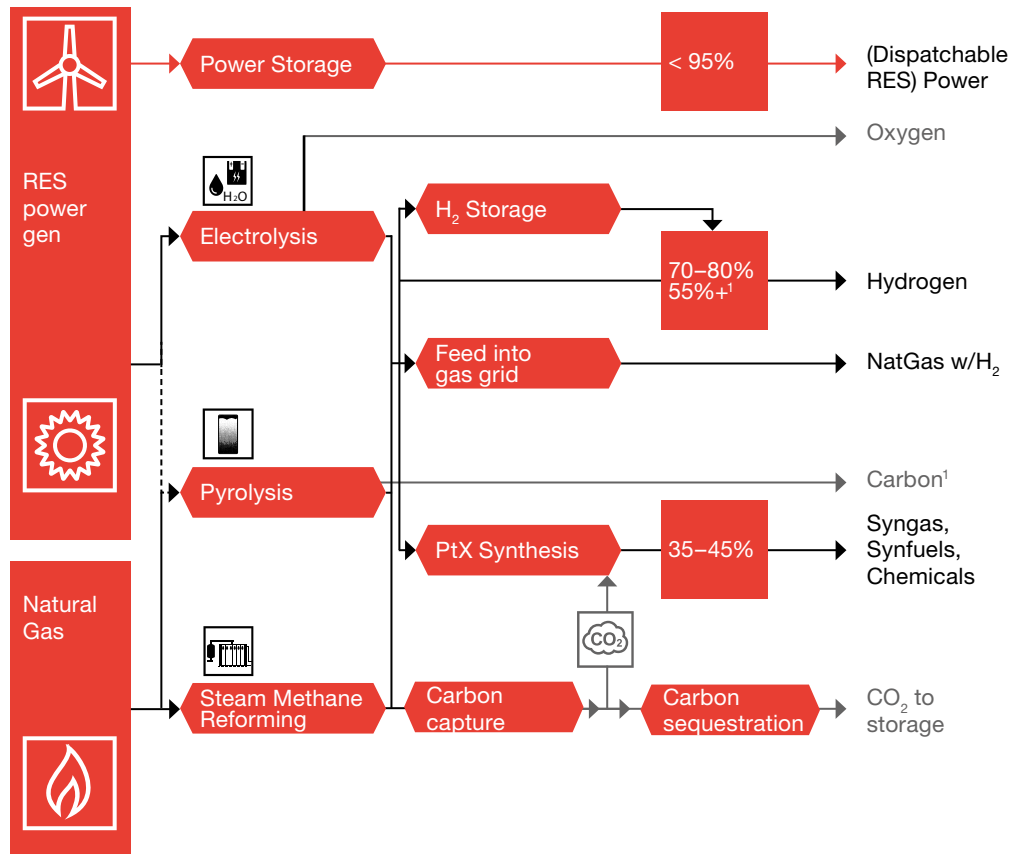


# Development of the Structure of the European Hydrogen Market and Implications for Energy Traders



# 1 Background & Motivation

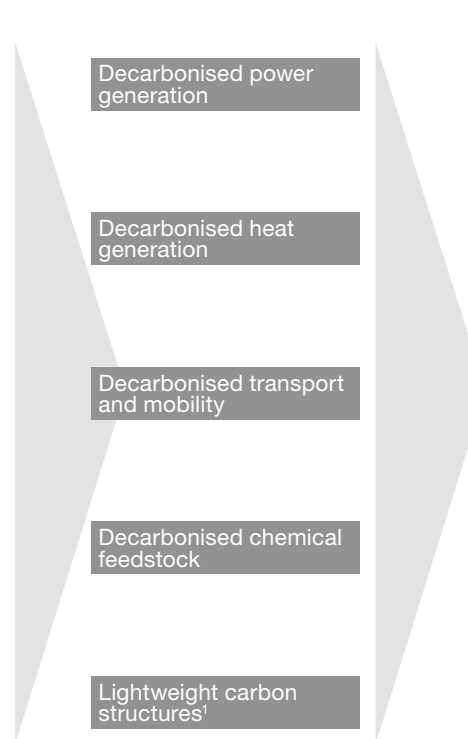
# The evolving hydrogen market offers “cross-commodity” trading opportunities for energy traders



Biological generation of green H2 not considered, Ammonia pathway not shown here but still relevant for fertiliser/chem. Feedstock

- Direct electrification
- Byproducts
- H<sub>2</sub>/PtX related

<sup>1</sup> for/with pyrolysis



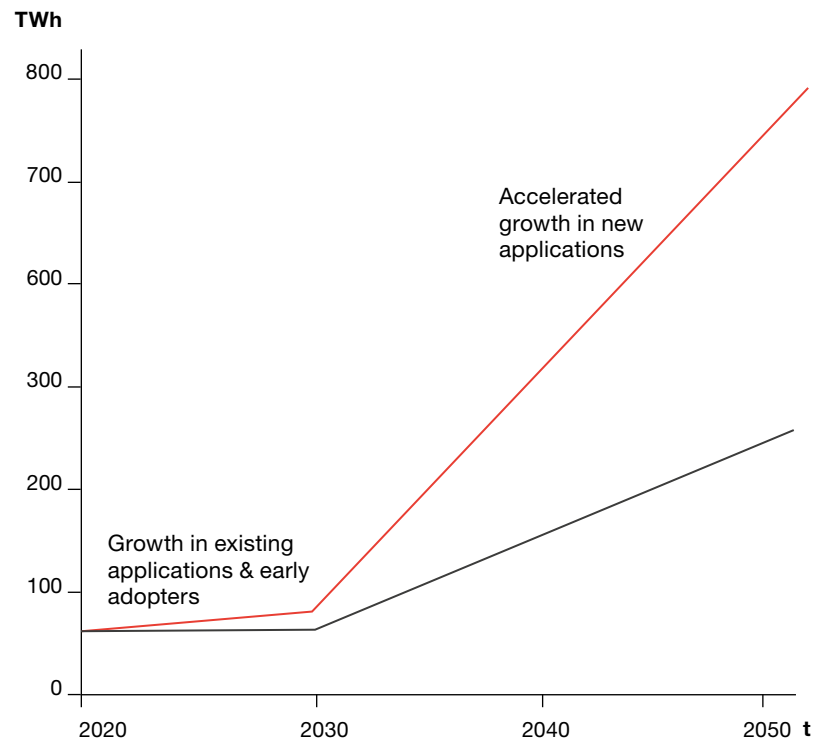
## Key considerations for trading companies

- The hydrogen value chain is based on transformation and processing of tradable commodities.
- This creates “cross-commodity” trading opportunities for energy traders:
  - Marginal costs of green hydrogen driven by power and carbon prices
  - Marginal costs of blue hydrogen driven by green power prices
  - Heat created by hydrogen production can be fed into the district heating market
  - Hard coal generated as a by-product of pyrolysis
- Electrolysers can be managed against market price movement, just like other physical assets employed by energy traders (“asset-backed trading”).
- Due to the geographic topology of future supply and demand centres, transportation will become a key issue in the hydrogen market.

Trading companies have the required capabilities to play an important role in the emerging “hydrogen market” business models.

# Demand for hydrogen in Germany and Europe is expected to grow significantly to 2050 ...

## Potential Growth Paths for Hydrogen in Germany<sup>2</sup>



### High Demand Scenario (100%)

- Hydrogen will even be used to provide energy in “low-heat” industrial processes that could also be supplied by other fuels.
- Hydrogen will play a major role in the transportation sector, including cars, trucks, barges, ships and also aircraft (wide adoption of power-to-X technologies).
- Hydrogen will also be used in the district heating market.

### Low Demand Scenario (95%)

- Hydrogen will only be used in processes which are difficult to electrify, such as “high-heat” production processes in the chemical and steel industries.
- Usage in the transport sector will be restricted to heavy transport; only limited adoption in other parts of the sector.
- Limited usage in the heating market due to energetic inefficiencies compared to heat pumps.

Government policy will determine which scenario will materialize. Key policy measures to monitor include:

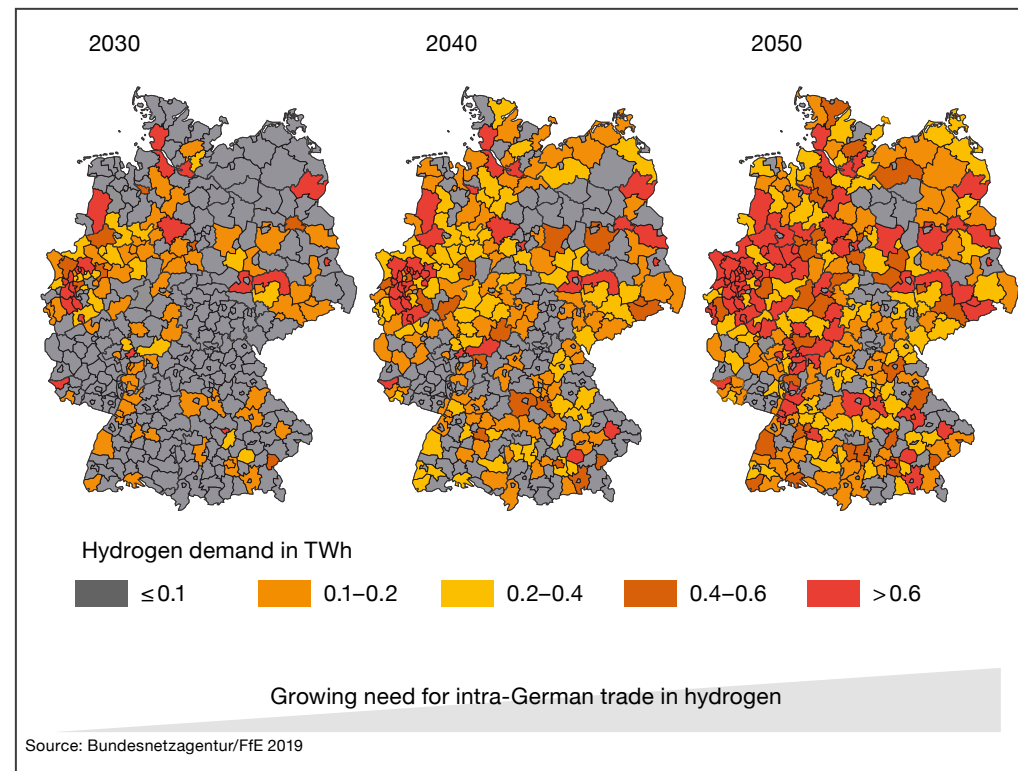
- Government support for different types of hydrogen applications (e.g. heating sector)
- Carbon price targets and emissions reduction paths for different sectors

The key determinant of supply growth for hydrogen are government policy objectives regarding the carbon intensity of the energy sector. Moving from a reduction target of 95% to a reduction target of 100% implies a substantial increase in hydrogen demand.

<sup>2</sup> BMWi (2020), Fraunhofer (2019)

# ... with growth in demand clustering in specific regions and specific industries ...

Growth of hydrogen demand will be clustered in specific regions ...



Note: Demand from heating sector excluded

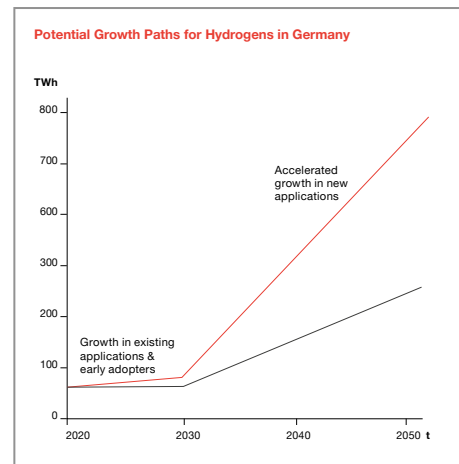
... and will also be clustered in specific industries

- **Initial phase (until approximately 2030)** – limited growth of hydrogen demand, concentrated in the following sectors:
  - Demand for green hydrogen will grow in order to substitute for “grey” hydrogen which is currently used in refineries etc.
  - “Early-adopters” in the transport and industrial sectors, “proof-of-concept” projects and subsequent scaling up of such projects will also contribute to the growth of demand for hydrogen.
- **Growth phase (after 2030)** – Strong growth in hydrogen demand will be driven by widespread adoption of hydrogen as an energy source in the following sectors:
  - Production of heat for industrial production processes (e.g. chemical industry and steel production)
  - Fuel for use in heavy-duty transport (e.g. long-haul trucking)
  - Shipping fuel
- The relevance of hydrogen for the German heating market is currently unclear.

