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German Renewables Week

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Is hydrogen an upside for renewables?

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FORESIGHT Climate & Energy

TAGESSPIEGEL ENERGIE & KLIMA BACKGROUND

On the pathway to net zero: What roadblocks will we hit?

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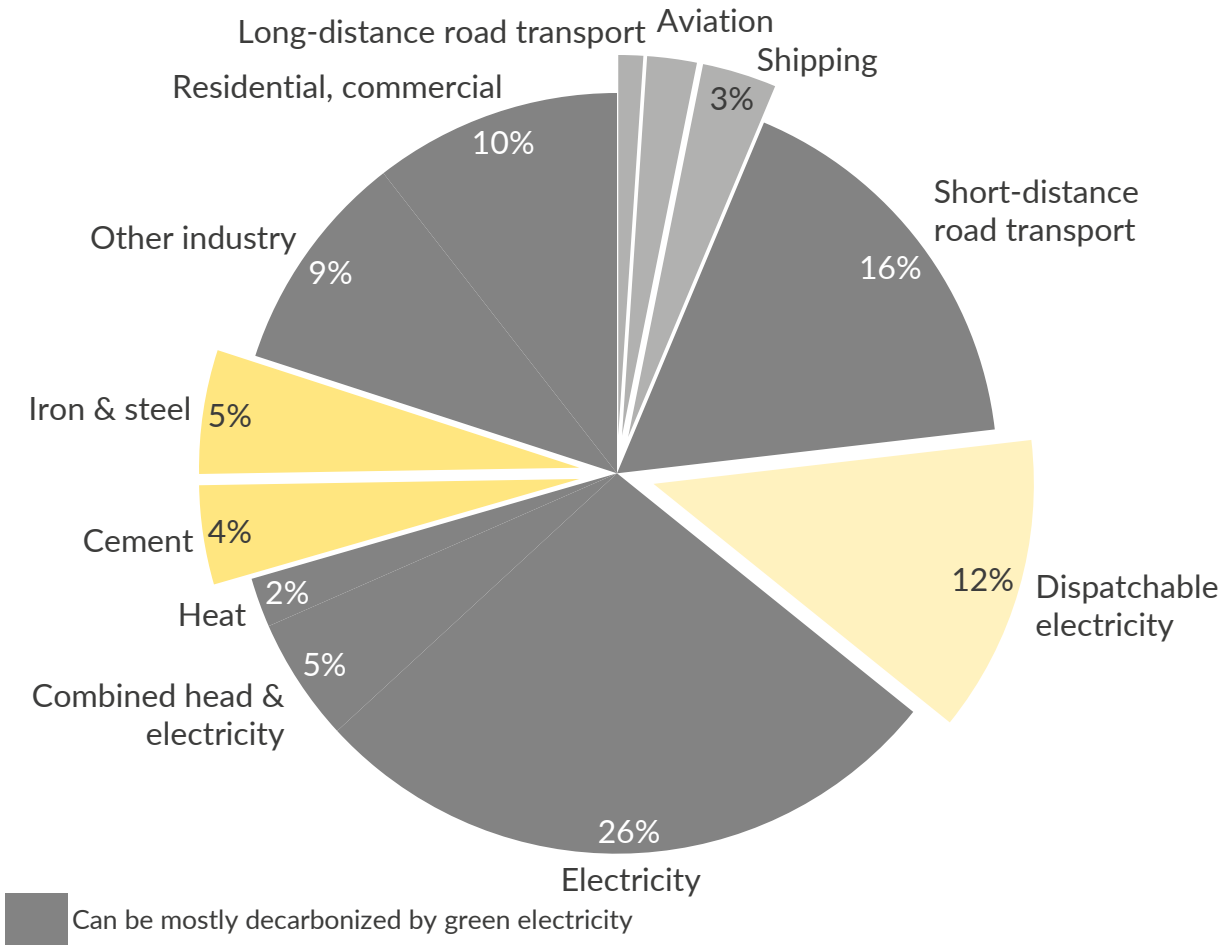
	Roadblocks (Selection)	Details
Society	Acceptance for renewables deployment	▪ NIMBY concerns towards hydro and wind power and grid extensions are growing
	Equitable distribution	▪ Redistributional effect from end-consumers to energy corporates ▪ Carbon pricing can lead to increase in inequality
	Required lifestyle change	▪ Drastic changes in diet and transport required
Market & policy design	Incentive for green investments	▪ Policy certainty required to avoid first mover problem
	Carbon leakage	▪ Risk that emission intensive industry moves to less ambitious regions
Technology	Seasonal storage of energy	▪ Options for seasonal storage of electricity are either expensive or hard to scale ▪ Molecules instead of electrons provide alternative
	Sectors that are hard to electrify	▪ Industrial processes with fossil feedstock require clean alternative ▪ High temperature heat and long-distance transport classes are expensive to electrify
	Carbon sequestration	▪ Scalable solutions are either expensive (Direct air capture) or still in early development (biochar, ocean alkalinity)

