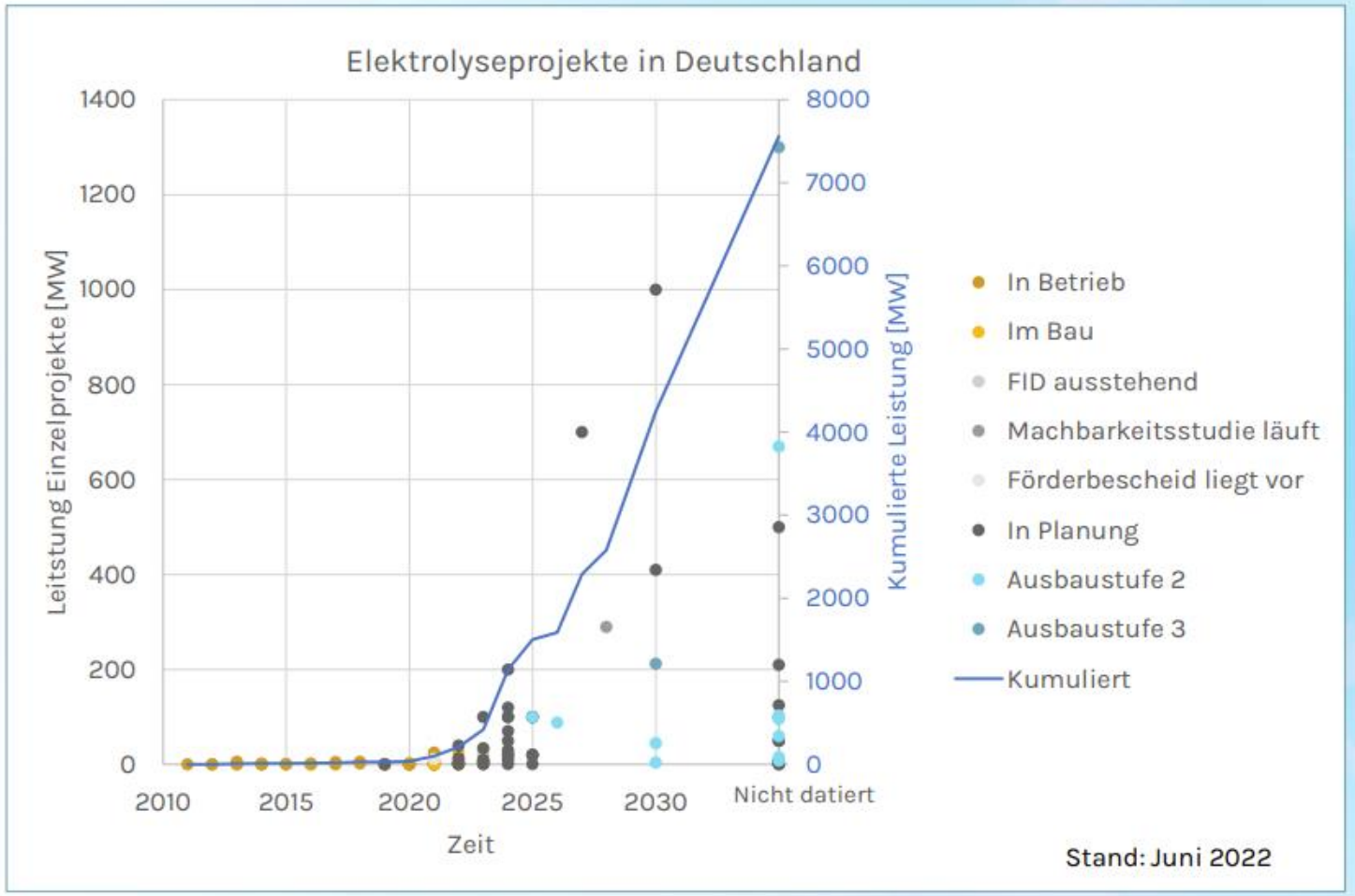
Elektrolysekapazitäten 2030

Geplante Wasserstofferzeugungsprojekte



Die gezeigten Elektrolyseprojekte sind nach (geplantem) Zeitpunkt der Inbetriebnahme und Leistung dargestellt. Es konnten nur Projekte mit bekannter Leistung abgebildet werden.

Die kumulierte Leistung aller aufgenommenen Projekte ist als Linie dargestellt und auf der rechten Achse aufgetragen.