The scaling up of the hydrogen market in Germany will require an appropriate transportation system in order to connect the various industrial and regional clusters of hydrogen demand to potential sources of supply.

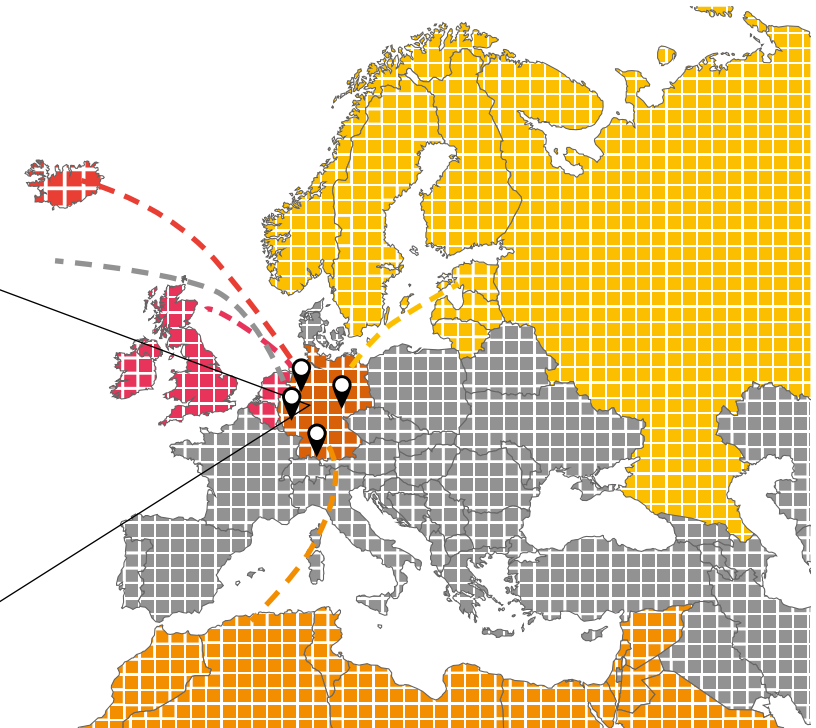
# ... but the potential to produce hydrogen in Germany and NWE is negligibly leading to a significant shortfall in local supply

- Germany may be able to generate sufficient own supply to meet its own demand until 2030 if the objectives of the “Nationale Wasserstoffstrategie” (110 TWh of own green hydrogen supply) are achieved.
- Afterwards, further growth potential for hydrogen production in Germany and most other European countries is fairly limited due to limited availability of land with suitable wind speed/solar radiation.
- Most competitive hydrogen supplies (excl. transport costs) will originate from countries with sufficient space for wind farms/solar farms and with favourable climatic conditions for renewable power production:
  - North Africa (e.g. Morocco)
  - Med Area (e.g. Spain, Italy)
  - US
  - Russia
  - Middle East
  - Iceland
  - Australia



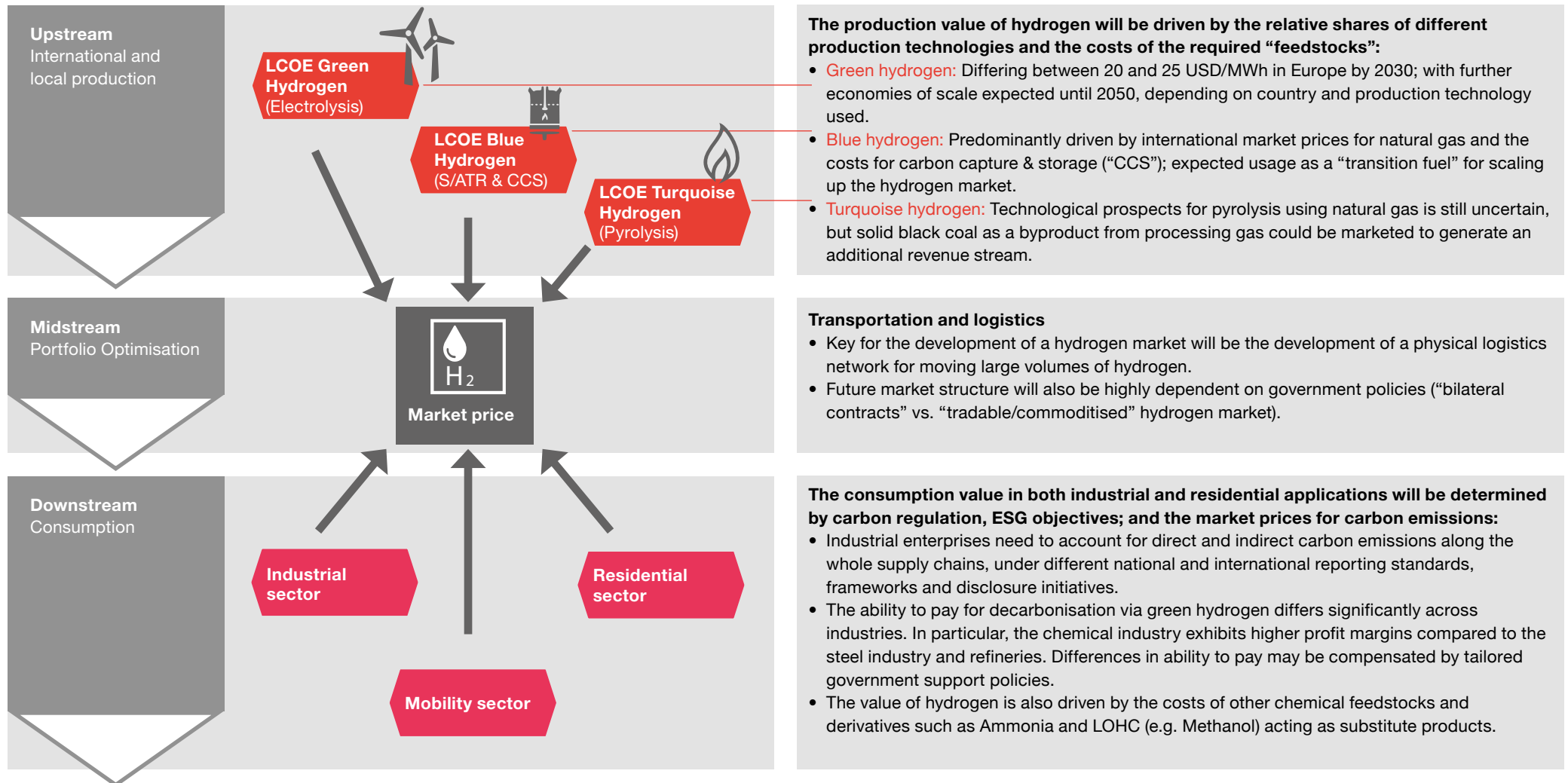
## Major sourcing destinations

■ Baltic ■ North sea/ NW Europe ■ Iceland ■ Rest of the world ■ MENA region



Transportation of hydrogen will become a major success factor for the future development of the hydrogen market.

# Fundamental value of hydrogen is driven by interactions between power, gas and carbon markets



# Appropriate government support will be the key facilitator for the development of the European hydrogen market

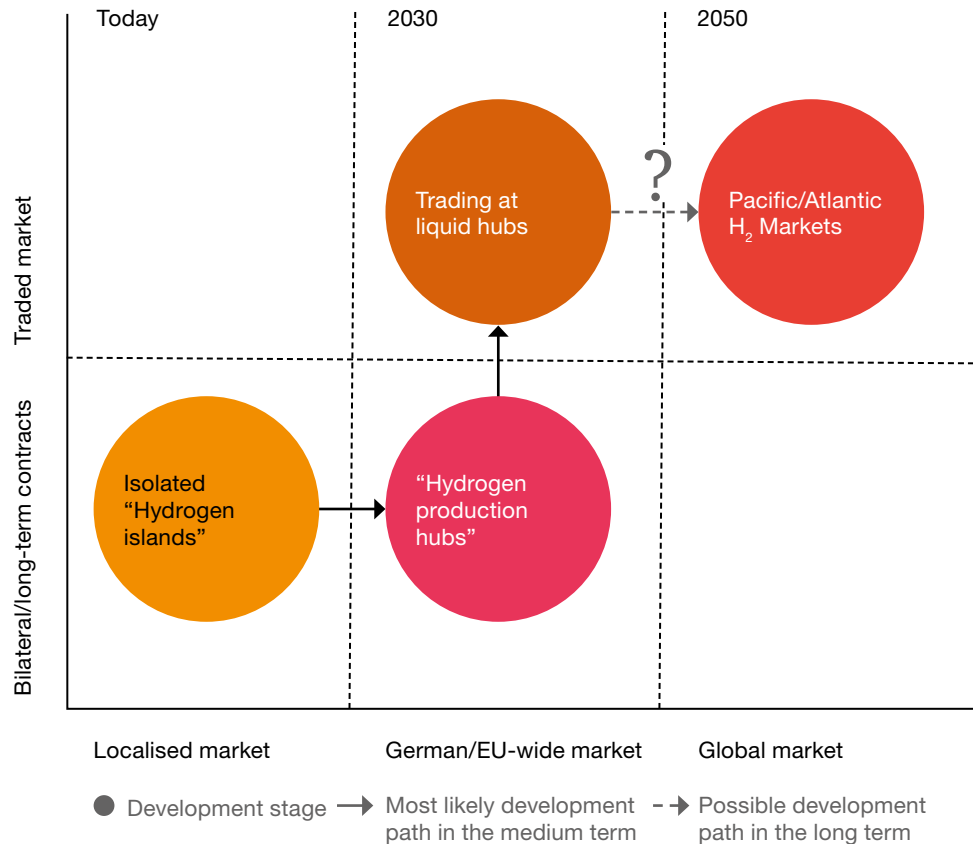
The EU and the German government have recognised the importance of hydrogen for the success of the “Energiewende” and for achieving the objective of being the first continent with zero emissions. For this purpose, the European Commission and the German government has prepared a “Green Deal” and the “National Wasserstoffstrategie”, respectively:

Hydrogen Supply	Hydrogen Usage/Demand	Hydrogen Transportation
<p><b>Key Government objectives in Germany:</b></p> <ul style="list-style-type: none"><li>• Focus on support of green hydrogen; blue hydrogen regarded more as a “bridge technology”.</li><li>• Limited support for carbon capture &amp; storage (required for pyrolysis)</li><li>• Development of “Energiepartnerschaften” with potential exporting countries of hydrogen (e.g. Morocco)</li></ul> <p><b>Policy instruments considered</b></p> <ul style="list-style-type: none"><li>• Carbon price as the key steering mechanism</li><li>• Build-out of offshore wind power</li><li>• Adjustments of the “EEG” to benefit hydrogen producers</li><li>• Funding of R&amp;D (e.g. scaling-up of the unit sizes for electrolysis and pyrolysis)</li></ul>	<p><b>Key Government objectives in Germany:</b></p> <ul style="list-style-type: none"><li>• Initial focus on the adoption of hydrogen in the steel and chemical industry</li><li>• Further focus on the transport sector, including PtX-technologies</li><li>• District heating market is regarded rather cautiously</li></ul> <p><b>Policy instruments considered</b></p> <ul style="list-style-type: none"><li>• Carbon price as the key steering mechanism</li><li>• Funding of R&amp;D (e.g. fuel cells)</li><li>• Establishment of EU-wide standards (e.g. tank design, hydrogen quality)</li><li>• Government support/subsidies for hydrogen investments (e.g. hydrogen-powered vehicles)</li><li>• Subsidies for operating costs (e.g. via contract-for-difference contracts in the chemical/steel industry)</li><li>• Definition of feed-in quotas (heating sector, transportation fuels)</li></ul>	<p><b>Government objectives:</b></p> <ul style="list-style-type: none"><li>• Support of grid development, transportation technologies and filling stations</li></ul> <p><b>Policy instruments considered</b></p> <ul style="list-style-type: none"><li>• Establishment of quotas and quality standards for hydrogen and certification of the origin of hydrogen</li><li>• Integration of long-term planning procedures and rules for power, gas and hydrogen networks (e.g. planning around congestion points)</li><li>• Investment support for build up of tank infrastructure</li></ul>

A synchronised development of infrastructure for hydrogen supply, hydrogen demand and hydrogen transportation/storage will be required. This needs to be coordinated at an international level.

