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for Economic Affairs
and Climate Action

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GLOBAL
ENERGY SOLUTIONS
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Hydrogen infrastructure opportunities: transportation options, regional H_2 hubs and back-up for the electricity system

Maike Schmidt

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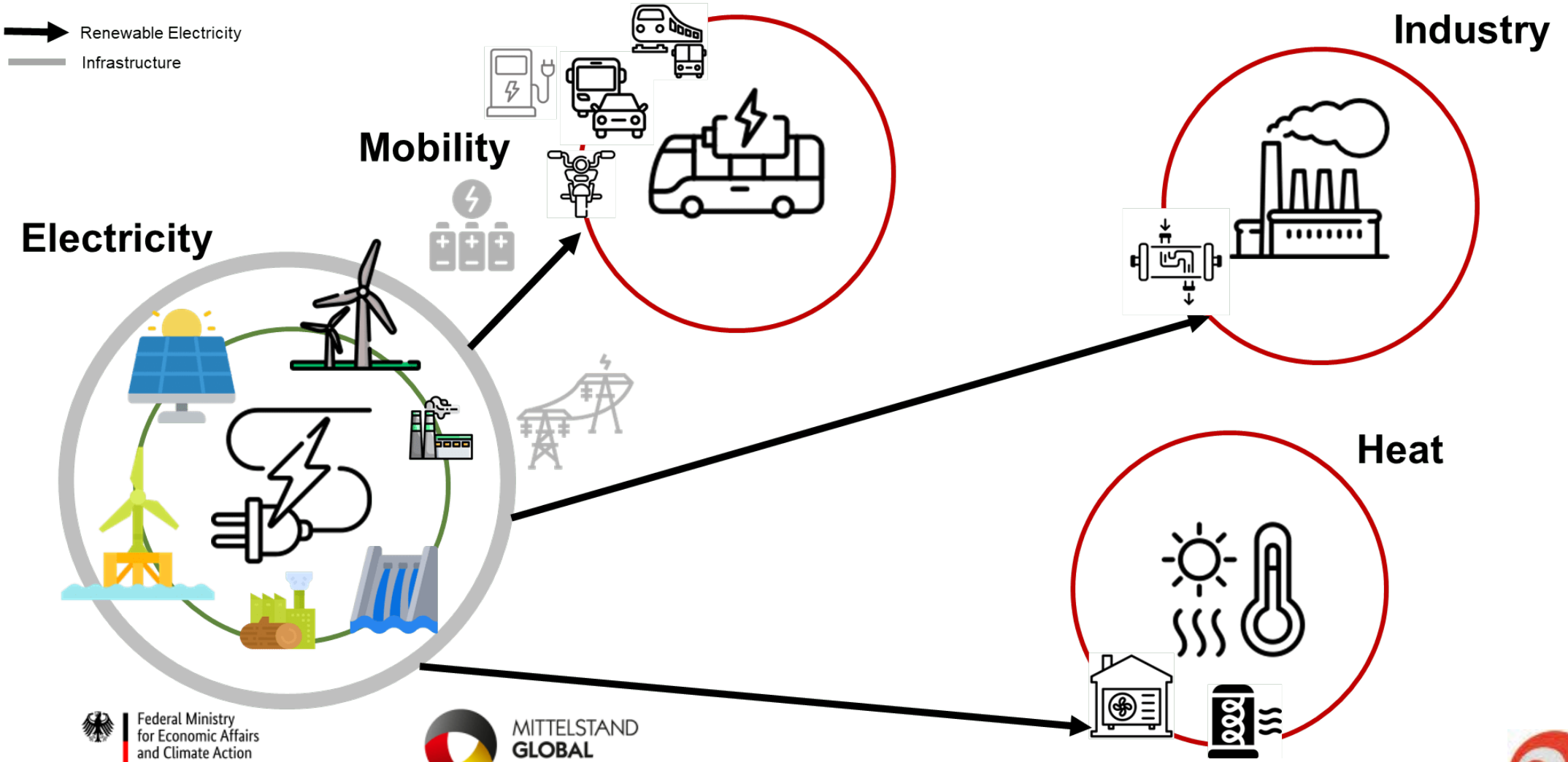
The role of hydrogen in the future energy system