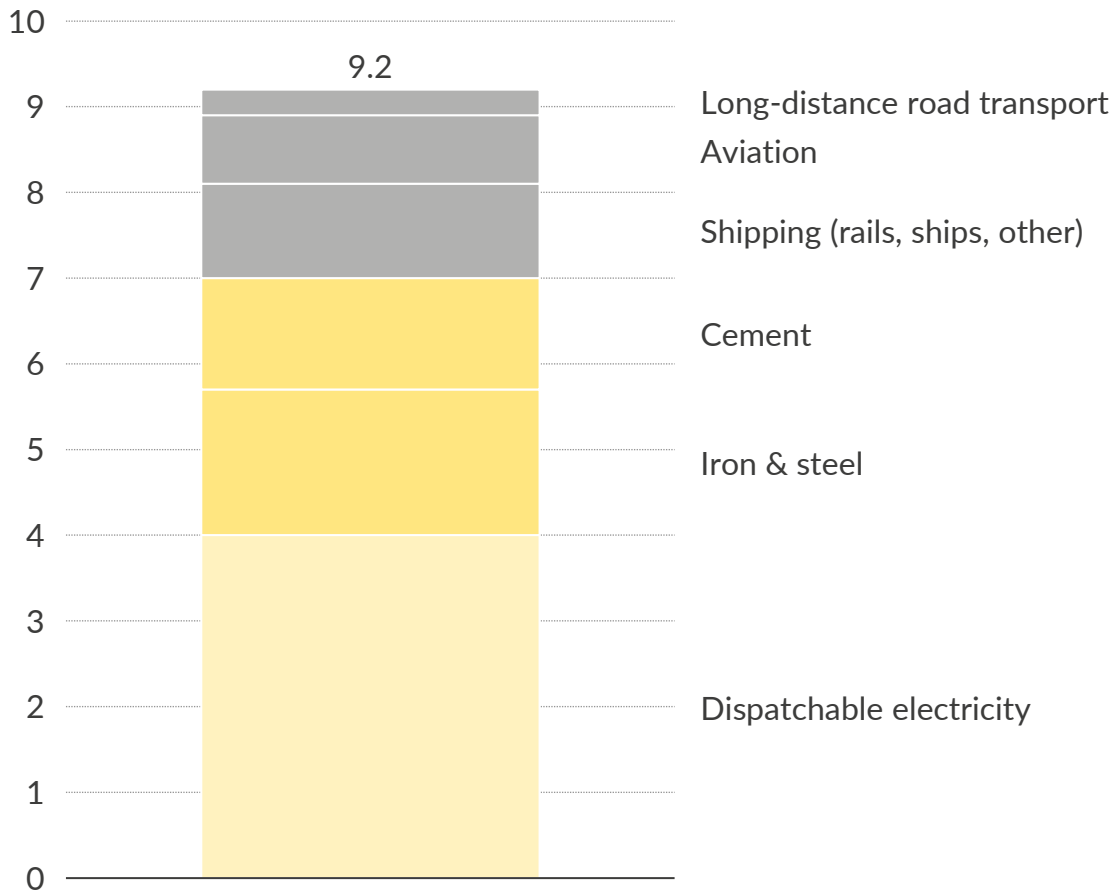
Source: Aurora Energy Research

Many sectors are difficult to decarbonize via green electricity – such as steel making or long distance transport