## 2 Expected Development of the European Hydrogen Market and its key drivers

# The European hydrogen market may evolve into a „traded market“ with multiple liquid trading hubs over time



## Development of isolated "hydrogen islands" during initial ramp-up period

- Hydrogen will initially be supplied locally within joint development ventures and industrial parks in which players from different sectors will combine their hydrogen-related business activities.
- "Hydrogen islands" will be sufficient to meet German demand of up to 110 TWh p.a. if production capacity is built up in line with "Nationale Wasserstoffstrategie" (target of 5 GW capacity by 2030).

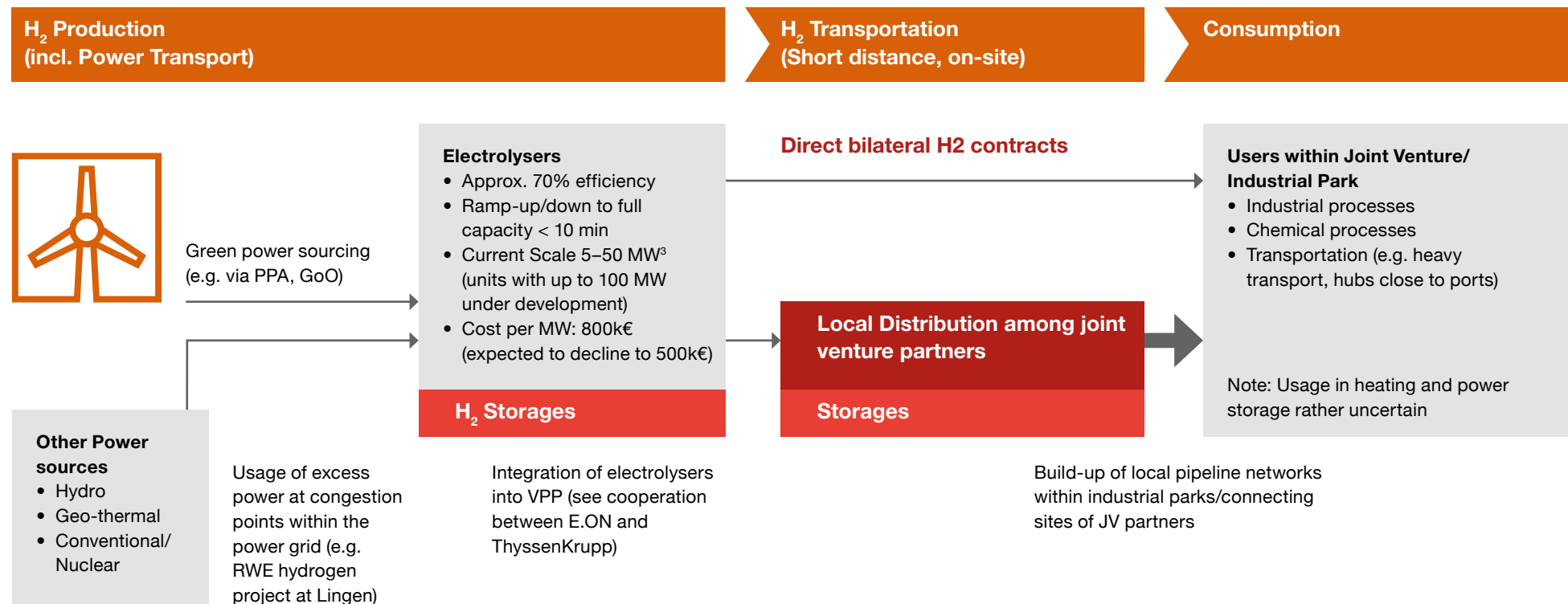
## Medium-term development of "hydrogen production hubs" and transition to regional hydrogen markets, facilitating stronger growth in volumes

- The "hydrogen islands" will converge towards an integrated German/EU-wide transportation network in several steps (see scenarios in "European Hydrogen Backbone", 2020):
  - Development of hydrogen "production hubs" within Germany/EU and alignment with international suppliers (e.g. Iceland, Morocco)
  - Development of local transportation networks around "hydrogen production hubs" and entry points (e.g. terminals/pipelines) for hydrogen imports
  - Subsequent connection of localised "sub-networks" into a Europe-wide network
- A liquid market for hydrogen may develop, based on a physical logistics network for moving high volumes of hydrogen. The scope of this market will depend on the structure of the transportation network and the regulatory framework.

## Long-term – Potential for the development of a global hydrogen market depends on economics of hydrogen shipping

- Significant differences in production costs will offer opportunities for international trade of hydrogen.
- But the economics of transportation may inhibit the development of a global market for hydrogen comparable to the international LNG market.

# Initially, there will develop „isolated hydrogen islands“ and there will be no trading/interregional transport of hydrogen ...



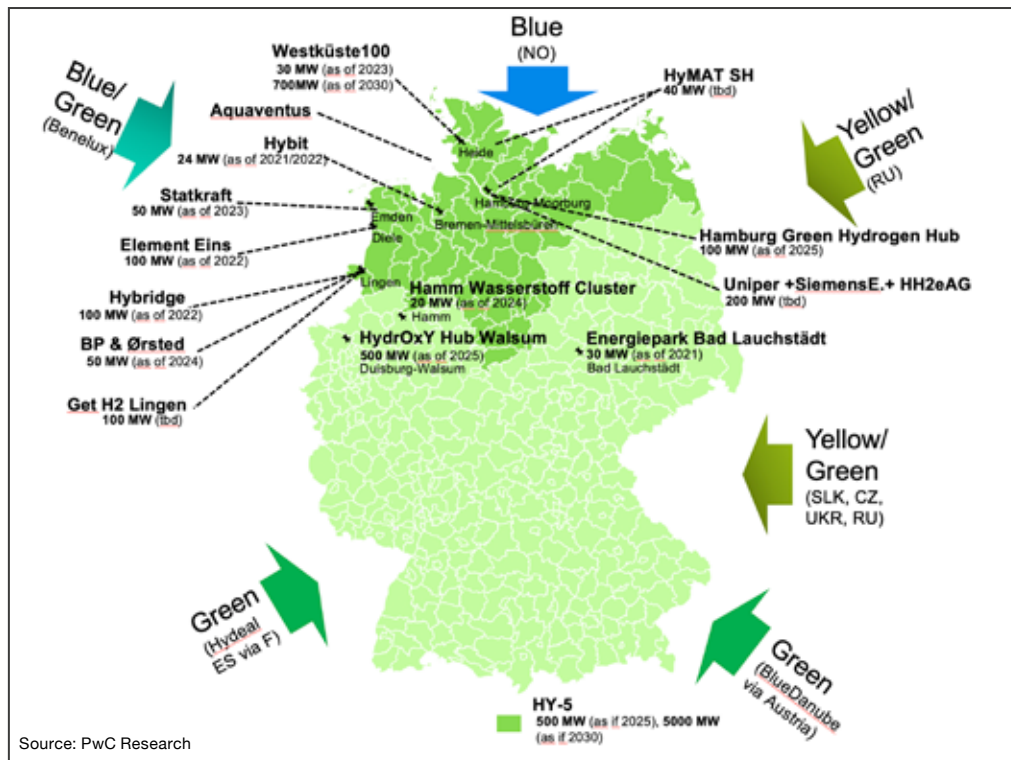
Note: Different colours of hydrogen not

Synchronised scaling up of production & consumption in local areas facilitates the realisation of economies of scale. Scope of trading activities is initially limited to power supply to hydrogen production and integration of electrolysers into virtual power plants.

<sup>3</sup> BMVI (2018)

# ... with a significant share of recently started projects for the production of green hydrogen located in North-West Germany

Origin of hydrogen supplies available in the German market (Overview of current projects, as of March 2021)



Drivers of the development path of the amount and location of hydrogen supply

Choice of location for electrolyzers, which is driving the geographical distribution of hydrogen production within Germany, is determined by several factors ...

- ... expansion path and locations of new renewable power assets (onshore/offshore wind, PV)
- ... expansion of the power transmission network (transport of “molecules” vs. “transport of electrons”), in particular North-South connections
- ... exploiting congestion points in the transmission network (e.g. Lingen)
- ... regulatory treatment and subsidies regarding power usage for hydrogen production (e.g. “EEG-Umlage”)
- ... opportunities for co-locating electrolyzers with other industrial assets to exploit residual heat from the electrolysis process

Hydrogen supply from international partners will enter the German market from different directions:

- **North-West Germany:** Green and blue hydrogen from Benelux countries, blue hydrogen from Norway; hydrogen imports via Rotterdam harbor having already signed partnerships with different countries (e.g. Portugal and Iceland)
- **Southern Germany:** Availability of regional supply crucially dependent on “Hydeal” and “Blue Danube” projects, aiming to establish a connections to hydrogen supplies from Spain (pipeline via France) and from Eastern Europe (barges).
- **Eastern Germany:** Availability of regional supply dependent on plans in Eastern Europe (Green vs. yellow hydrogen).

While North-West Germany may have excess supply of hydrogen, a balance between supply and demand is not assured in Southern Germany.

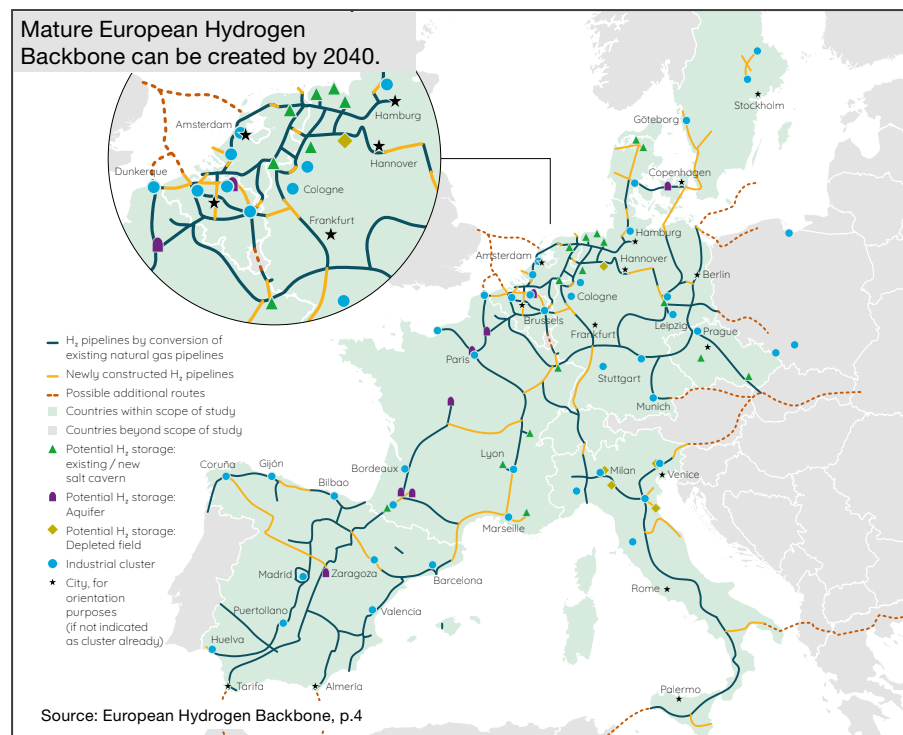
# Subsequently, “production hubs” for hydrogen will emerge and intra-EU hydrogen flows will be shaped by the economics of hydrogen transportation

At the beginning, hydrogen “production hubs” will develop which need to be complemented by regional grid development before ...