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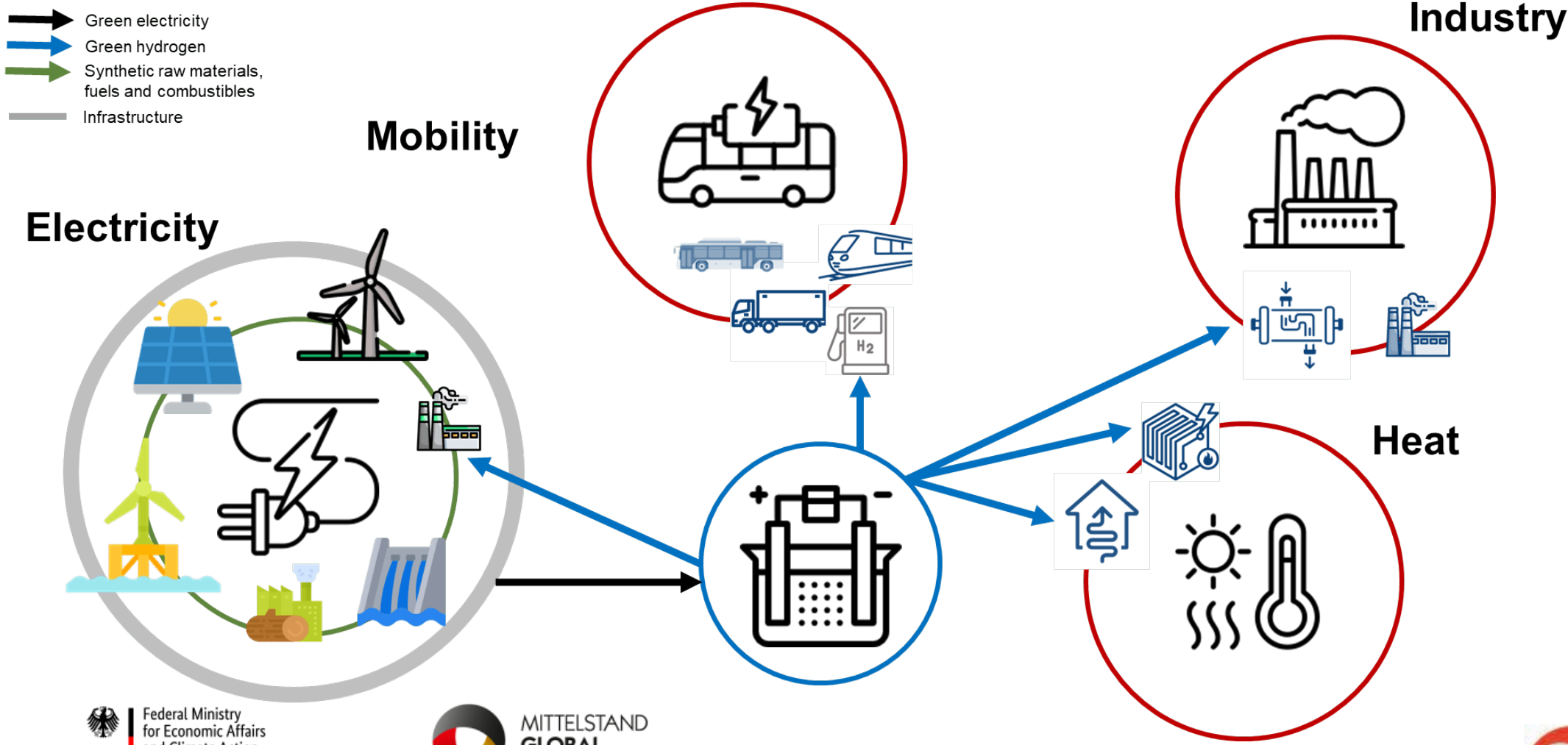
The dual role of hydrogen: energy carrier and energy storage



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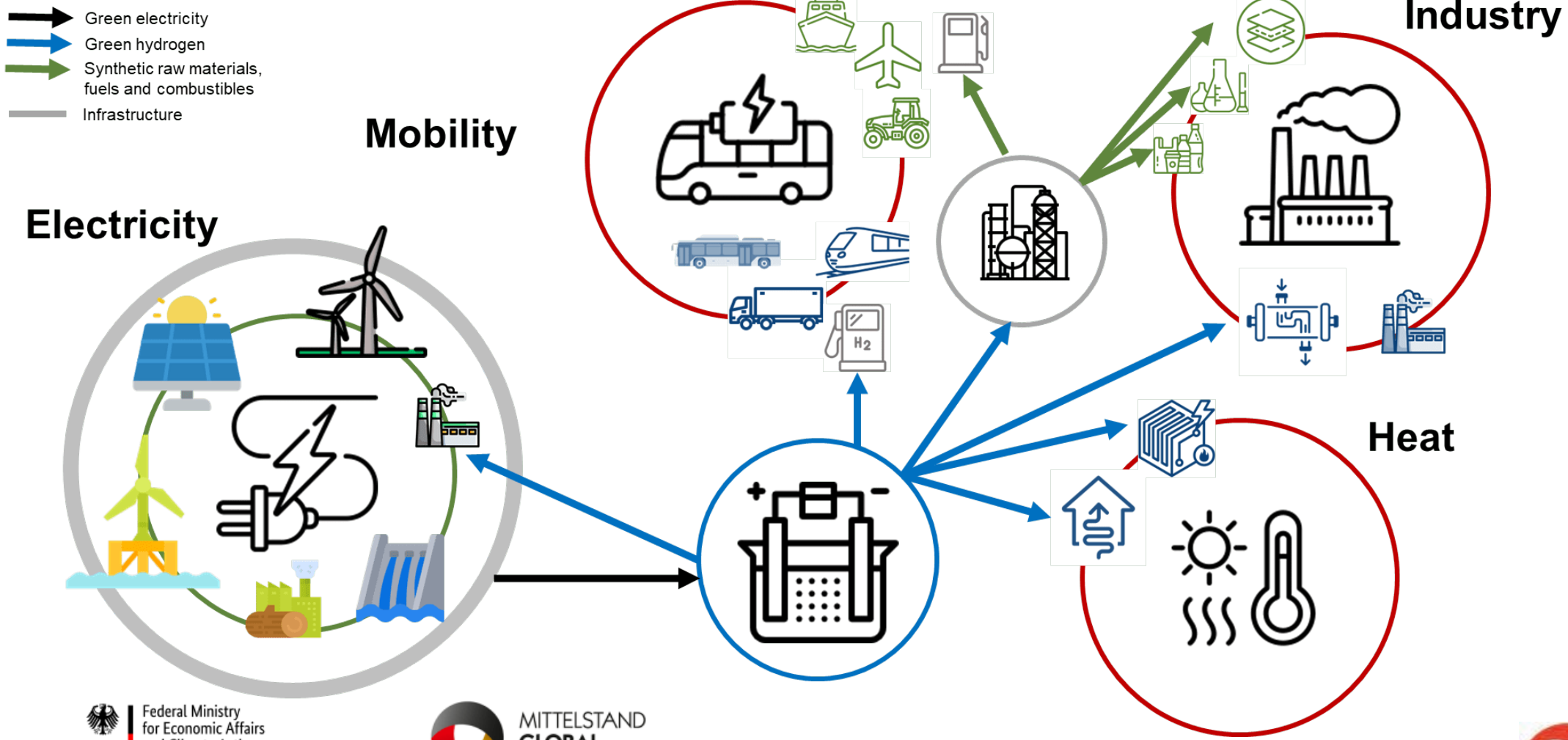