Global fossil fuel & industry emissions in 2014, by sector
% of total (33.9 Gt CO2e)



Hard-to-abate emissions in 2014,
Gt CO2e



Source: Aurora Energy Research

Industry will become the first demand sector with large potential – high penetration in heat and transport at question

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Low H_2 Demand

1a *Industry*

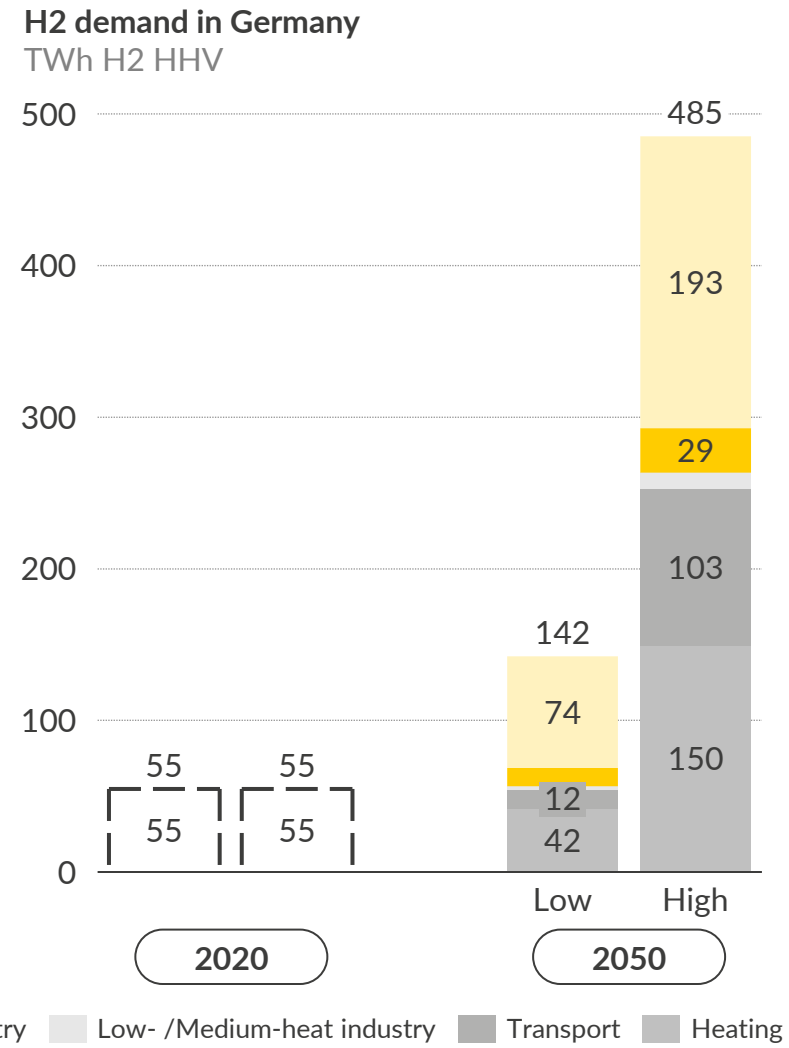
- Replacing grey H_2 in feedstock and use in steel and further chemical processes
- Use H_2 as high-heat source

1b *Transport*

- Goods vehicles and public buses partly switch to H_2 due to high utilization and long operation hours

1c *Buildings Heat*

- District heating is partially run on hydrogen starting in 2040 and expanding until 2050



High H_2 Demand

1a *Industry*

- Growth of sectors and higher H_2 penetration
- H_2 used also for low temperature processes with dedicated networks

1b *Transport*

- Higher H_2 penetration for goods vehicles
- Liquid H_2 or H_2 derivatives to replace fossil fuels in aviation & waterway transport

1c *Buildings Heat*

- H_2 is used for district heating from 2030
- Gas boilers start to use green CH_4 in 2030, avoiding the high upfront costs of heat pumps

Note: H2 demand from the power sector (power-to-power) is an output of Aurora's power & hydrogen market model. Hence, not part of the assumptions.