- The geographic configuration of the supply side of the hydrogen market depends on various factors:
  - Co-location of electrolyser capacity and renewable energy assets, leading to clustering of supply in NWE.
  - Location of key import points depends on development of “energy partnerships” with international suppliers such as Iceland and Morocco (favoring ARA area).
  - Further build-up of hydrogen “production hubs” at locations which are close to potential offtakers and which also offer cheap access to power supplies (e.g. congestion points within the power grid).
- Build-up of the supply side needs to be complemented by regional hydrogen grid development (e.g. project by Gasunie in NWE)
  - The existing natural gas pipeline system and storage system may only partially be used for transporting hydrogen.
  - The decision whether dedicated hydrogen pipelines will be built or quotas for mixing hydrogen into the existing natural gas transportation networks will be prescribed by regulators also depends on use cases on the demand side.

... a pan-European market can develop sequentially based on a continuously expanding “European Hydrogen Backbone” until 2040



- The energy density of hydrogen is appr. 1/10 of the energy density of natural gas, substantially pushing up transportation costs.
- The European TSO's plan for building a “hydrogen backbone” by 2040 consisting of 23,000km of rededicated natural gas as well as new pipelines implies an estimated transport cost of €2.10–6.90 per MWh per 1,000km.<sup>4</sup>

Government/EU funding for transport infrastructure required in order to create a European hydrogen market.

<sup>4</sup> European Hydrogen Backbone (2020)  
[https://guidehouse.com/-/media/www/site/downloads/energy/2020/gh\\_european-hydrogen-backbone\\_report.pdf](https://guidehouse.com/-/media/www/site/downloads/energy/2020/gh_european-hydrogen-backbone_report.pdf)

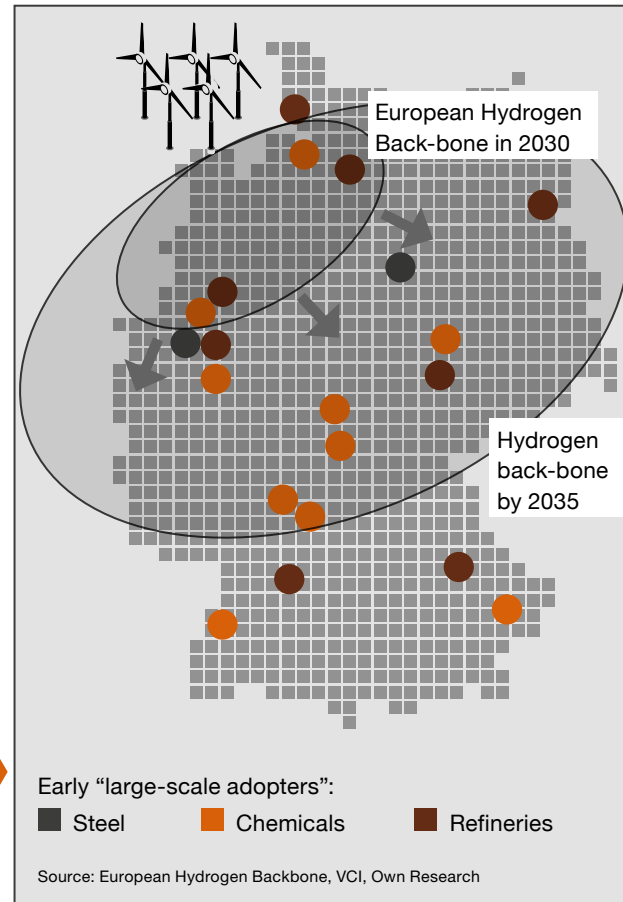
# The Supply/Demand Balance within the German Hydrogen Market will depend on the location of production & import hubs and local consumption networks

## Initial Growth of Hydrogen Demand by Early Adopters

- Early adopters such as heavy-transport, chemical companies and refineries will be the initial drivers of market growth.
- “Co-location” of hydrogen production next to industrial areas with a demand for by-products (e.g. oxygen, heat) will lead growth in hydrogen demand in specific geographic clusters (capture “Verbundeffekte”).
- Broad-based application in heat and other markets will follow at a later stage of market development.

## Growth of hydrogen supply and hydrogen transportation networks

- Key sources of hydrogen supply will be clustering in North-West Germany:
  - German hydrogen supply generated by renewable power assets in the North Sea
  - Connection to Dutch hydrogen market via pipelines (see Gasunie project) and to hydrogen supply from ARA via barges
  - Import terminals for liquid hydrogen/ammonia
- Role of other regions regarding production of green hydrogen will be closely tied to the development of the power transportation grid until a hydrogen logistics network covers all German areas.

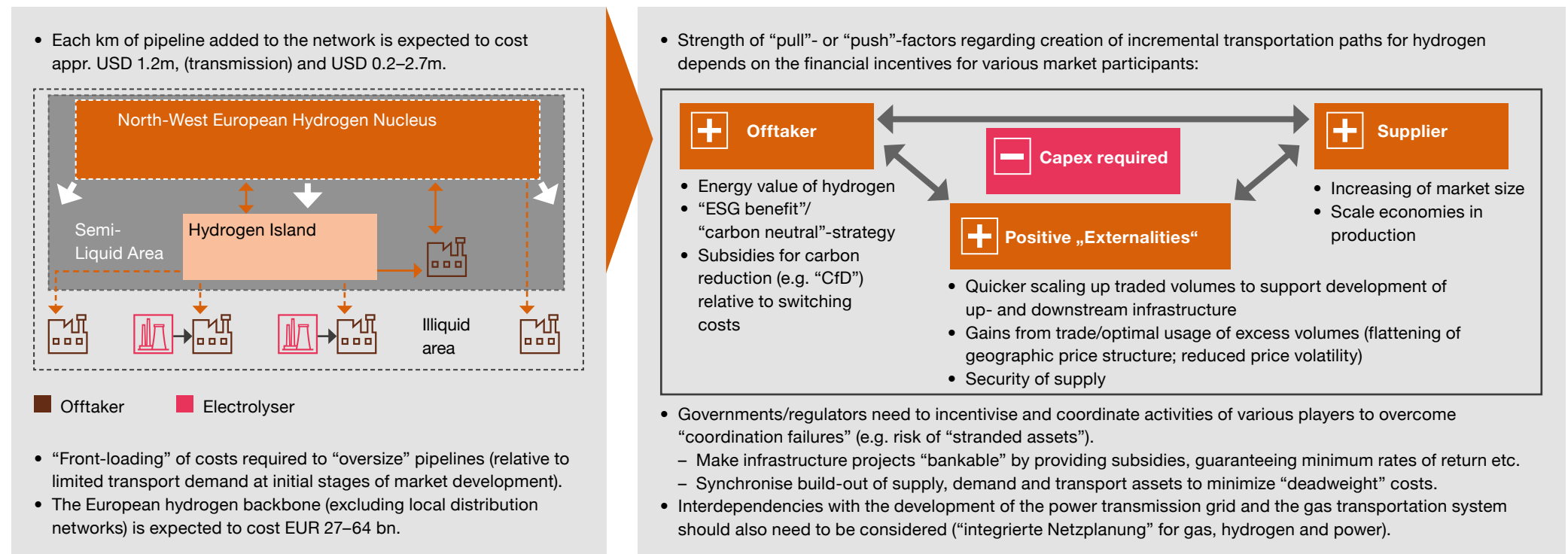


- Completion of a hydrogen transportation network covering all German demand centers not expected until 2040.
- “De-Carbonization” of industry in Southern Germany is only feasible if bottlenecks in the power transportation grid are solved or dedicated supply projects bring sufficient volumes to the South (e.g. “Hydeal”, “Blue Danube”).
- Key open issue relates to role of “blue hydrogen” as a transition fuel.

# The expansion path of the hydrogen network will be driven by financial incentives of market players and needs to be coordinated by regulators

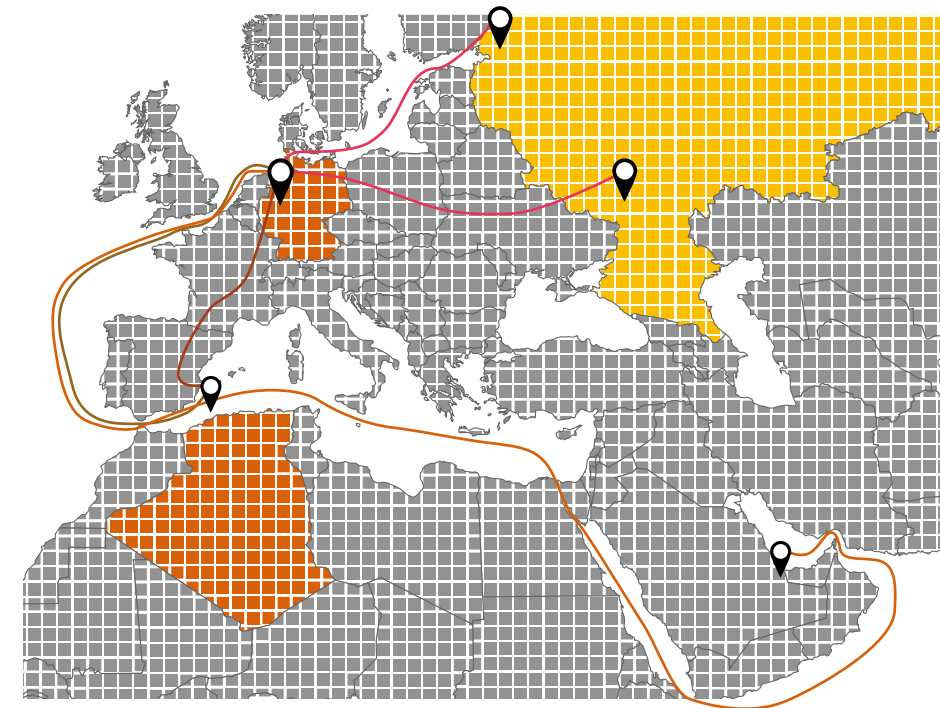
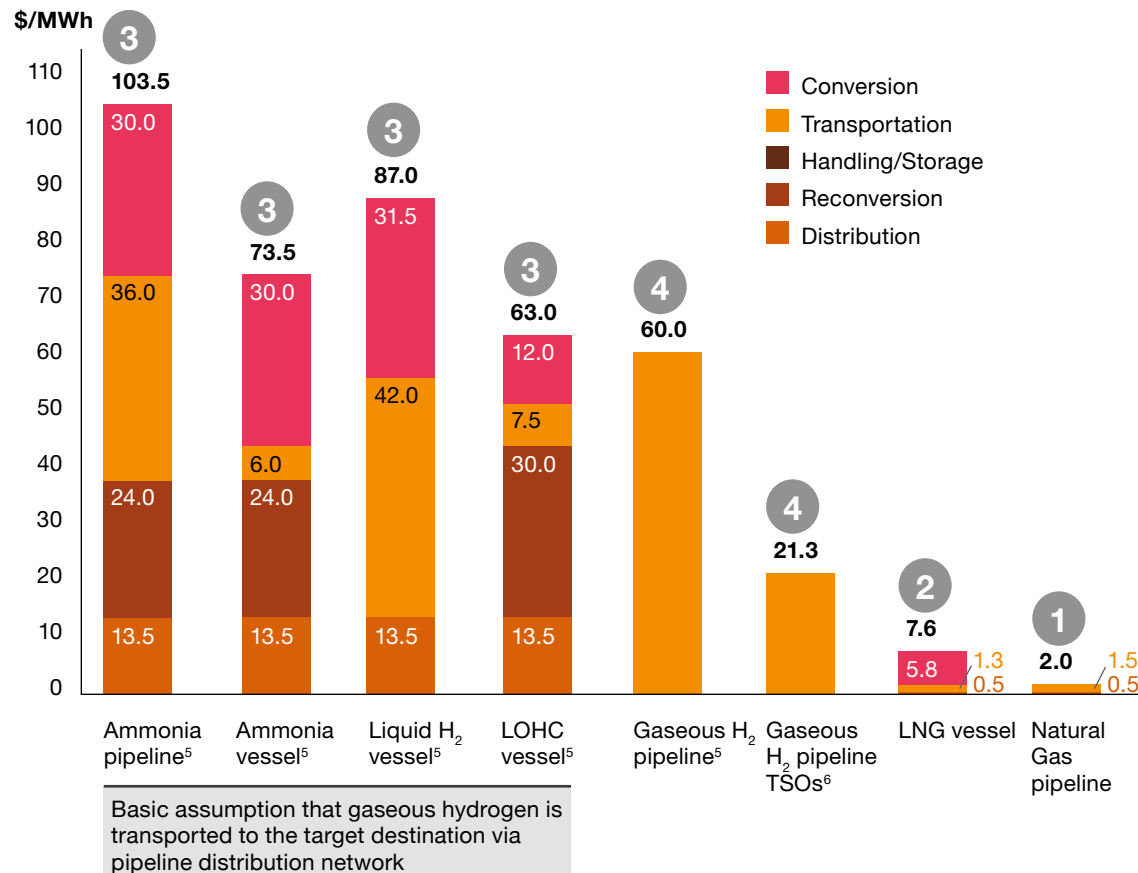
The transportation network for moving hydrogen across Germany/Europe will grow gradually over time, requiring substantial investments ...