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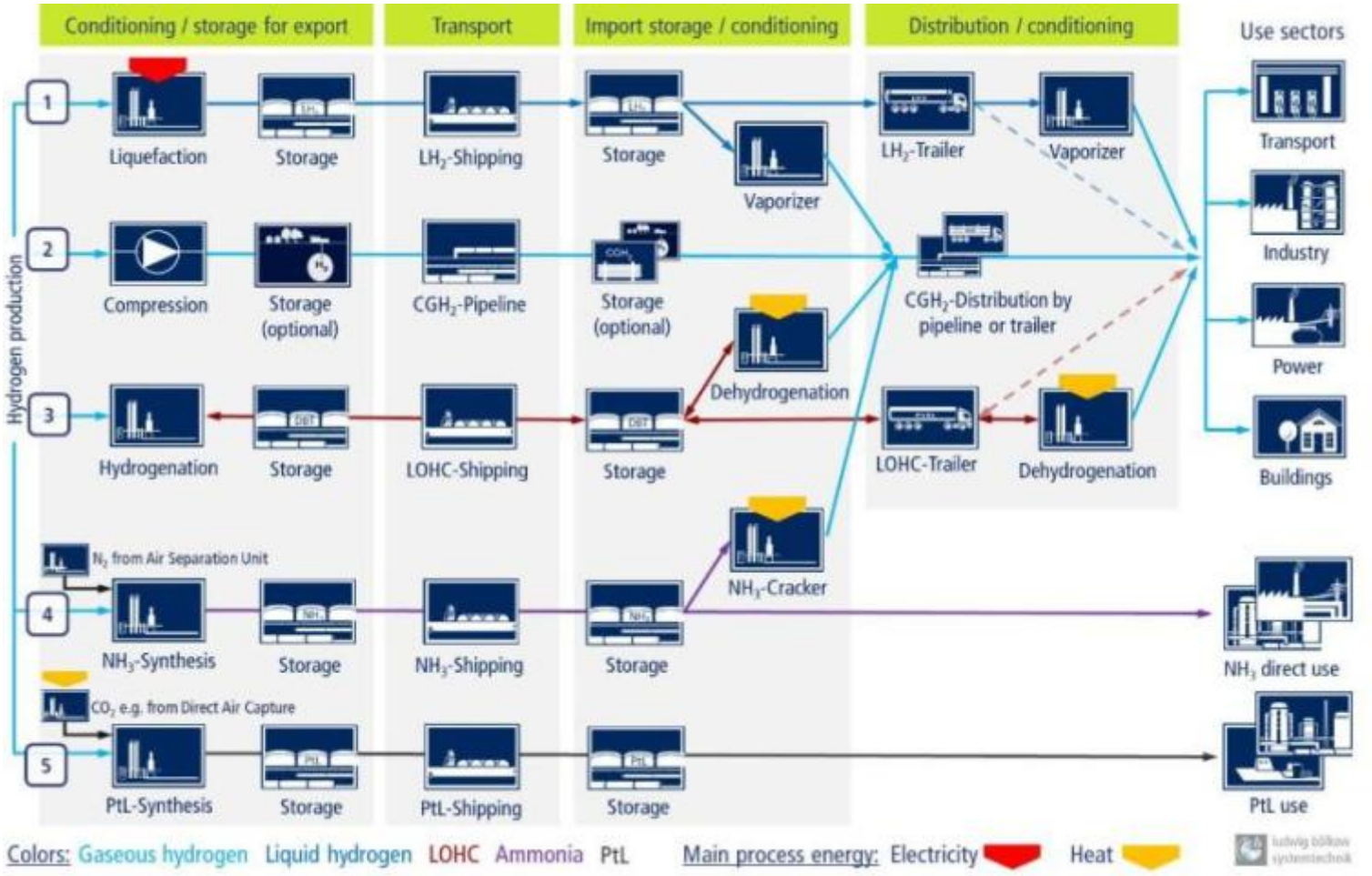
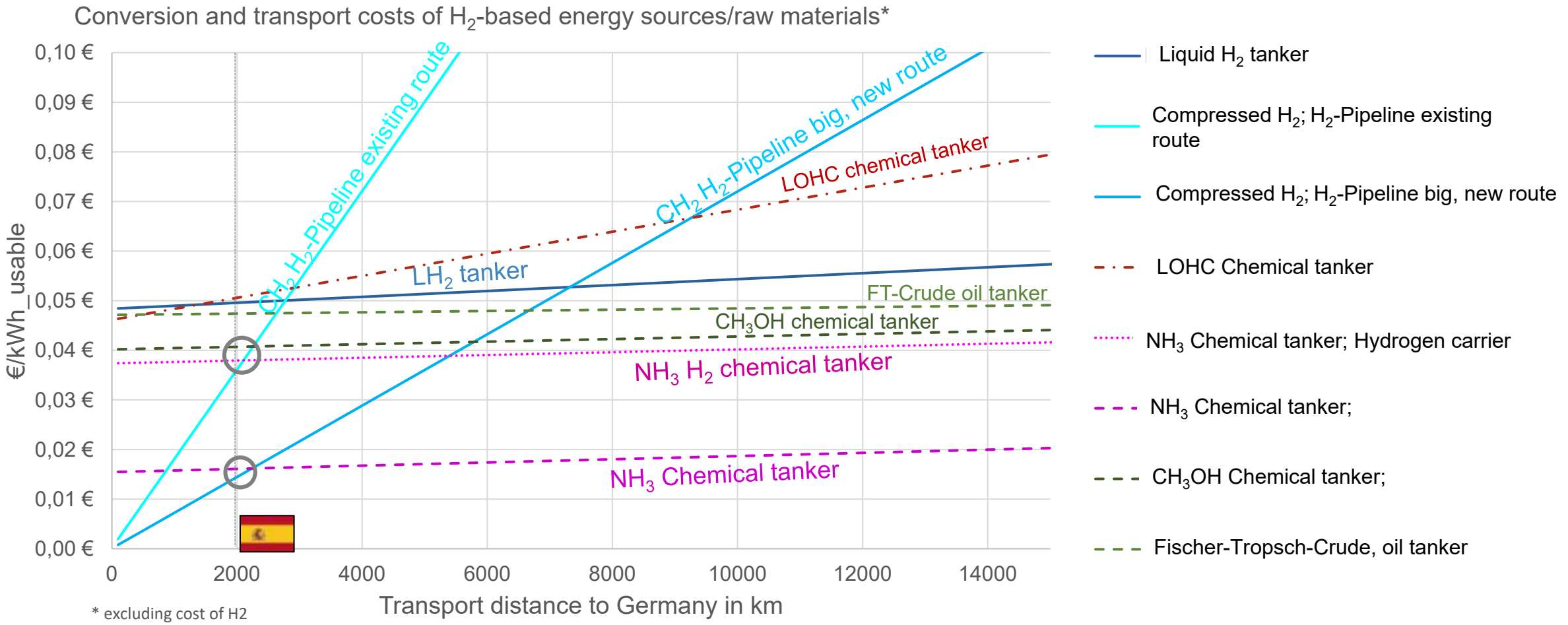
Hydrogen as energy carrier – How to transport hydrogen?