Sources: Aurora Energy Research, German Hydrogen Strategy, ISPT

We identified four upsides for renewables

1. **Increase of capture prices**
2. **PPA potential**
3. **Global hydrogen usage as a driver for accelerated renewable deployment**
4. **Capture otherwise curtailed power**

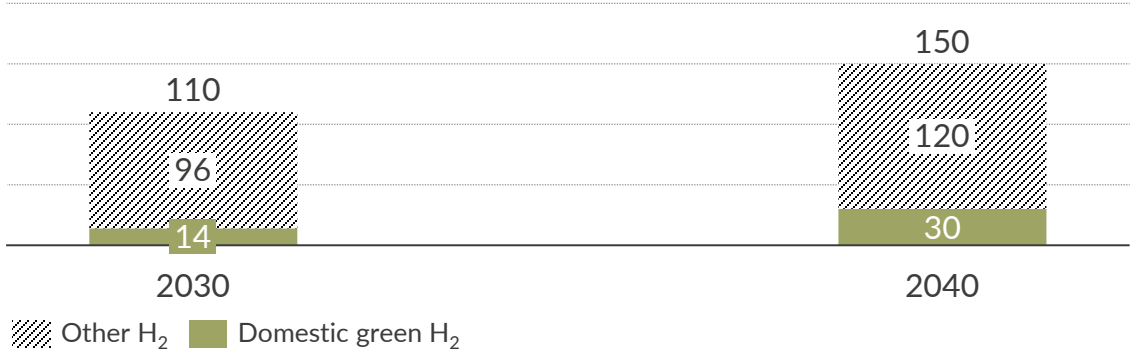
Sources: Aurora Energy Research

Deployment of electrolysers along the German strategy can improve renewables economics by ~12%

The recent German hydrogen strategy envisions to ramp up domestic green H2 production, …