... which need to be funded considering the economic benefits to various stakeholders involved



Governments should be expected to play a key role in facilitating/coordinating the build-out of upstream-, downstream- and transportation infrastructure.

# The major sources of international hydrogen supply will be determined by the economics of hydrogen transportation



**Comparison of gas/hydrogen import routes**

- ① Natural Gas import via pipeline from Russia
- ② LNG import via vessel from Qatar
- ③ H2/LOHC/Ammonia via vessel from Algeria
- ④ H2 via pipeline from Algeria/Spain
- Target destination North Rhine-Westphalia

Transportation costs have a substantial impact on the “all-in” costs of hydrogen supply delivered at the German border. The magnitude of this impact critically depends on (re-)conversion costs which may be smaller at locations with low opportunity costs for power usage.

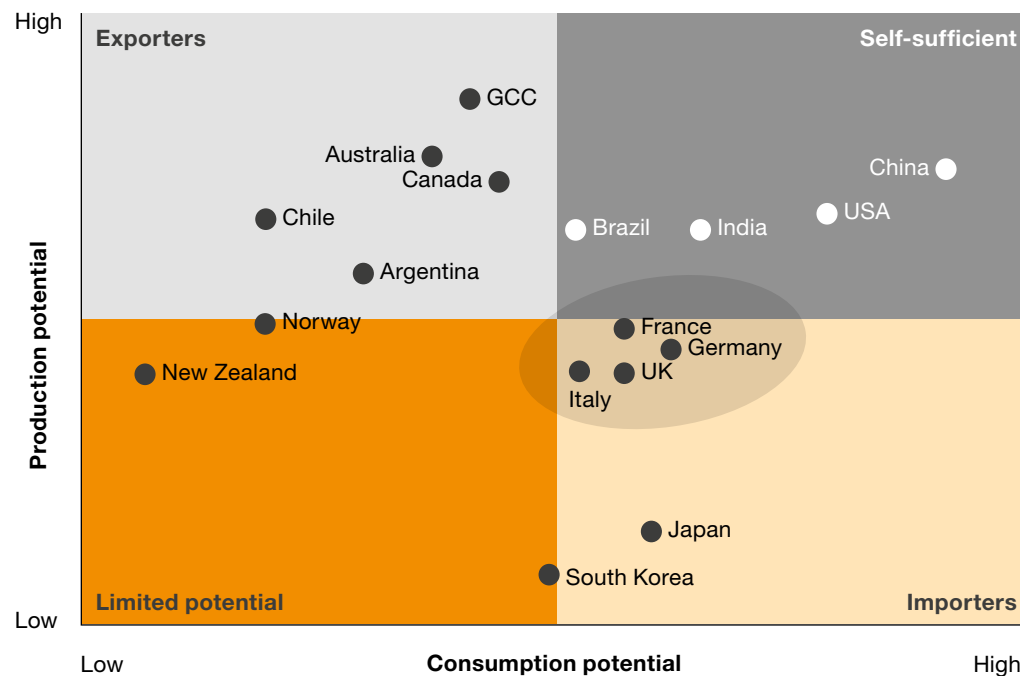
<sup>5</sup> IEA 2020, The Future of Hydrogen, p. 78–80.

<sup>6</sup> EHB (2020)

# The magnitude of global hydrogen flows will not be comparable to international LNG flows with currently available transportation technologies

Based on LCOE differentials, there should be substantial scope for international trading in hydrogen ...

... but the economics of liquifying and shipping hydrogen by ship will significantly curtail the magnitude of such trading activities



Source: Strategy& Research



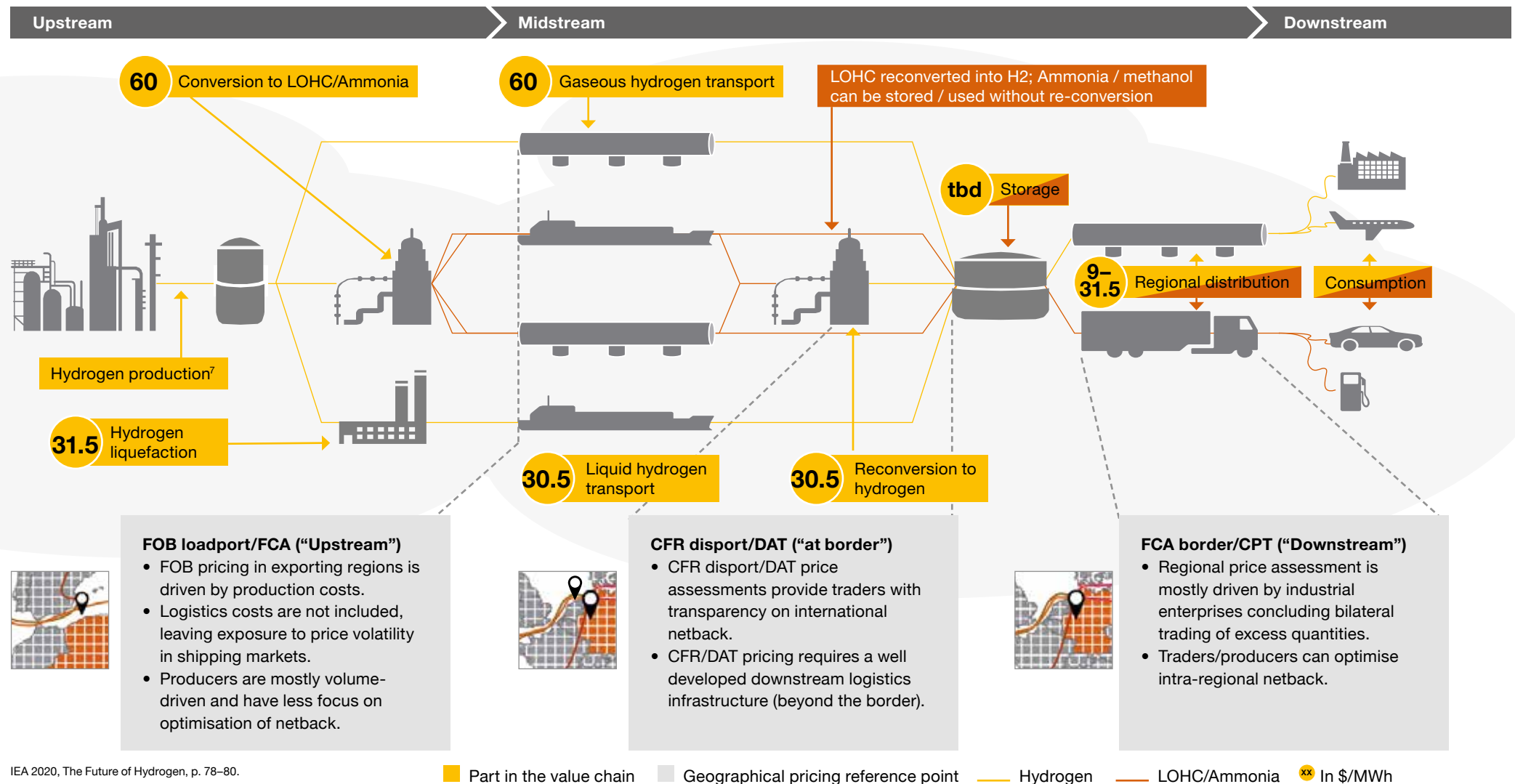
- Most countries with favourable conditions for hydrogen production cannot be connected to the European market by pipeline so that hydrogen would need to be transported by ship.
- Shipping of hydrogen may not be economical for the following reasons:
  - Hydrogen exhibits a very low energy density so that each vessel can carry only a limited amount of energy (appr. 1/10 compared to natural gas).
  - Hydrogen has a very low cooling point ( $-252^{\circ}\text{C}$ ), leading to high conversion losses in liquefaction and substantial amounts of “boil-off” during transportation.
- The cost of conversion, carrying liquid hydrogen for a distance of 3,000km and re-conversion is estimated around USD73.50/MWh.
- The cost of conversion, carrying hydrogen as LOHC and ammonia, respectively for 3,000km and re-conversion is considerably USD49.50–60.00/MWh.



Source: IEA (2020)

International shipping of hydrogen will be inhibited significantly by high transportation costs resulting from low energy density of hydrogen and high conversion losses involved in the liquefaction process.

# Transport economics predominantly depend on the mode of transport and determine geographical pricing reference points



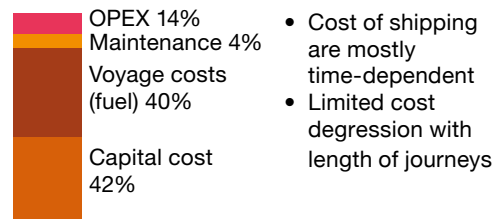
IEA 2020, The Future of Hydrogen, p. 78–80.

<sup>7</sup> Production cost in Morocco USD3/kg according to IEA 2020

# The costs of ocean-going hydrogen transport depend on shipping costs and (re-)conversion costs

## Ship's Cost Structure

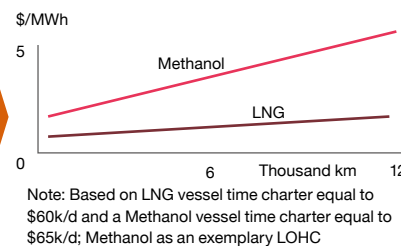
### Cost structure of ships



- Cost of shipping are mostly time-dependent
- Limited cost degression with length of journeys

Source: Capesize bulk carrier, Stopford 2009

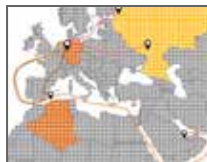
### Overview of distance-dependent transport costs



- Charter rates for LNG vessels are shown as a proxy for liquid H<sub>2</sub> shipping costs.
- Capex for vessels for liquid H<sub>2</sub> is still uncertain.
- Scale economies may drive future path of capex for new liquid H<sub>2</sub> ships.

## Shipping patterns ("ballasting")

### High "Ballasting Costs" in Liquid H<sub>2</sub>/LOHC Shipping



- No flexibility to use LNG/liquid H<sub>2</sub> vessels for other commodities.
- LOHC shipping requires backhaul of carrier molecules to port of origin.
- ➔ Empty backhaul voyages drive up costs of liquid H<sub>2</sub>/LOHC shipping.

### Limited "Ballasting Costs" in Ammonia / Methanol Shipping



- Shipping of ammonia / methanol involves flexible ships
- Ability to pick up "back-haul cargos"
- ➔ Empty backhaul voyages drive up costs of liquid H<sub>2</sub>/LOHC shipping.