1. Liquid Hydrogen (LH_2) via ship
2. Compressed Hydrogen (CGH_2) via pipeline
3. Liquid Organic Hydrogen Carrier (LOHC) via ship/ pipeline
4. Ammonia (NH_3) via ship/ (pipeline)
5. Power-to-Liquid (FT-Crude or methanol) via ship/ pipeline

Source: WEC/LBST; International Hydrogen Studies (2020)

Conversion and transport cost of H_2-based energy sources / raw materials



* excluding cost of H2

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Leopoldina Nationale Akademie der Wissenschaften · acatech Deutsche Akademie der Technikwissenschaften · Union der Deutschen Akademien der Wissenschaften

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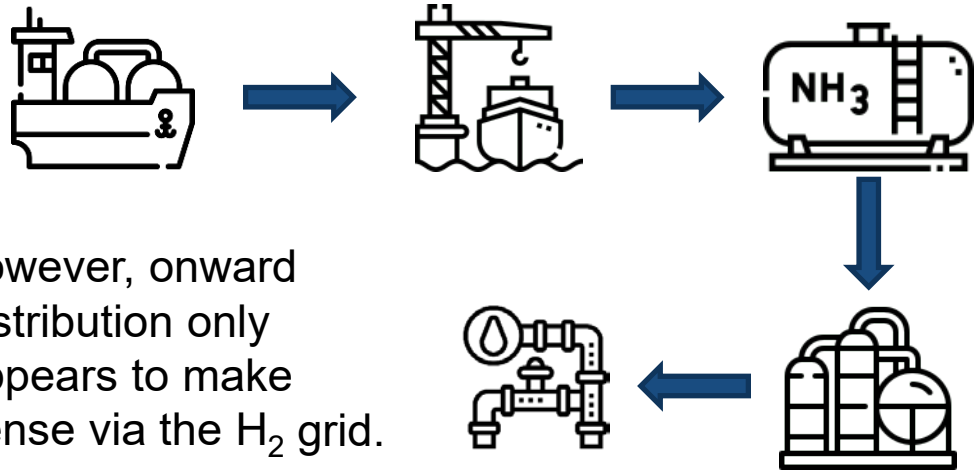
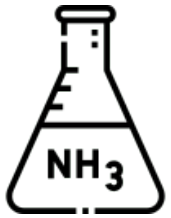
A quick look at synthetic downstream products of H_2

"Green" ammonia is an import option for green hydrogen by ship,

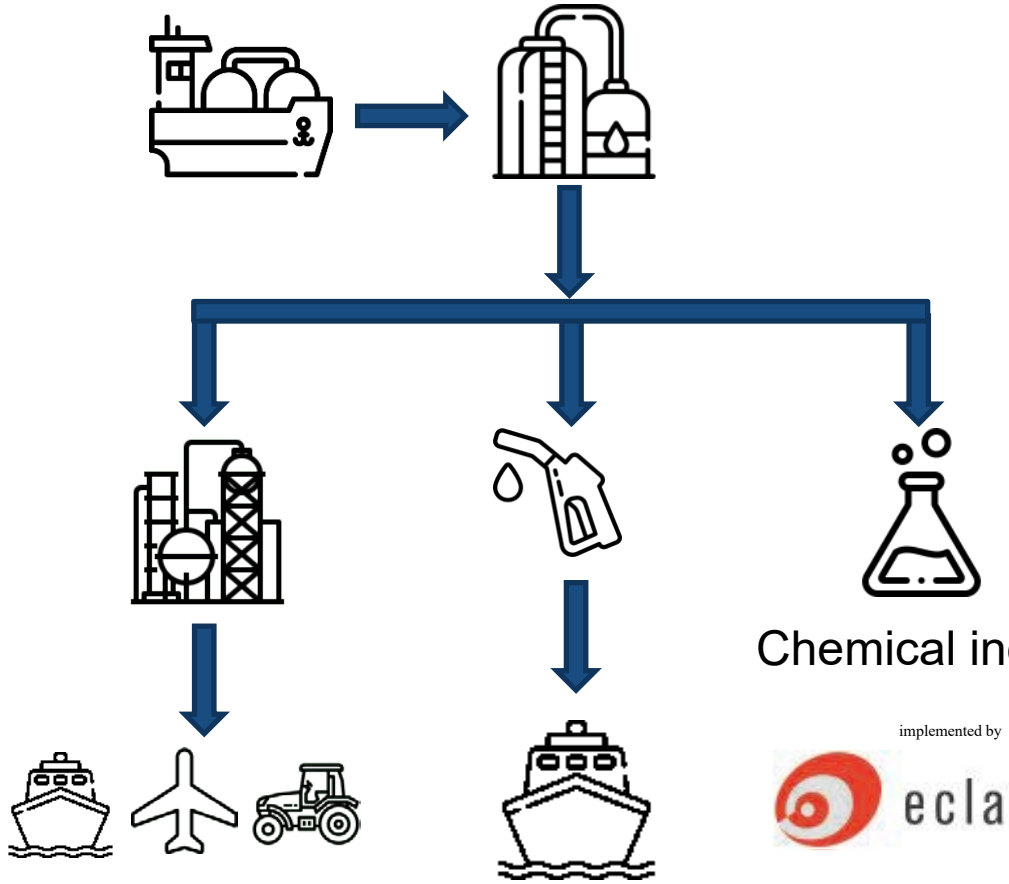


however, onward distribution only appears to make sense via the H_2 grid.