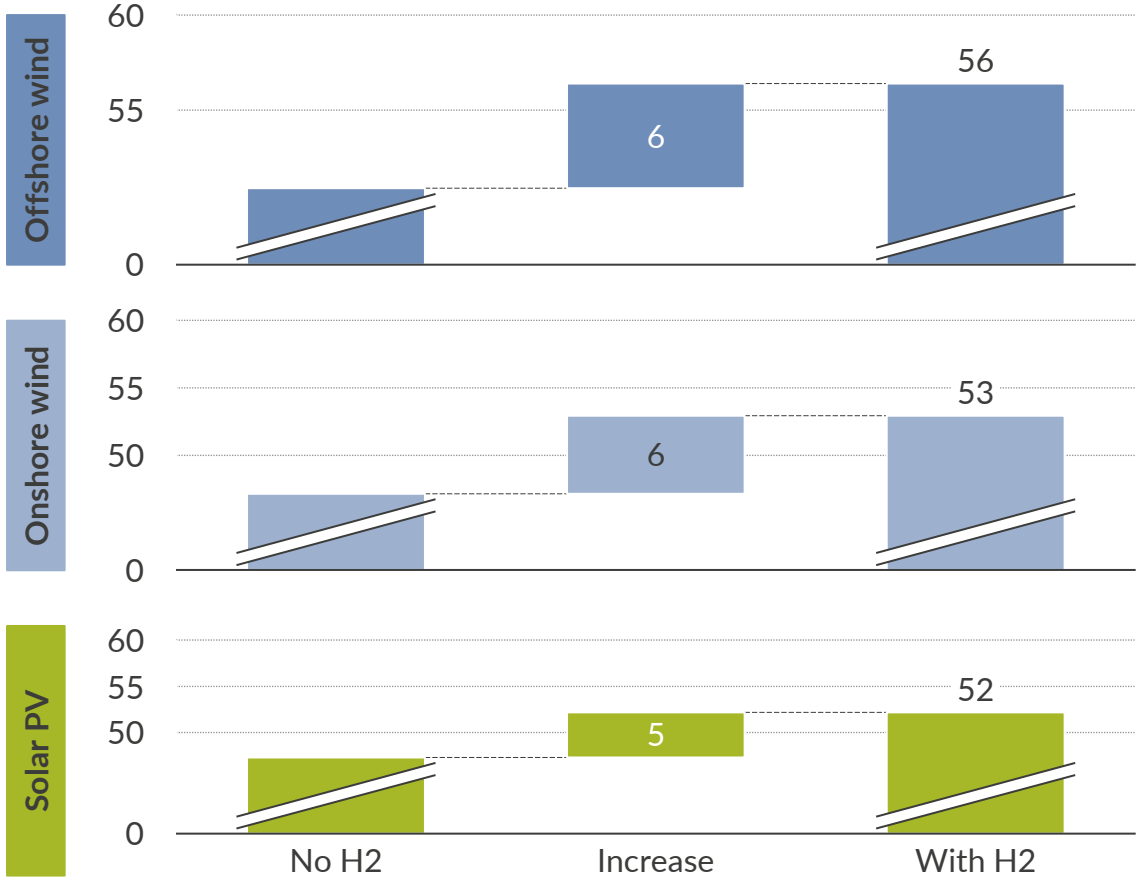
Electrolyser capacity and storage
GW

H_2 demand
TWh



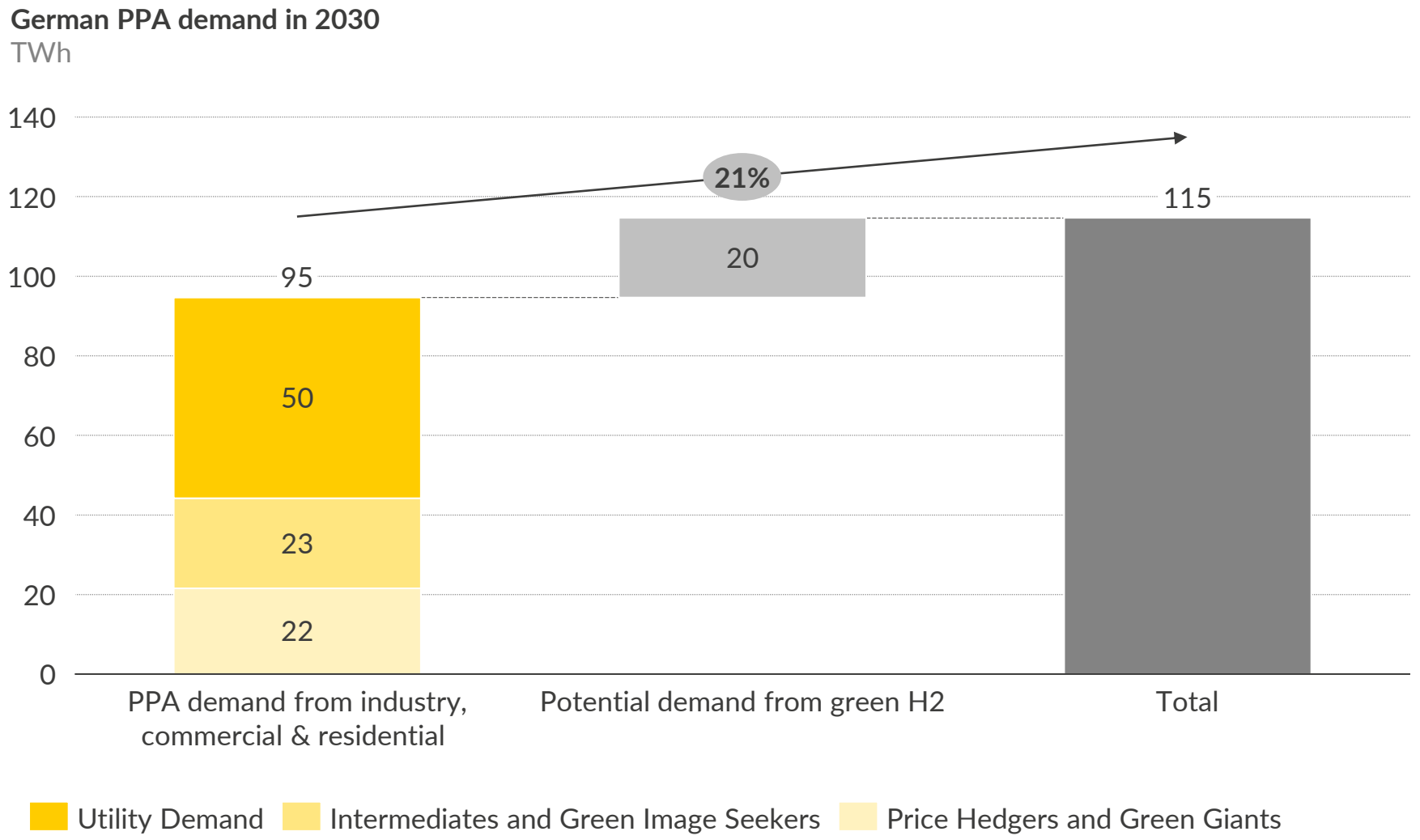
…, which soaks up low prices when RES generate resulting in significant upward pressure on capture prices – on average 12%