## "All-in" Transport Costs

## Energy Efficiency

	Liquid H <sub>2</sub>	Ammonia	LOHC <sup>a</sup>	LNG
Cooling Point (in °C)	-235	-33	65	-161
Density (in MWh/m <sup>3</sup> )	2.36	4.25	4.44	6.83
Calorific Value (in MWh/mt)	33.33	4.80–5.20	5.47	13.98
Conversion Costs (in \$/MWh)	32.50	3.00	12.00	5.77
Re-Conversion Costs (in \$/MWh)	n.a.	24.00	30.00	1.50
Boil-off gas (in %/day)	0.20	0.00	0.00	0.12–0.20

- Liquid H<sub>2</sub> shipping involves
  - High liquefaction/conversion costs due to low boiling point
  - High boil-off volumes during transit
- ➔ Limited energy efficiency increasing costs of liquid H<sub>2</sub> shipping

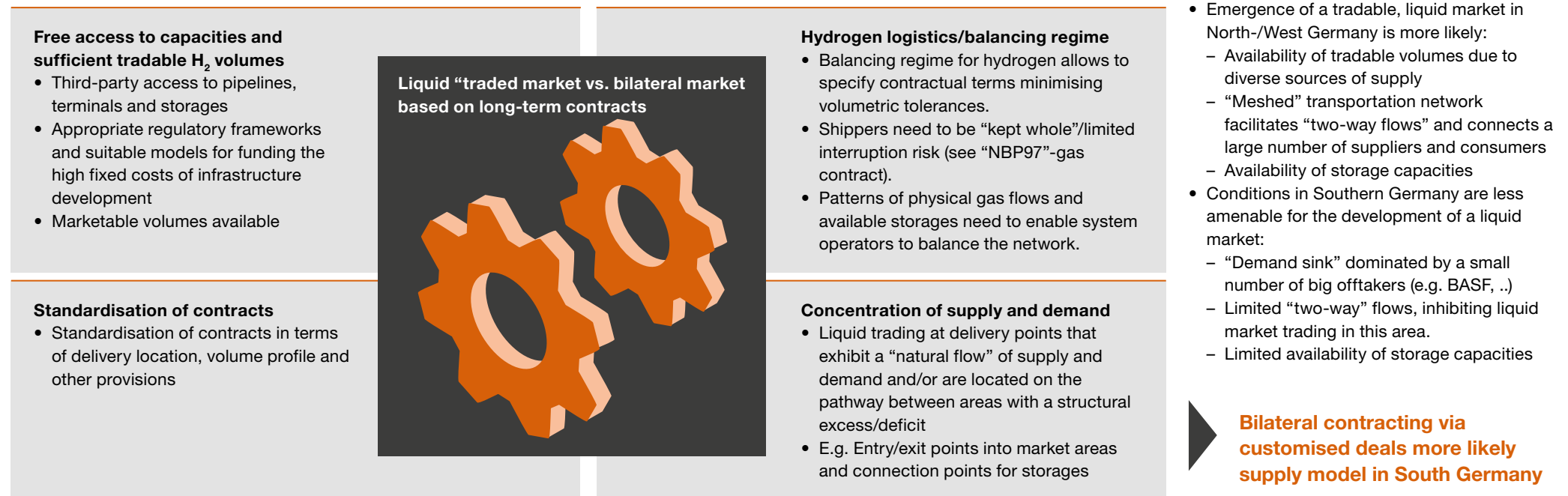
### Optimal transportation path dependent on trade-offs between

- High number of "ballasting days" for liquid H<sub>2</sub> and LOHC
- High cycling costs (conversion/reconversion) for LOHC and ammonia (in case not used as ammonia at the destination)

<sup>a</sup> Methanol as an exemplary LOHC

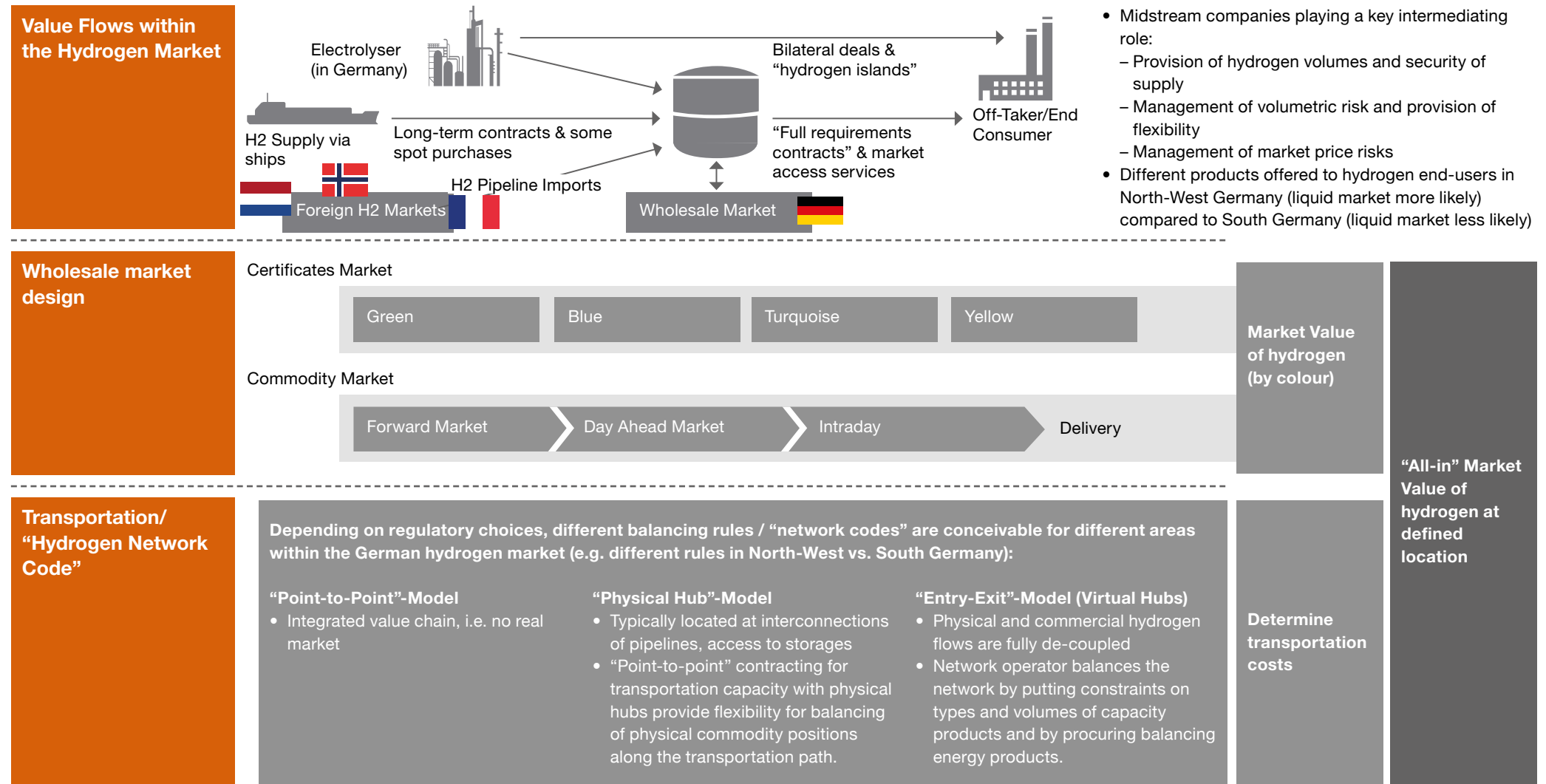
# The hydrogen market will further develop from a bilateral market into a “traded market” if several preconditions are fulfilled

The transportation network for moving hydrogen across Germany/Europe will grow gradually over time requiring substantial investments ...



Different market structures should be expected in North-Western and South Germany.

# The structure of the German market for hydrogen will consist of several components mirroring the traditional structure of natural gas markets



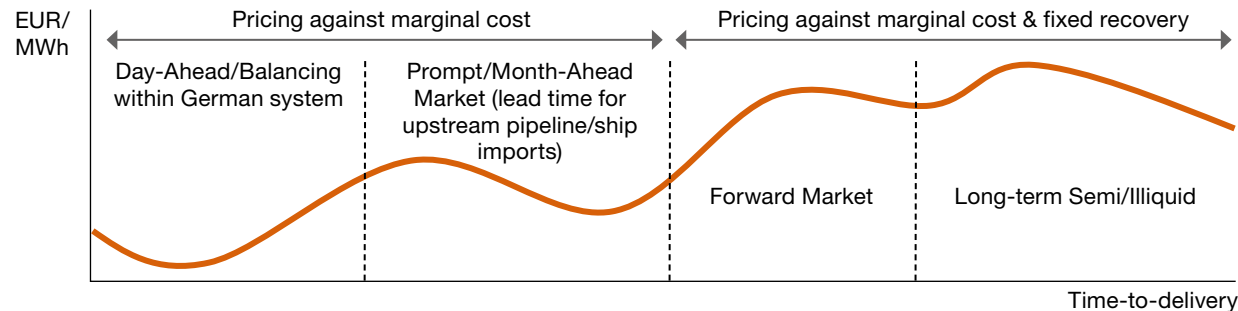
# The pricing of hydrogen will be closely tied to the structure of the hydrogen market



# The pricing structure of hydrogen depends on the lead time in physical procurement as well as the availability of transport capacities

Merit Order of suppliers & willingness to pay of users are likely to change over time as the market progresses.

Marginal players setting market prices will shift over time.



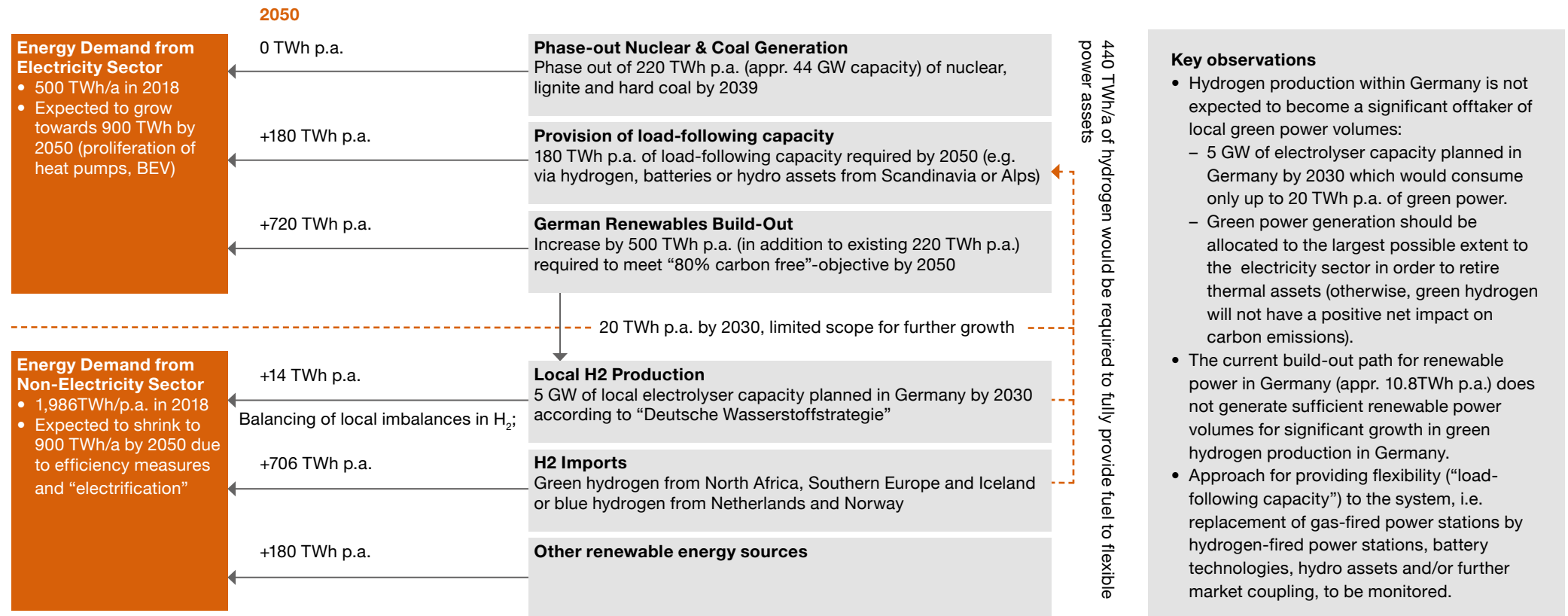
Areas Outside European H <sub>2</sub> Backbone	<ul style="list-style-type: none"> <li>Electrolysers and hydrogen storages located in Germany acting as marginal units</li> <li>Volatility spill-over from day-ahead / intraday power markets to hydrogen markets</li> <li>“Shaving” of “negative spikes” in power prices when electrolysers are optimised against the market</li> </ul>	<ul style="list-style-type: none"> <li>Forward prices for hydrogen driven by:                             <ul style="list-style-type: none"> <li>Power forward prices</li> <li>Value of savings in carbon emissions by end-users</li> <li>Fixed costs/amortisation of capex of local hydrogen producers.</li> </ul> </li> </ul>
Areas Within European H <sub>2</sub> Backbone	<ul style="list-style-type: none"> <li>Marginal unit determined by merit order of “net supply”</li> <li>Merit order consisting of local electrolysers, flexible supply (e.g. ships nearby, flexible contract volumes), hydrogen storages and flexible consumers.</li> </ul>	<ul style="list-style-type: none"> <li>Forward prices for hydrogen driven by:                             <ul style="list-style-type: none"> <li>Expected costs of supply of international producers incl. transport costs ( “supply mix” in terms of country of origin and technologies)</li> <li>Value of savings in carbon emissions by end-users</li> <li>Fixed costs/amortisation of capex of international hydrogen producers.</li> </ul> </li> <li>Seasonal shaping dependent on seasonality of supply and demand</li> </ul>

## Additional developments to be monitored:

- Number of pricing zones within Germany will depend on the geographical design of the transportation network.
- Role of hydrogen may also expand to heating sector and/or other applications that predominantly rely on natural gas.
- Role of blue hydrogen (e.g. from Norway or Netherlands) as a “transition fuel” is still unclear.
- Relevance of transporting hydrogen via natural gas pipelines may lead to “gas-to-hydrogen” competition for transport capacity.
- Changes in power market design (e.g. capacity mechanisms).