Exception: "Green" ammonia as a substitute for fossil-based ammonia in the chemical industry is transported directly from the port to the industrial sites, e.g. by tank wagon



"Green" methanol is also an import option, but should either be used directly or processed further. As an intermediate product, it can be stored in large quantities in tank facilities.



Chemical industry

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Hydrogen infrastructures – Pipelines and Storage

2032

In Germany H_2 power plants are important anchor customers for the H_2 core grid.

Large H_2 storage volumes can only be developed in Northern Germany due to the geographical conditions. The H_2 core grid is initially designed for a North-South transport direction and uses storage options along the route (the southernmost storage facility is located in Lampertheim (Hesse)).

In addition smaller storage units are used in local H_2 hubs, precisely in order to be able to use available electricity for H_2 production at low cost and at the same time to be able to serve the purchase profiles of H_2 customers at any time.

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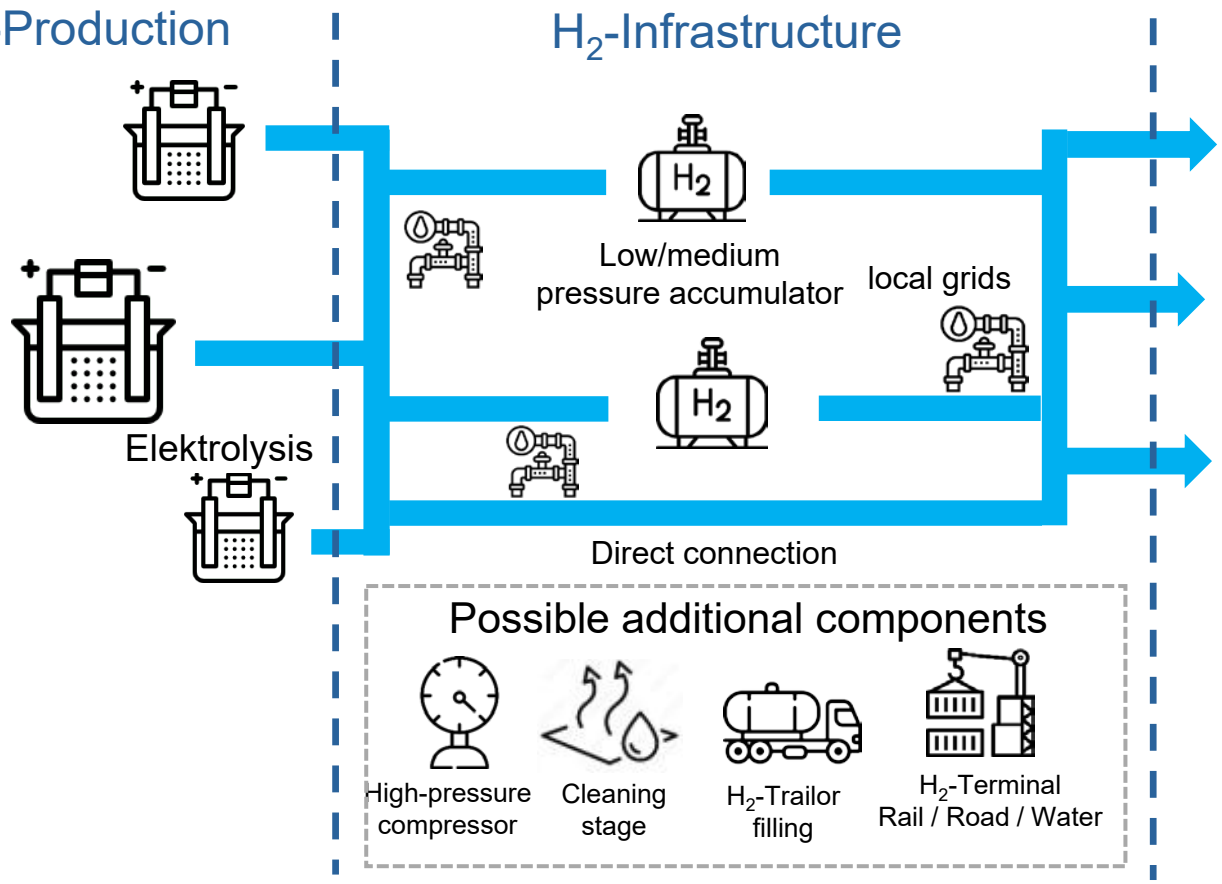
How can local H_2 hubs contribute to systems stability?



H_2 off-take Industry for process heat

H_2 off-take Industry as raw material (e.g. for chemical processes)

H_2 off-take mobility sector (trucks, busses, municipal vehicles)