Source: Acatech / Dechema Wasserstoffkompass PowerPoint-Präsentation (wasserstoff-kompass.de)

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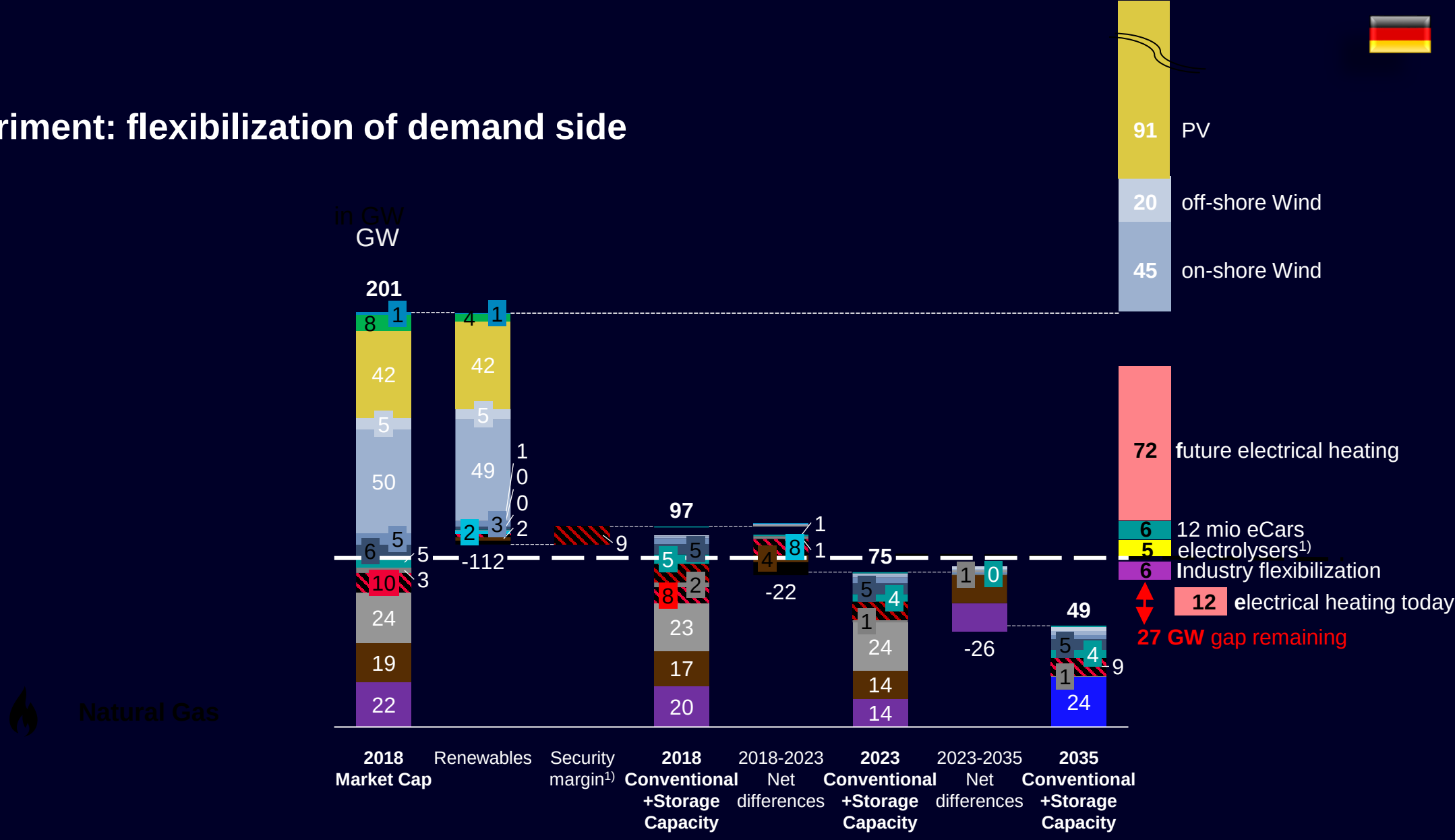
mental experiment: flexibilization of demand side