Average capture price between 2030-2040
EUR/MWh (real 2019)



Source: Aurora Energy Research

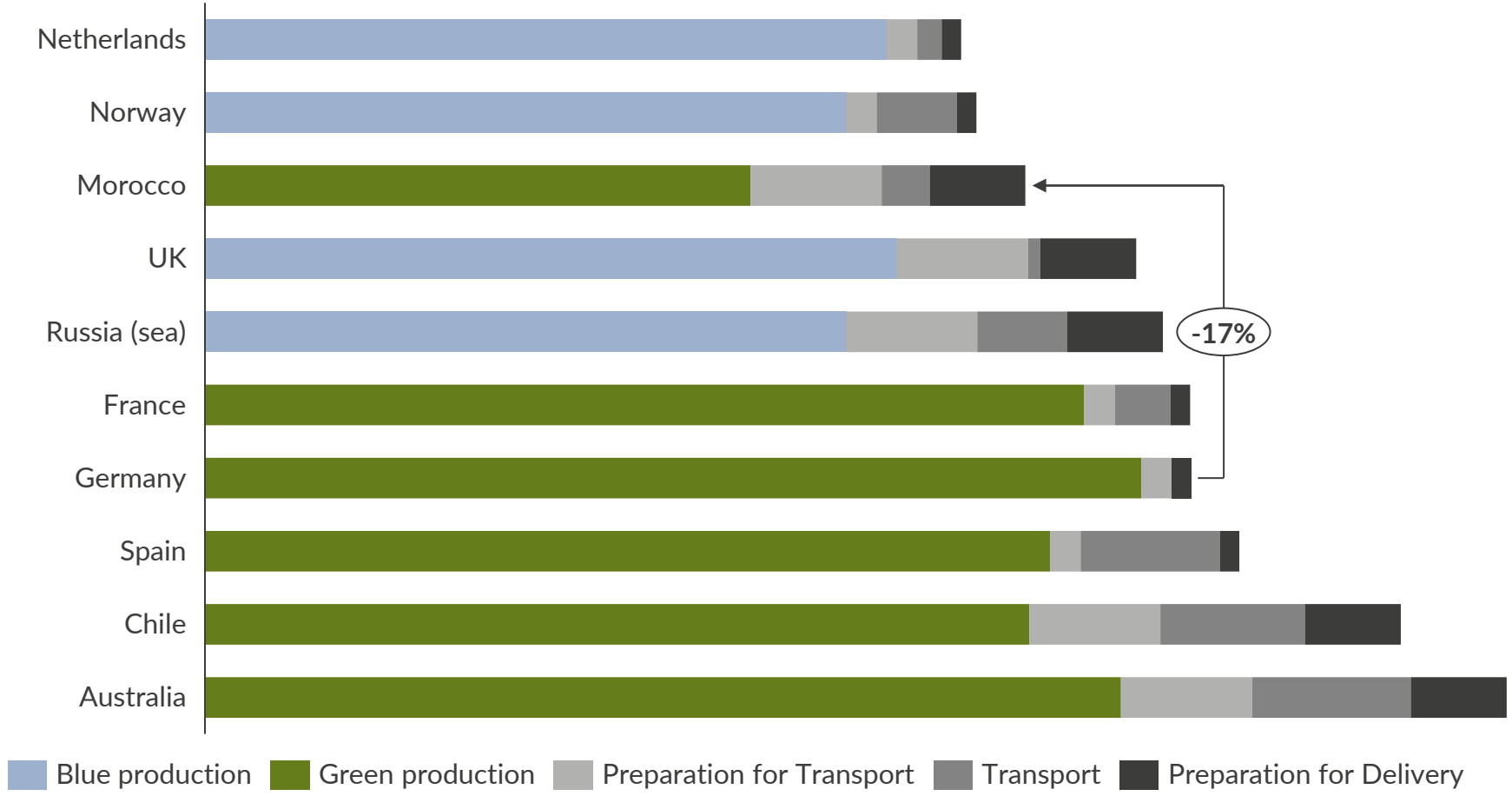
The volume of the German PPA market could grow – but questions on power procurement for electrolysis remain