Pricing in the short-term is mainly determined by short-term optimisation of local capacities and in the long-term determined by production and transport lead time

# Impact of Hydrogen on Price Formation in National Power Markets



Source of figures: OIES (2020)

Hydrogen may not have a significant impact on the average level of power prices reflected in forward price – but electrolyzers being optimised against the market may smooth out intraday price fluctuations due to their very short ramp up/down periods (reduction in premia for “price structure risk”).

# Lessons learned from the gas market can be used to assess the expected evolution of the structure of the European hydrogen market

## Key events shaping the development of today's Natural Gas markets in Europe

Third-Party Access	Gas Release Programs	Start of Bilateral Trades	Standardisation of Contracts	Emergence of Liquid OTC Trading	Financial Products
<ul style="list-style-type: none"> <li>Access to infrastructure assets (pipelines, storages) opened to all market participants enforced by governmental regulation</li> </ul>	<ul style="list-style-type: none"> <li>Market power of dominant suppliers to specific market areas curtailed by gas release programs enforced by governments.</li> <li>Increase in the share of gas import volumes that are available for free market trading</li> </ul>	<ul style="list-style-type: none"> <li>Start of bilateral trading at entry points into the national gas systems</li> <li>Short-term physical balancing of excess volumes as key trading objectives</li> </ul>	<ul style="list-style-type: none"> <li>Standardisation enabled the growth of market liquidity.</li> <li>Key terms to be standardised included delivery profile and balancing obligations (see NBP 97).</li> </ul>	<ul style="list-style-type: none"> <li>Growing tenor of transactions as market participants increasingly use the market for risk management and trading purposes</li> </ul>	<ul style="list-style-type: none"> <li>Market entry of financial players</li> </ul>

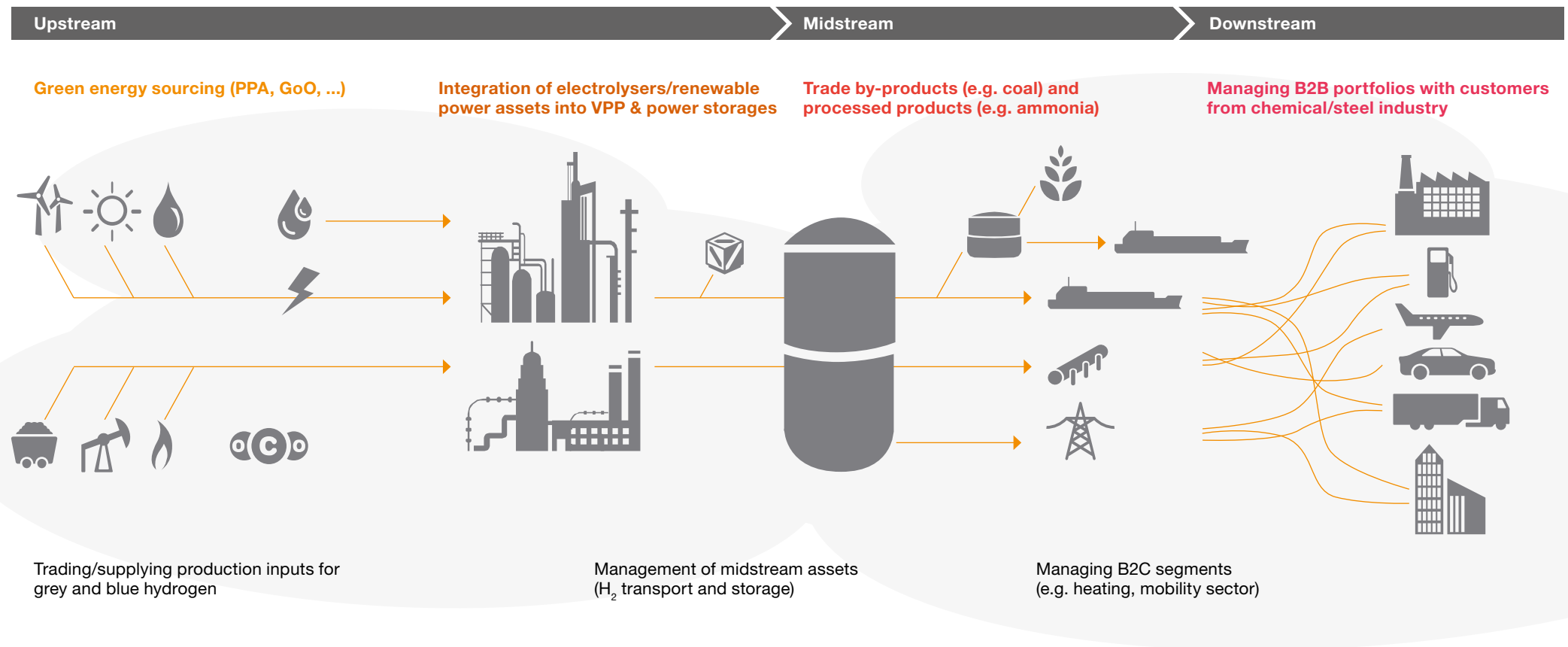
Growing price transparency (press, ICIS)/Expanding tenor of forward curve

### Lessons learned that are relevant for the development of the hydrogen market:

- Regulatory mechanisms ensuring free and cost competitive access to transportation assets such as terminals, pipelines and storage are key prerequisites for the emergence of liquid trading of hydrogen.
- A sufficient share of hydrogen volumes must be freely available for trading by market-based traders (i.e. should not be tied up under long-term contracts).
- Liquid hubs are most likely to emerge at delivery points in the network where supply and demand naturally meet. If such physical hubs do not exist then there may be a need for the regulator/system operators to create market areas with virtual hubs.
- Creating a common standard for a market-based hydrogen trading contracts may be a difficult exercise as the interests of diverse types of market participants need to be taken into account.

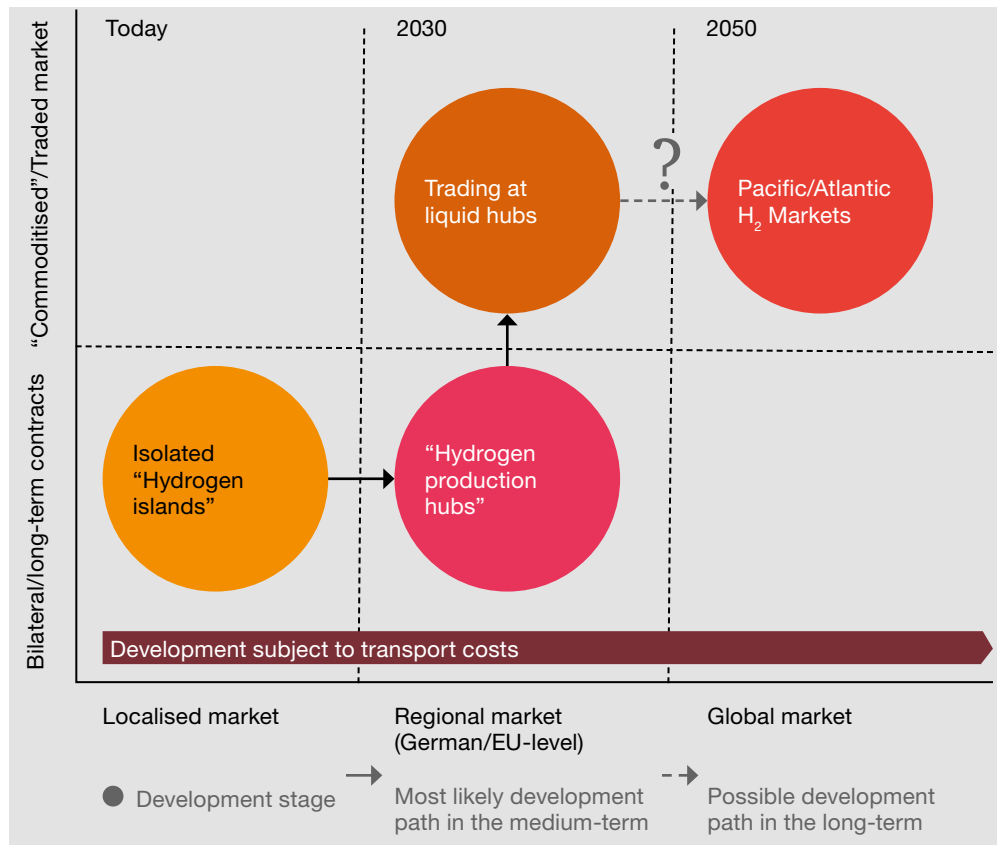
# 3 Implications for Trading Organisations

# Opportunities for “asset-backed” trading approaches along the hydrogen value chain



Energy traders can leverage on their existing capabilities and extend their activities in the emerging hydrogen market.

# The European hydrogen market may evolve into a „traded market“ with multiple liquid trading hubs over time



Potential business models based on connecting supply and demand are highly dependent on the structure of the hydrogen market ...

Commoditised/  
Traded Market

**"Asset-Backed" Trading** business models which can include the following types of trading activities:

- **Geographical Arbitrage & Freight Optimisation**, i.e. exploiting mismatches between supply and demand in various regions.
- **Cross-Commodity Trading**, i.e. taking positions on the developments of price spreads between hydrogen, power, gas and carbon on the back of physical production assets.
- **Midstream supply business**, i.e. taking positions along the physical hydrogen logistics chain based on physical transportation assets (e.g. pipelines, terminals, storages) and providing flexibility to other players into the hydrogen market.

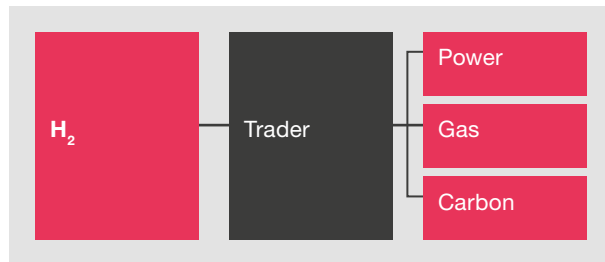
Bilateral/  
long-term  
contracts

- Logistics business similar to **"pre-liberalisation" natural gas business, LPG "trading" or distribution business** for industrial gases (outcome dependent on future design of hydrogen logistics system).
- Pure energy trading business models mainly focused on **offering optimisation of cost of supply services** (management of power, natural gas and green certificate positions) for owners of hydrogen production assets.