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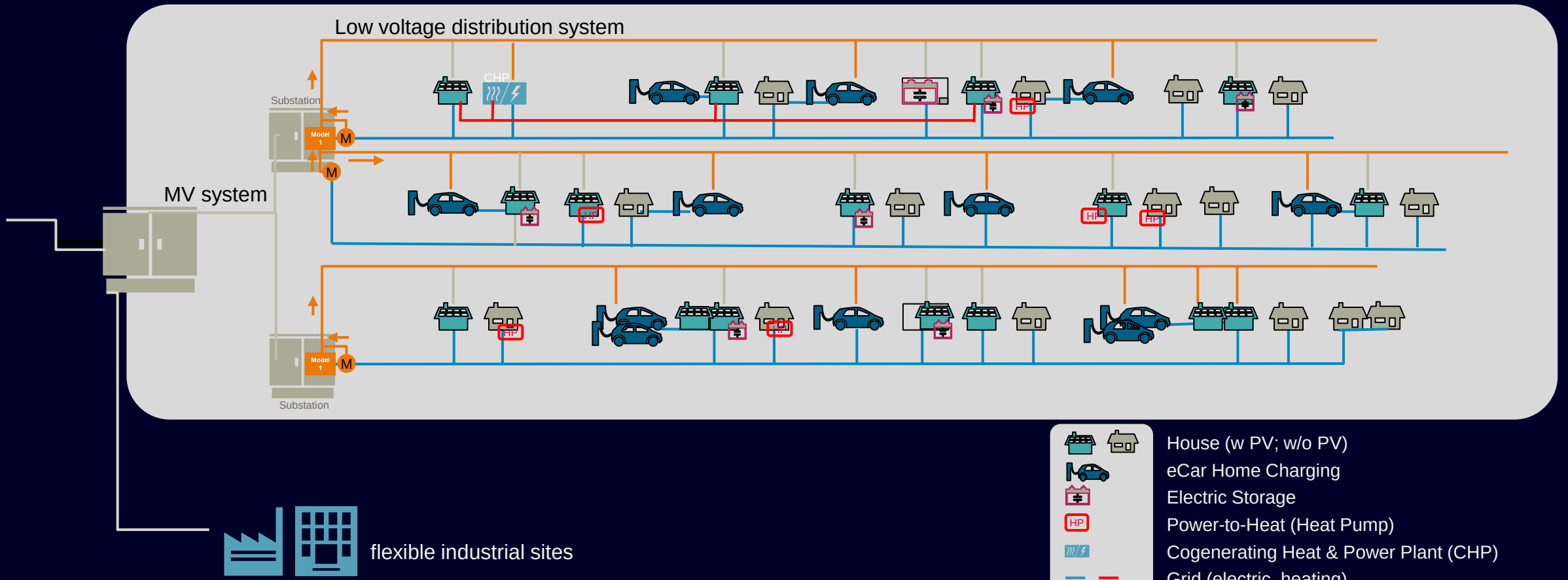
Context-aware, cooperative units in an intelligent distribution grid allow to generate 30% of the consumption locally by 2045

Prosumer Swarms on feeder level → Need for intelligent distribution grids



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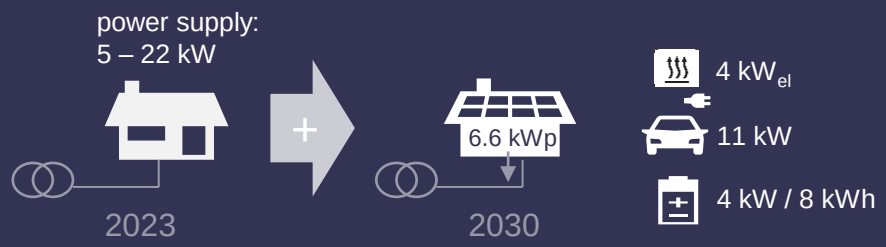
Smart control of decentral actors in the low voltage grid buys essential time needed for grid expansion

Distribution grids are changing:

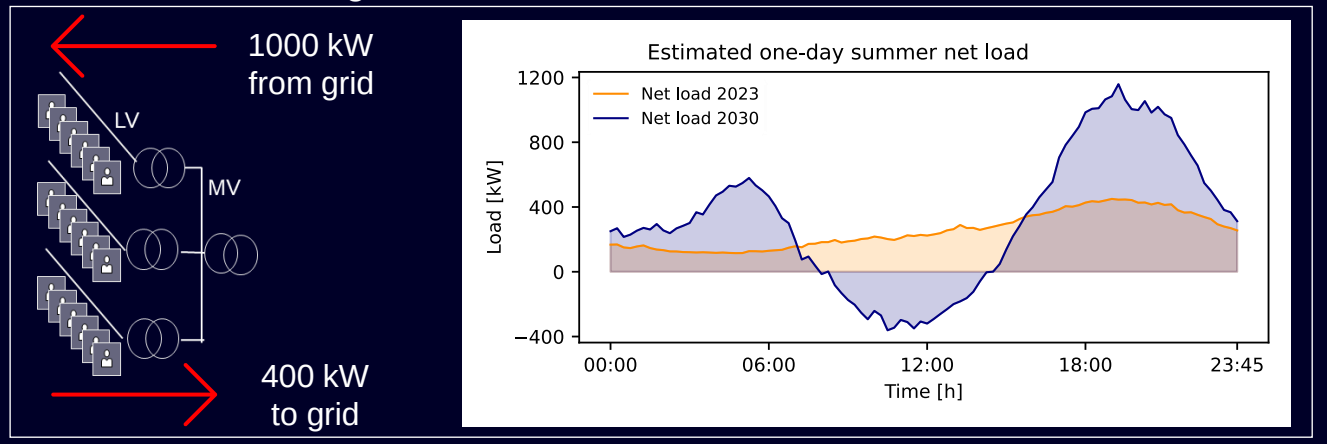


- Stress on grid increases due to decentral generation and increased consumption

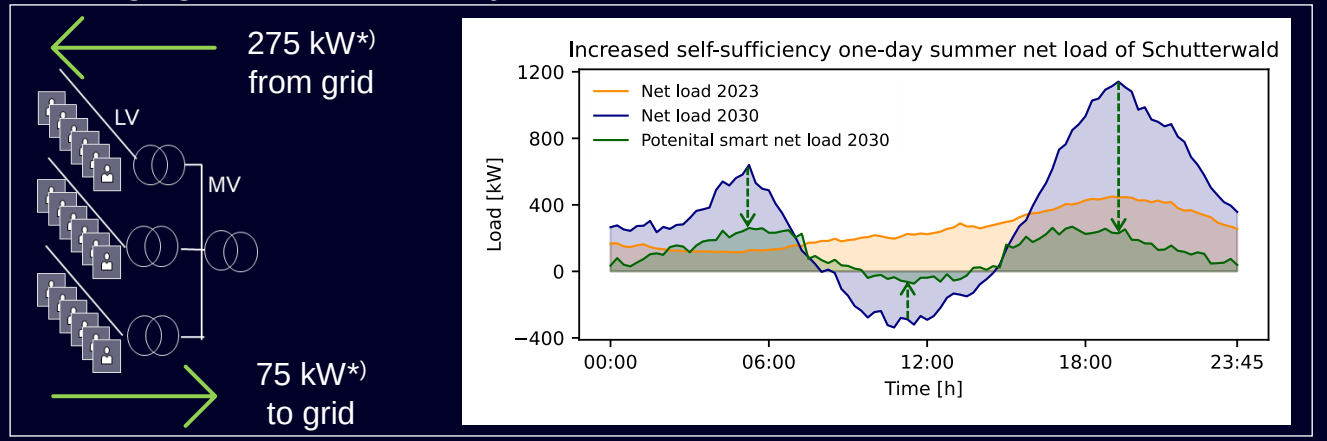
but

- Battery systems, PV and smart utilization of demand side management can decrease the electricity flow across MV/LV substations significantly