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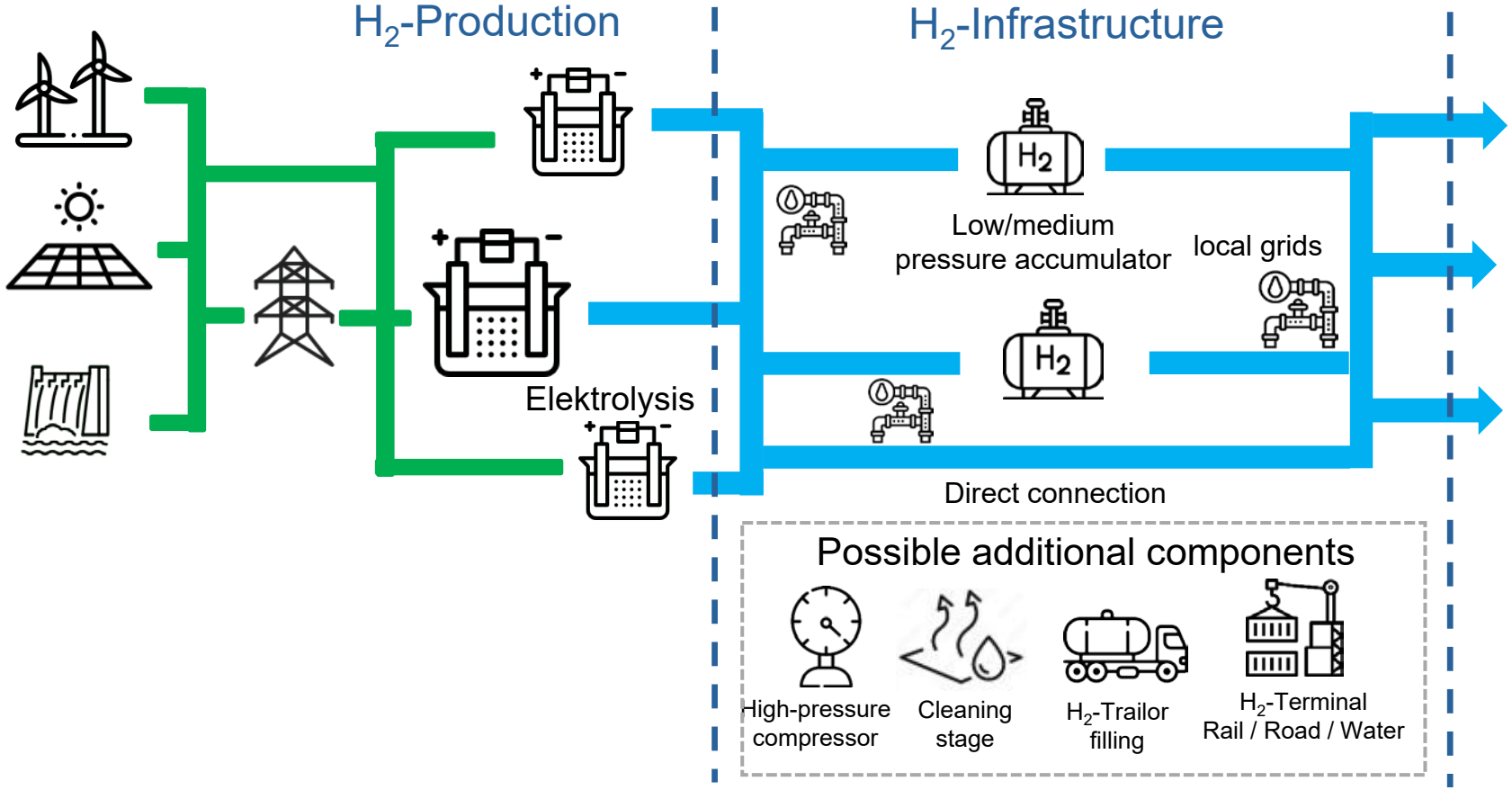
How can local H_2 hubs contribute to systems stability?

Green Electricity



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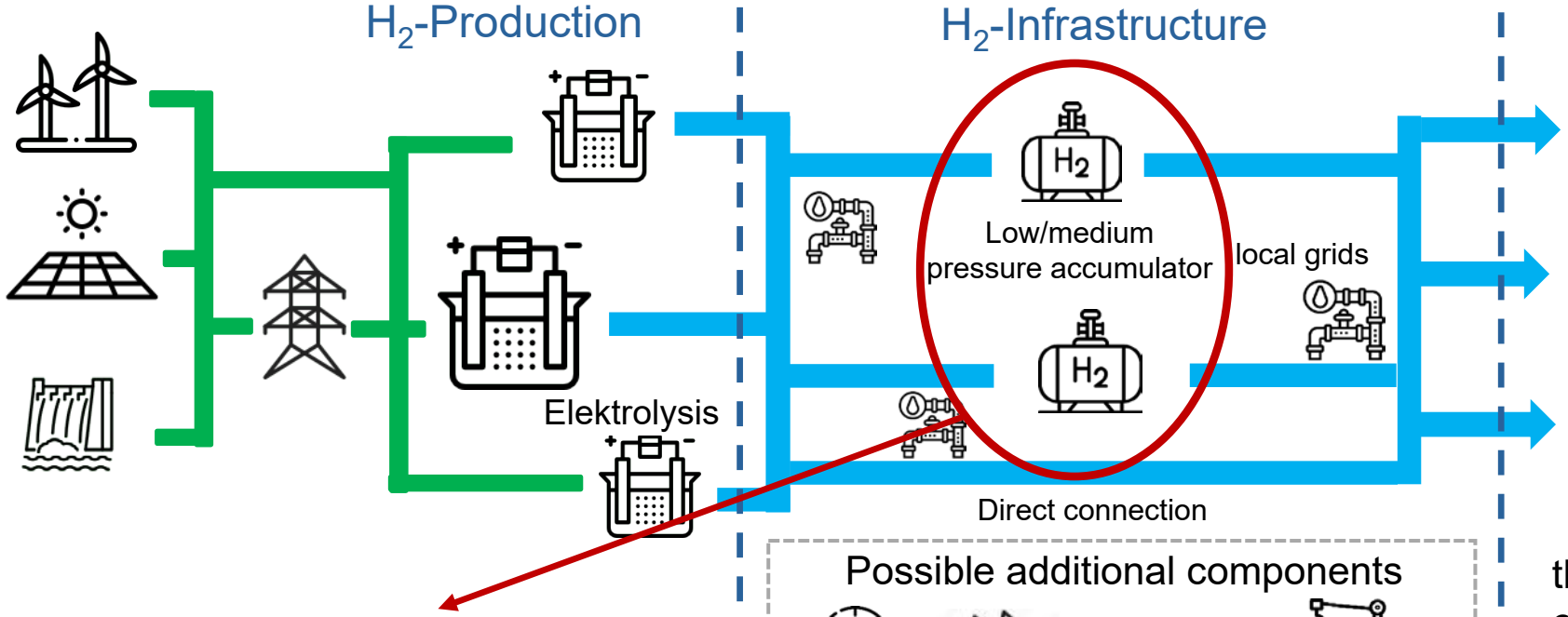

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Storage facilities in the context of H_2 hubs do not store H_2 quantities on an energy-economically relevant scale, as cavern storage facilities do, but enable the demand-oriented supply of H_2 customers while at the same time using times with low electricity prices for the most cost-effective hydrogen production possible.