Source: Aurora Energy Research

But how much will be produced in Germany, if imports can be cheaper?

Levelised cost of delivered hydrogen to Germany in 2030
€/MWh H_2 (HHV)



Values show the cheapest combination of hydrogen source, energy vector, and transport

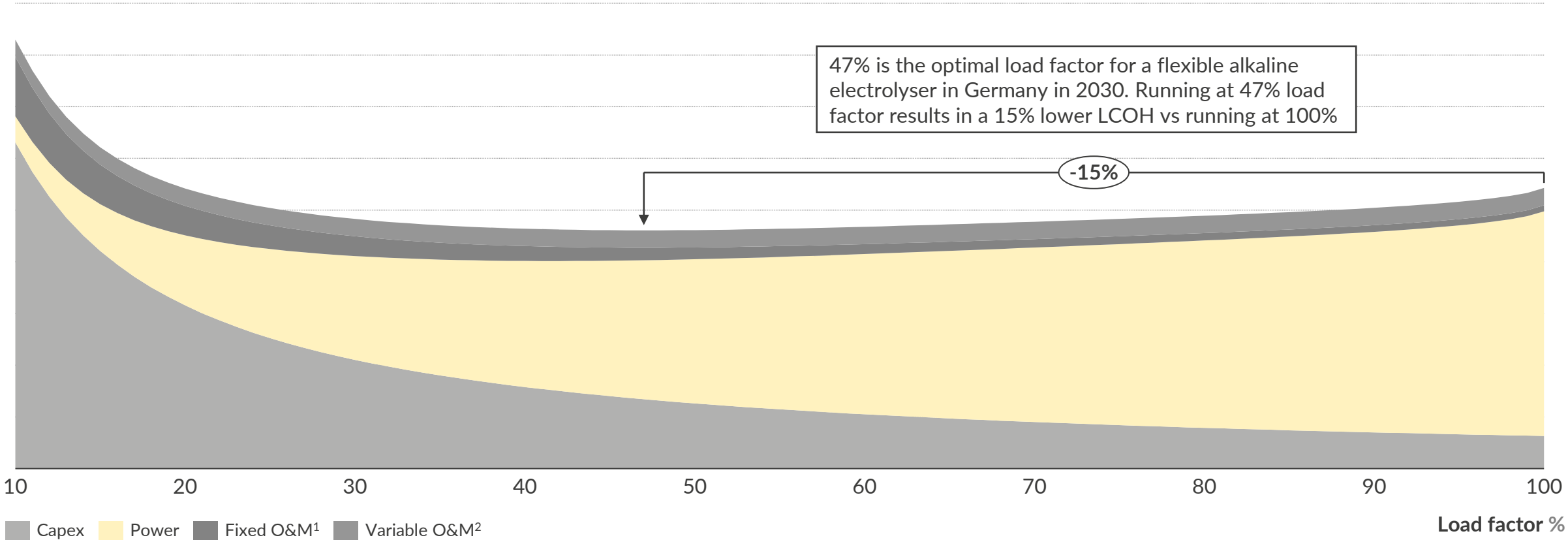
- Blue H_2 by autothermal reformer with CCS
- Green H_2 by alkaline electrolysis
- Continental H_2 transported in greenfield pipelines
- Otherwise, by sea transport as ammonia

Source: Aurora Energy Research

Bringing down electricity costs through load factor optimisation will be key for competitive domestic production

Flexible electrolysers can optimise their load factor to produce the cheapest hydrogen

LCOH for a grid-connected alkaline electrolyser in Germany in 2030, by component
€/MWh H_2 (HHV)



Source: Aurora Energy Research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