Increased stress on grid feeders:



Leveraging decentral flexibility:



*) exemplary numbers

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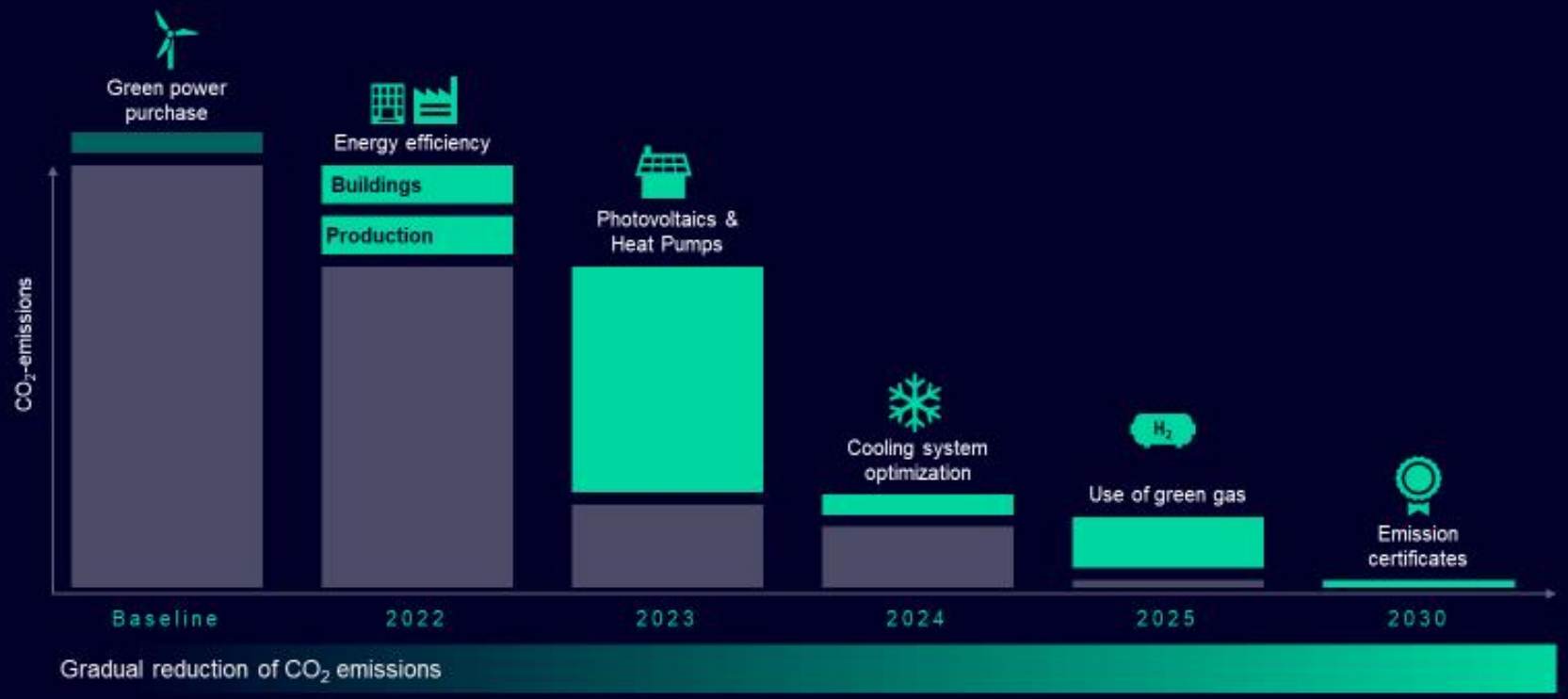
Sustainability Lighthouse: Siemens Factory at Amberg