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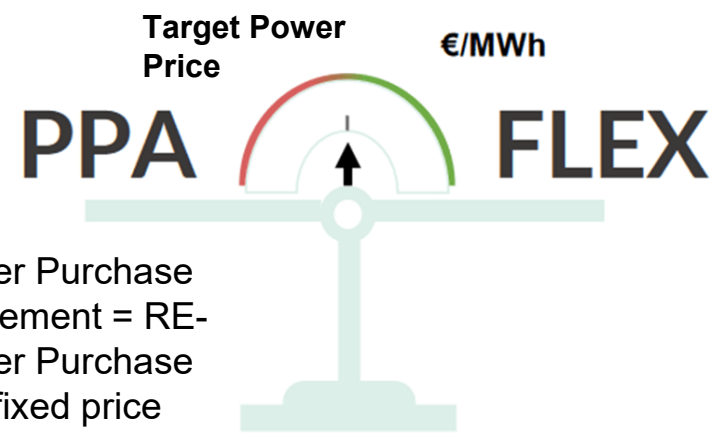
How can electrolyzers be operated economically today (one example from Germany)?

- The electrolysis operator purchases its renewable electricity via a PPA at a fixed price.
- When electricity prices are low, he always produces hydrogen.
- Above a certain electricity price threshold, he does not produce hydrogen but sells his electricity on the power exchange.



Power Purchase Agreement = RE-Power Purchase at a fixed price

Flex = Income from the sale of PPA electricity on the exchange at high electricity prices

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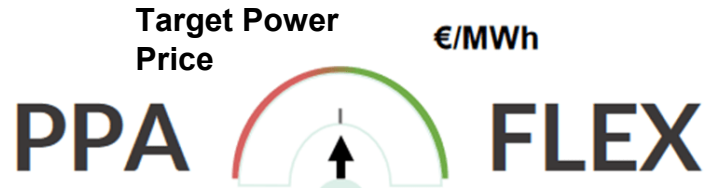

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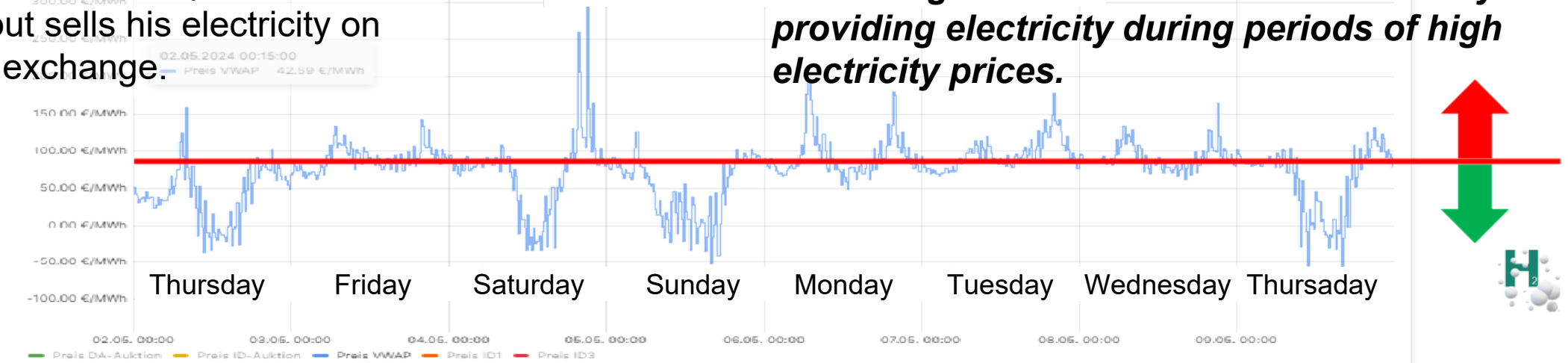
This behavior can be beneficial to the system or even the grid if bottlenecks are avoided by providing electricity during periods of high electricity prices.