13 January 2023

By Gunter Beitinger: →

The Journey to a Sustainability Lighthouse awarded by the World Economic Forum

The World Economic Forum (WEF) has named the Siemens Electronic Works in Amberg, Germany, as Sustainability Lighthouse. The designation acknowledges its proactive approach to drive the future of sustainable manufacturing with energy and resource-efficient operations. How did we do that? And why is it still not enough? Let me take you on a short journey to a lighthouse of sustainability.



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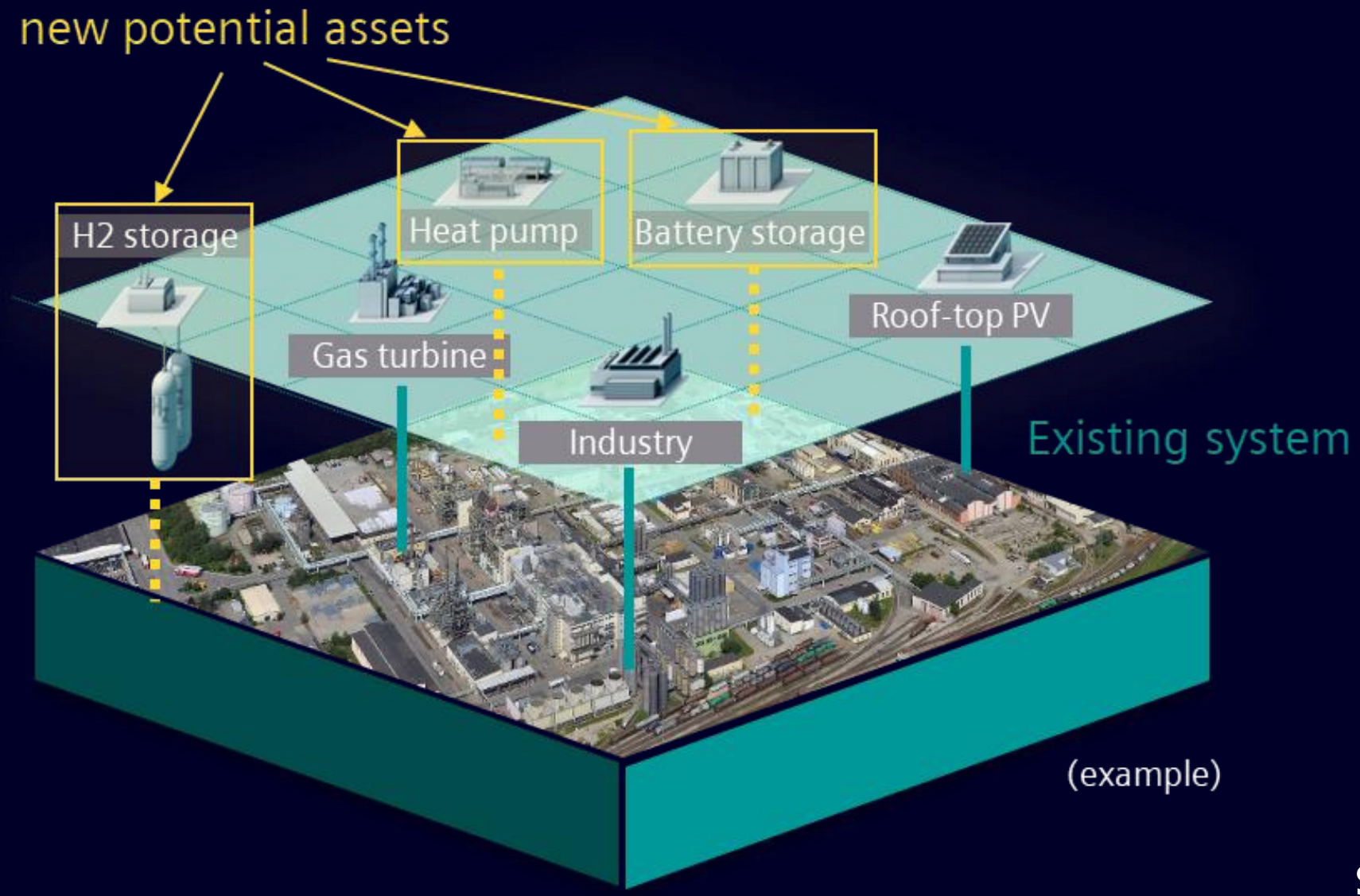
Optimal setup of onsite energy systems with a holistic digital twin



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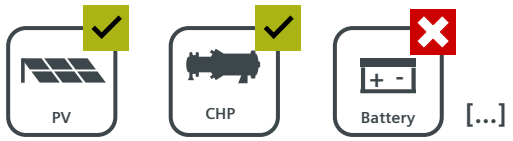
Simultaneous optimization of design and operation

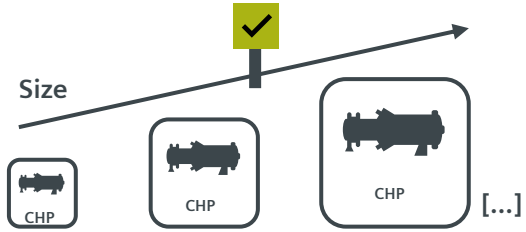
Minimize total expenditures, carbon dioxide emissions, and/or primary energy consumption by ...

... (discrete) assets selection



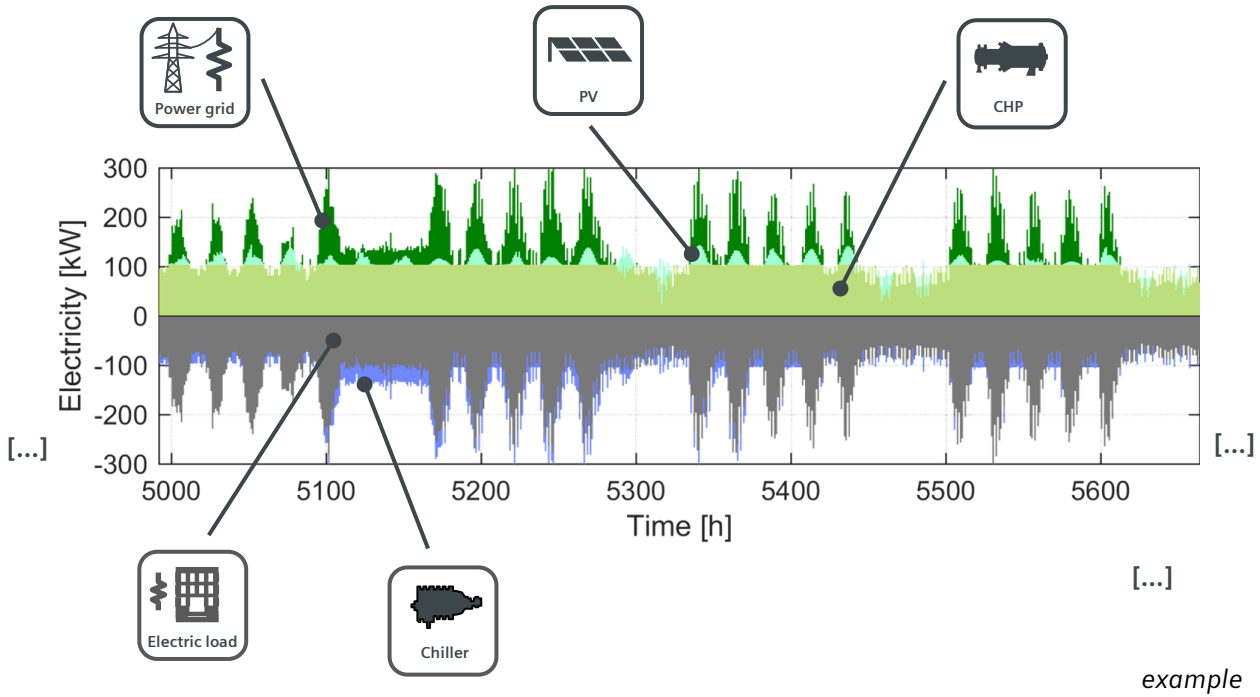
example

... (continuous) assets sizing



example

... (economic) dispatch of assets in multi-modal energy system



example

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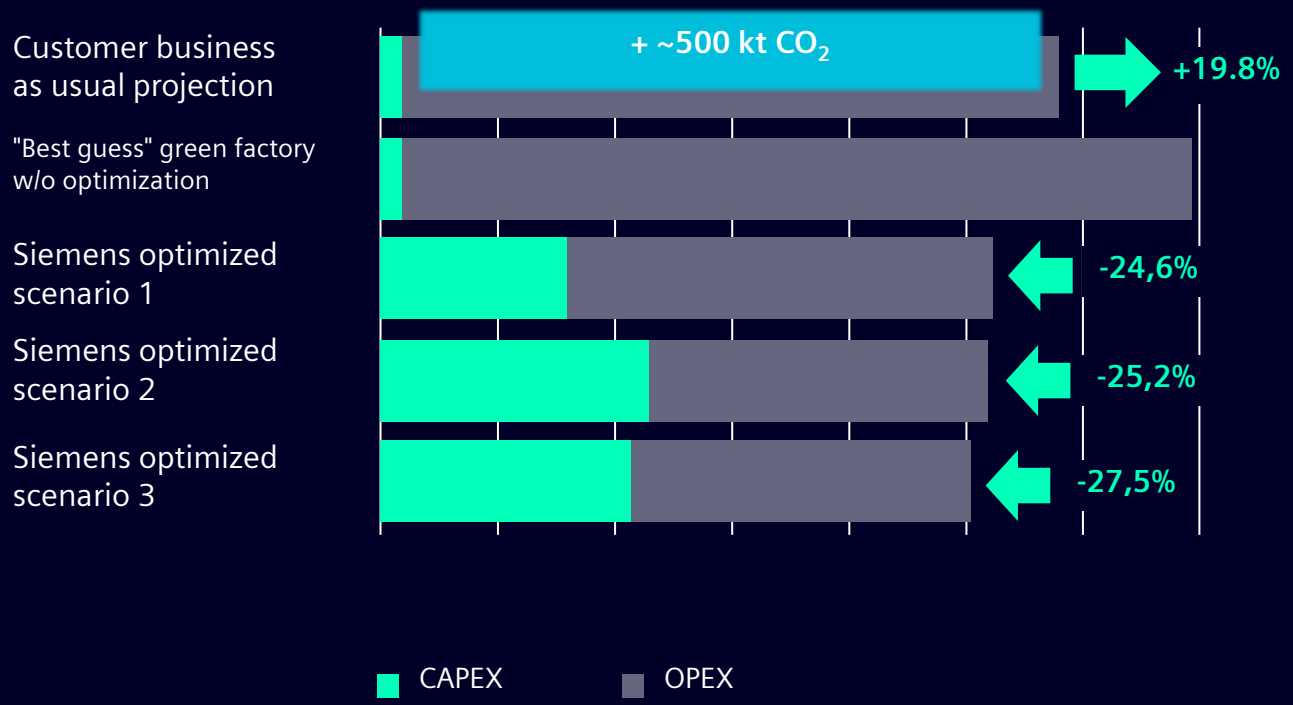
Greenfield automotive factory