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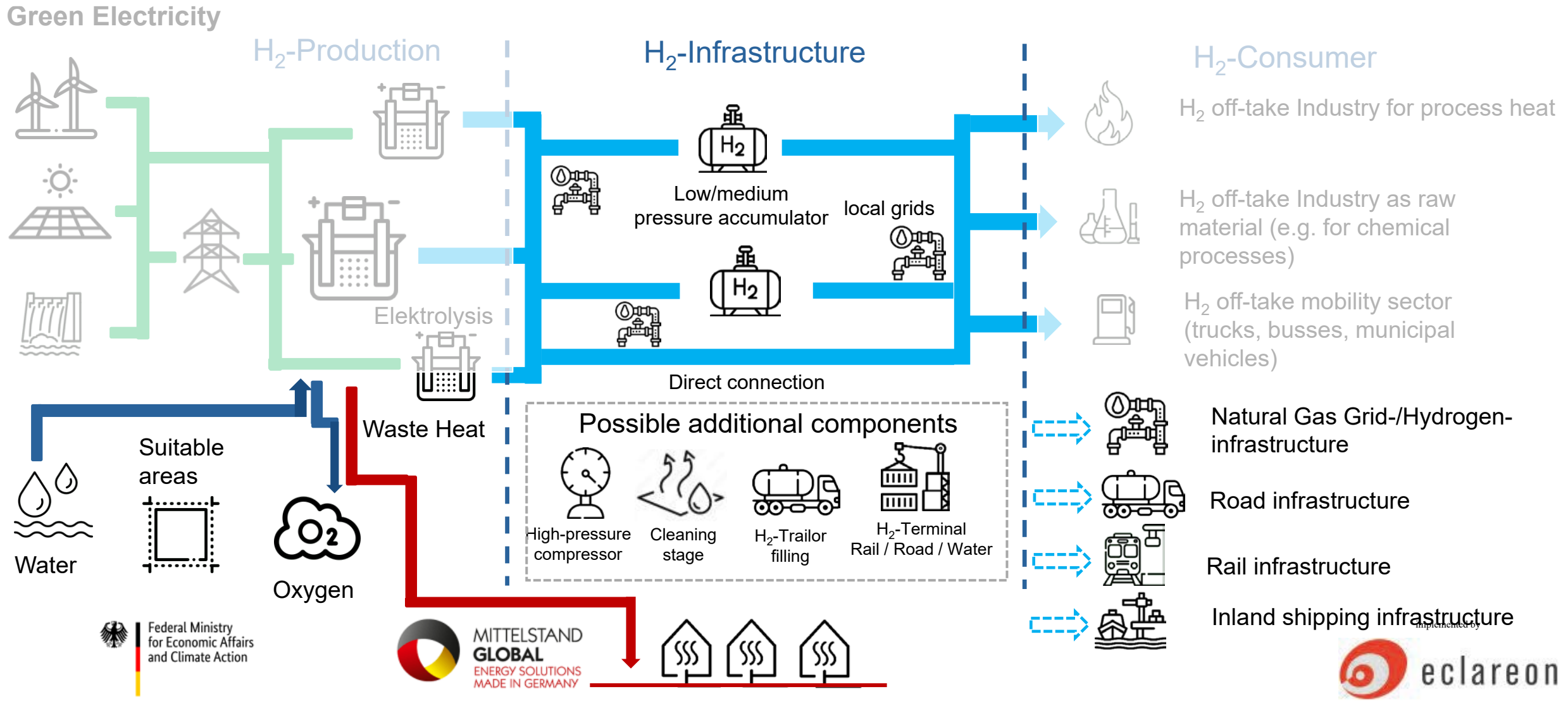
What other location factors influence an H_2 hub?



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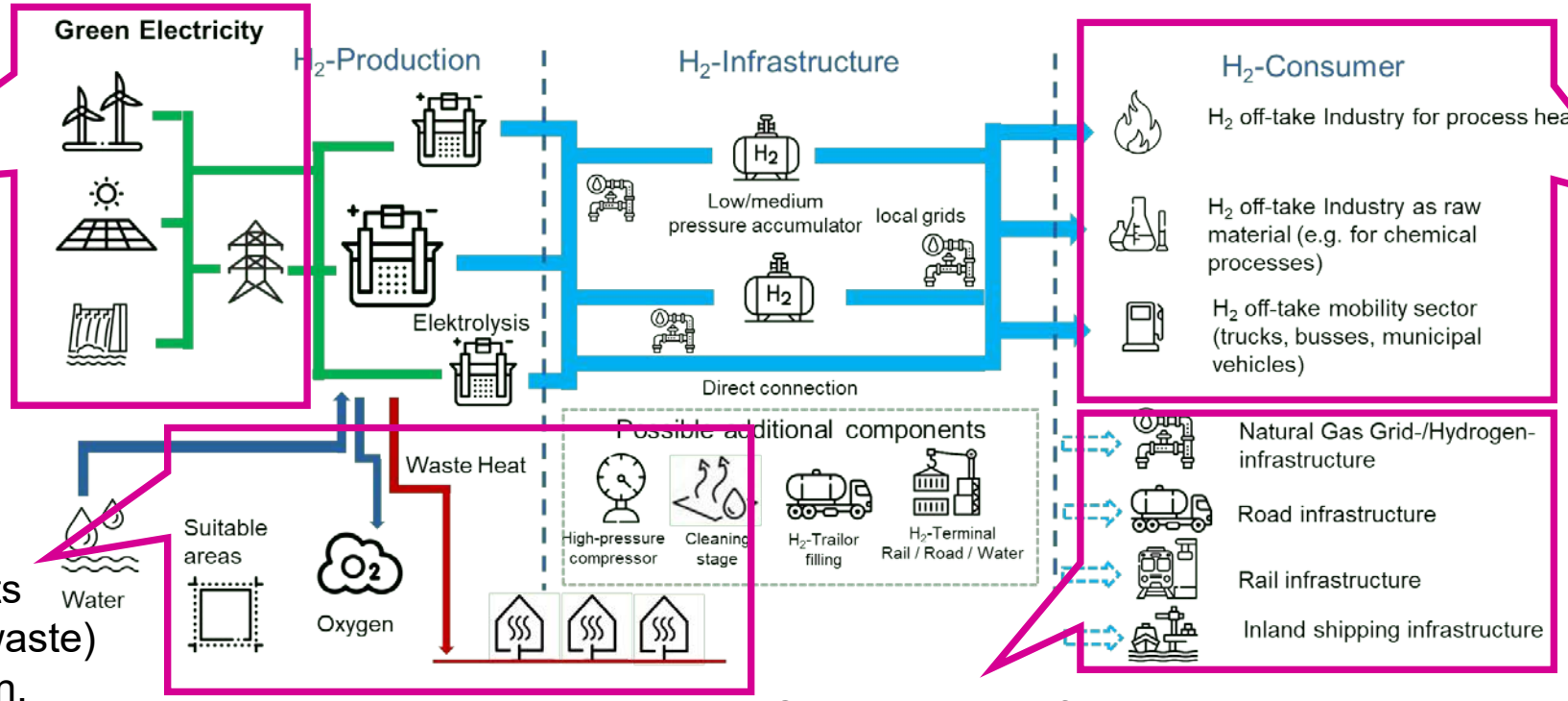
System usefulness of electrolysis at different levels

Local H_2 hubs meet the requirements to support “the optimal design and operation of the entire energy system in terms of costs, resources and emissions”.

Utilization of local/regional potential, without purchase from the transmission grid. Potential use of surpluses from photovoltaics at the lower grid levels.



Local off-take of H_2, no need for large transportation infrastructures.

Potential additional benefits through the provision of (waste) heat and the use of oxygen.

Consideration of existing and emerging infrastructures to avoid stranded assets.

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