Total CAPEX and OPEX

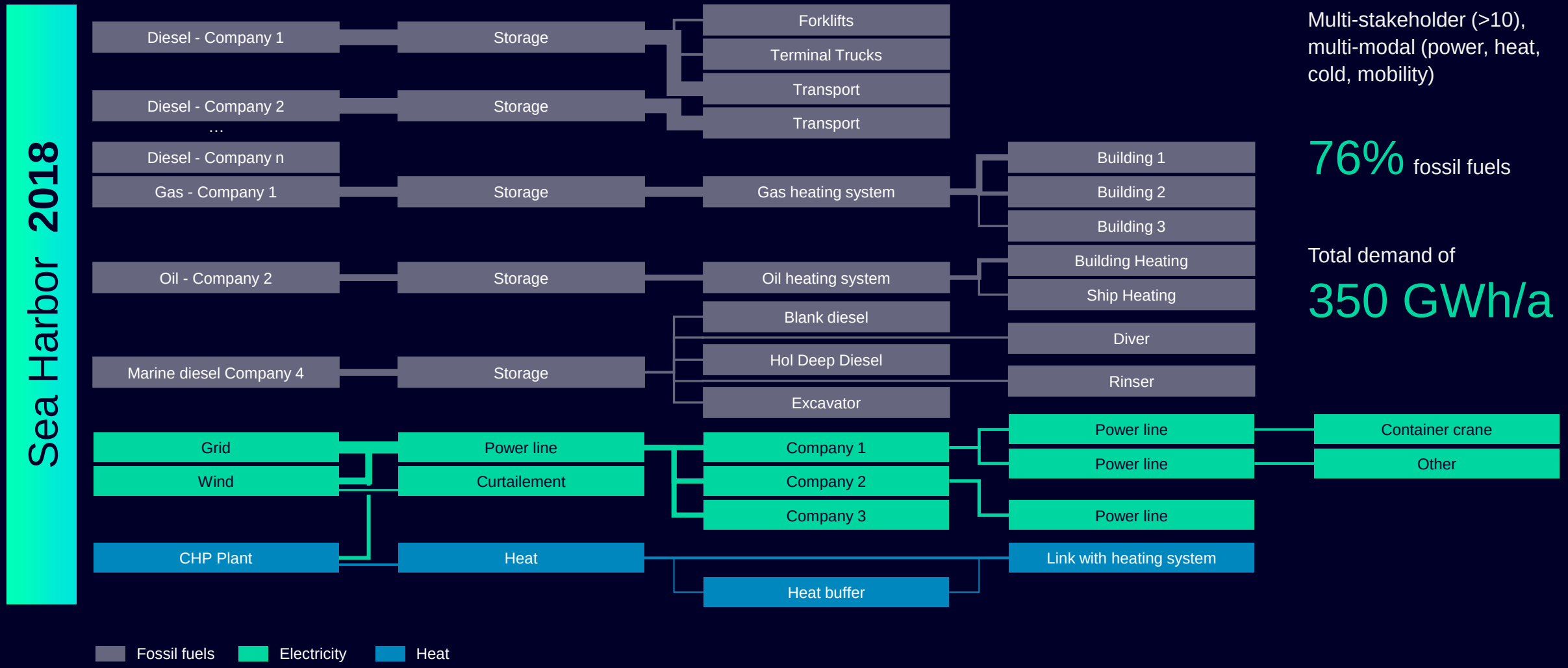


Greenfield Automotive “Green Factory”

- ✓ CO_2-free green factory for electric vehicles
- ✓ 25% lower TOTEX for digitally optimized design
- ✓ CAPEX compensates OPEX

Sea harbor Bremerhaven

Sea Harbor decarbonization



Multi-stakeholder (>10), multi-modal (power, heat, cold, mobility)

76% fossil fuels

Total demand of

350 GWh/a

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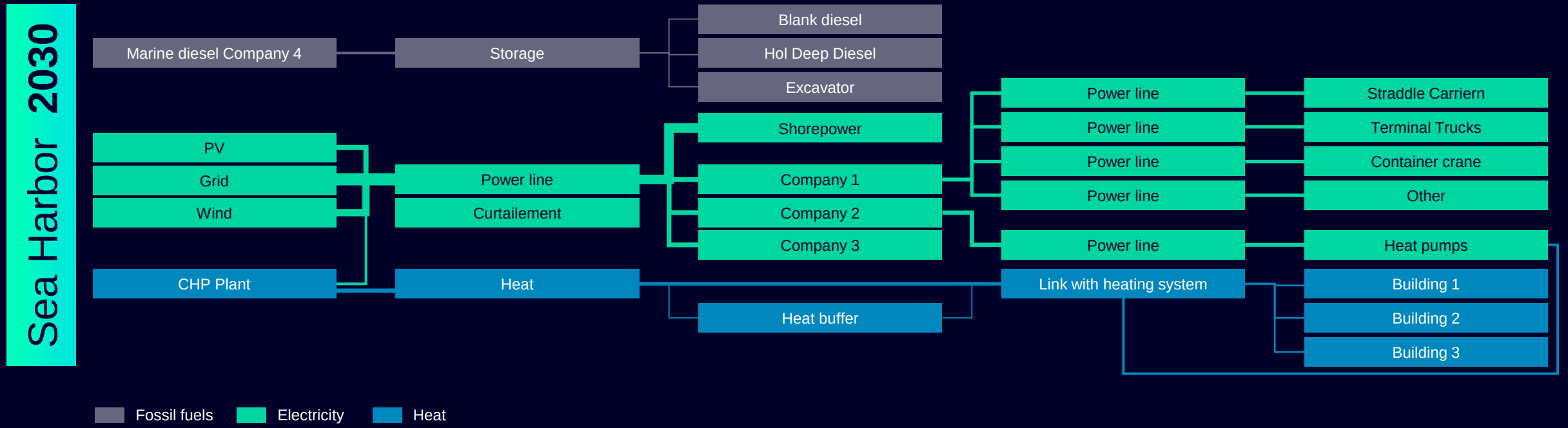
Sea Harbor decarbonization

Digital twin of harbor with load profiles
Concept for decarbonization pathway incl. business models

99% can be electrified
Additional potential identified



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Decarbonization is only possible with digitalization

Our increasingly complex energy system to maintain security of supply requires more and more

- measurements and control
- decentral computing
- communication
- semiconductors