- Despite high levels of uncertainty, major international trading companies such as Vitol and Trafigura are taking first steps which enable them to build up the know-how and relationships which are required to quickly enter the market once first trading opportunities emerge (e.g. invest in physical assets along the hydrogen value chain, (re-)build their power and gas trading activities).
- Transition to a commoditised hydrogen market is highly likely if the following conditions materialise: (1) Concentration of supply and demand at specific points with the hydrogen logistics system (e.g. entry points into national systems, production/consumption hubs with material "two-way" flows of hydrogen), (2) open access to logistic capacities (pipelines, storages, terminals), (3) availability of an appropriate logistics/balancing regime for hydrogen, (4) standardisation of hydrogen contracts.
- Transition to a global hydrogen market is highly dependent on technological progress regarding hydrogen transportation (current technologies for converting back-and-forth between hydrogen and ammonia involve high (re-)conversion losses).

# Deep Dive into “asset-backed” trading business models

## Product Arbitrage & Cross Commodity Optimisation



## Midstream supply business (transportation, Storage Optimisation & Flexibility Provision)



## Geographical arbitrage and Freight Optimisation



### Key rationale

- Capturing cross-commodity price differentials between hydrogen, power, gas and carbon on the back of physical hydrogen production assets.
- Integration of electrolyzers into virtual power plants.
- Short vs. long-term trading strategies.

### Required Capabilities

- Insights into customer demands in “downstream markets” for hydrogen.
- Insights into “upstream markets” for power, gas and carbon.
- Access to hydrogen production assets and storages.

### Existing activities of energy traders

- Power (Short- and Long-Term), gas and carbon trading activities.
- Typically strongest position in their home market where they have their physical asset base.

- Utilise access to cheap storage and logistics assets to capitalise on inefficiencies in the term structure and locational structure of hydrogen prices.
- Provide flexibility to other market participants.
- Operating within pipeline-based hydrogen markets.

- Sales channels for structured deals to large off-takers.
- Access to storage and logistics assets.
- Long-term hydrogen supply contracts (as long as the market is not fully liquid).
- Funding of working capital requirements (depending on storage requirements of trading strategies pursued).

- Gas trading and midstream business activities
- Own storage business (needs to be kept strictly separate from trading business for regulatory reasons).

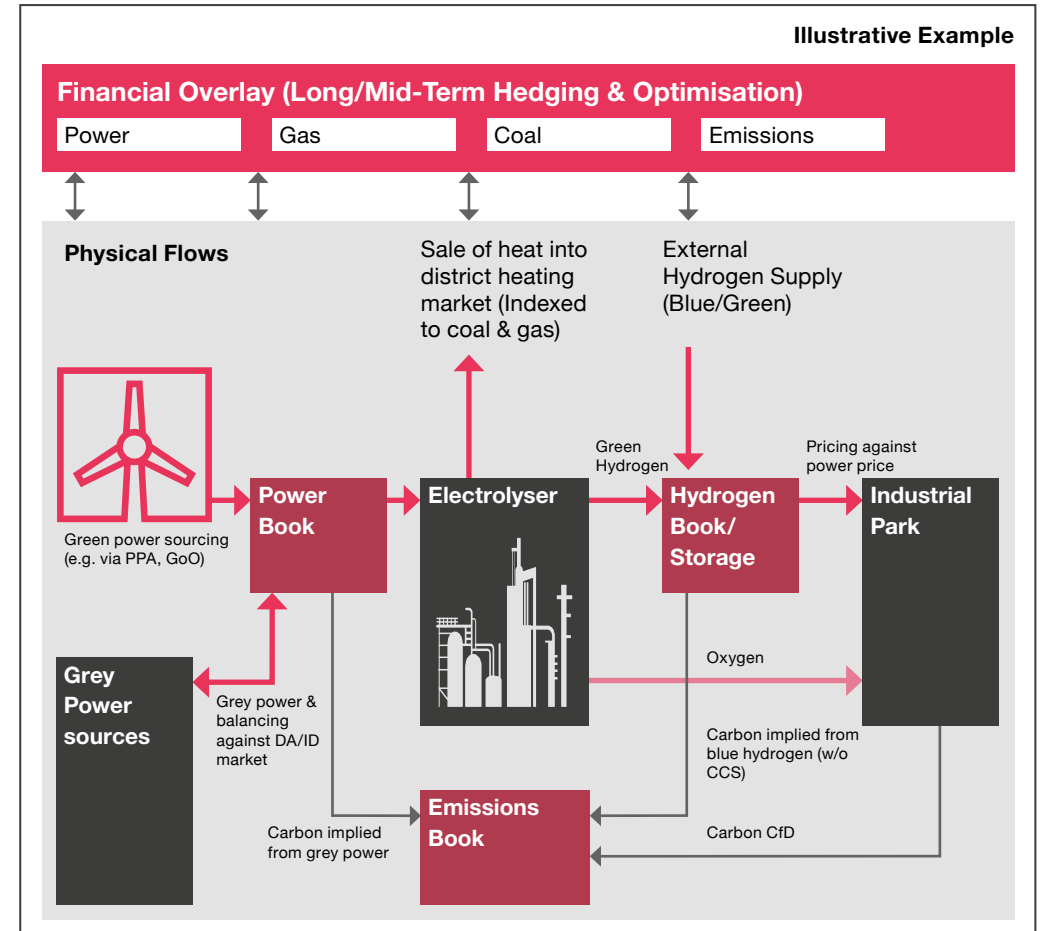
- “Triangulation” of global freight movements exploiting regional imbalances between supply and demand
- Build up of hydrogen and freight positions in all key market areas allows to “triangulate” trade flows and capture the savings in overall logistics costs.

- Overview of supply-demand imbalances and their dynamics in key regional hydrogen markets.
- Access to transportation assets and export/import terminals.
- Global portfolio of hydrogen positions and long-term hydrogen supply contracts (need for “security of supply” in order to become “go-to” player in the market).
- Funding of high working capital requirements

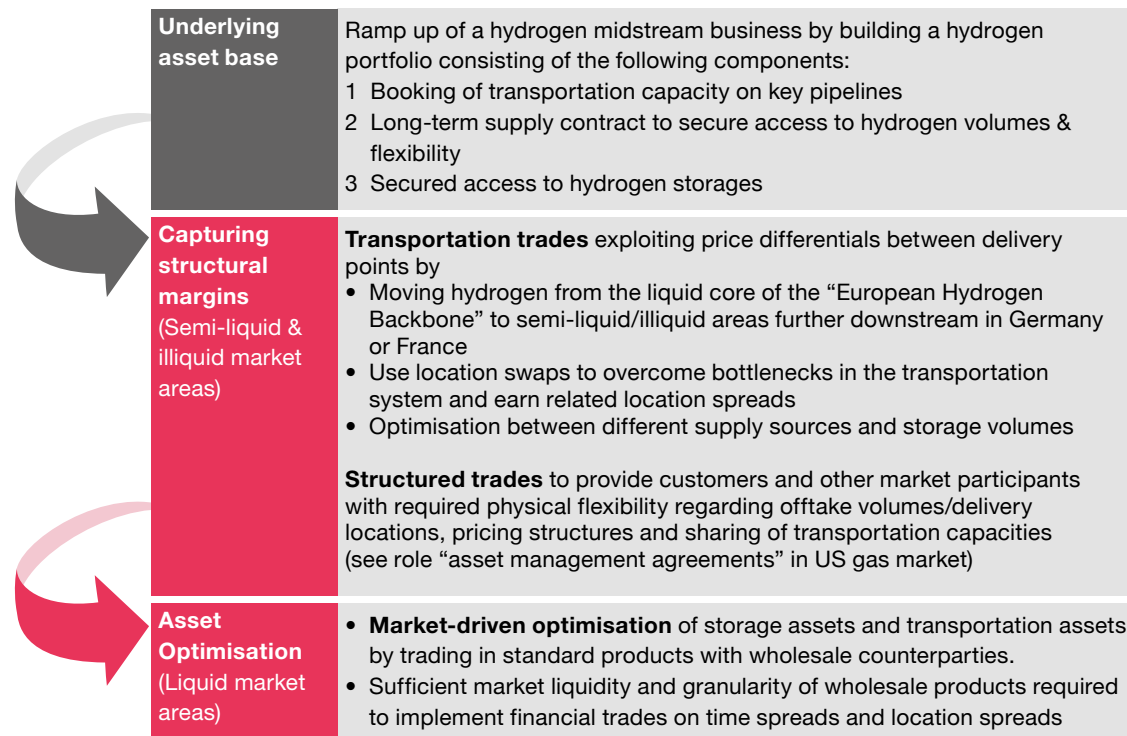
- LNG and coal supply and trading activities.

# Case Study – Cross Commodity Optimisation to minimise cost of energy supply

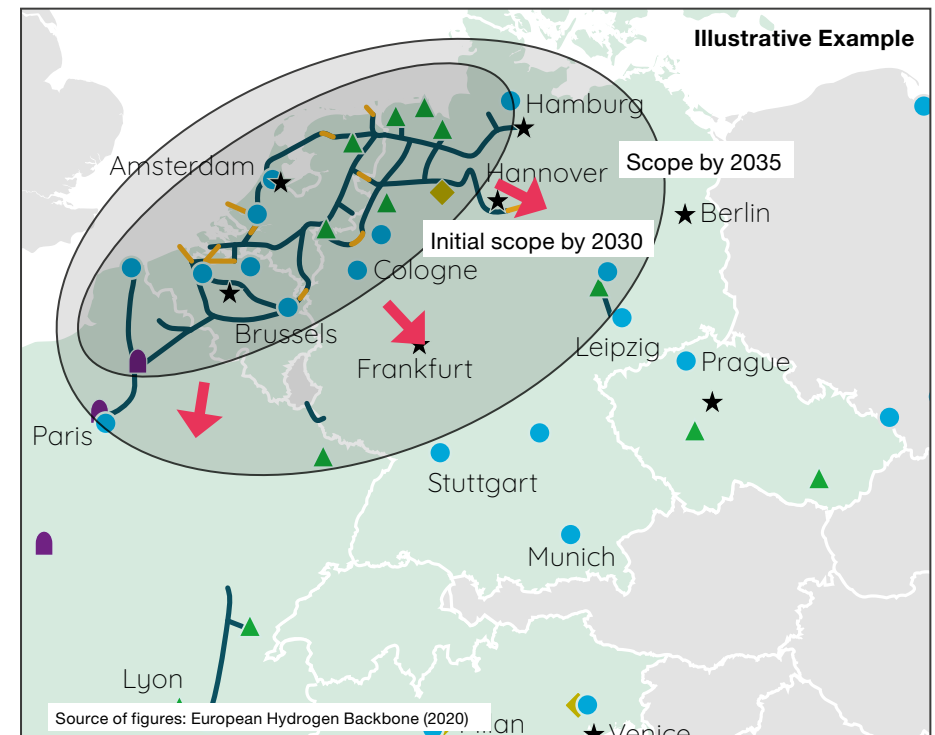
<b>Underlying asset base</b>	<ul style="list-style-type: none"> <li>Industrial park sourcing its hydrogen demand using its own local electrolyser.</li> <li>Green electricity is provided to the electrolyser using a PPA and GoOs</li> <li>On-site storage capacity for hydrogen available</li> </ul>
<b>Optimization of cost of “all-in” commodity supply</b>	<p>Energy trader optimises the electrolyser and the hydrogen storage against tradable products in energy markets:</p> <ul style="list-style-type: none"> <li><b>Long/Mid-term hedging &amp; optimisation</b> in forward markets to protect margins/lock-in “all-in” costs of hydrogen supply</li> <li><b>Short-term optimisation</b> of electrolyser &amp; hydrogen storage against day-ahead/balancing markets to generate additional revenue.</li> </ul> <p>Key basis is modelling of physical value flows and “real-time” integration of production forecasts of industrial park into position management (high requirements regarding data interfaces, processes etc.)</p>
<b>Further optimisation Potentials</b>	<ul style="list-style-type: none"> <li>Demand Response approaches</li> <li>...</li> </ul>



# Case Study – Growing a Midstream Supply Business in a growing Hydrogen Market



Expected Evolution of the European Hydrogen Backbone

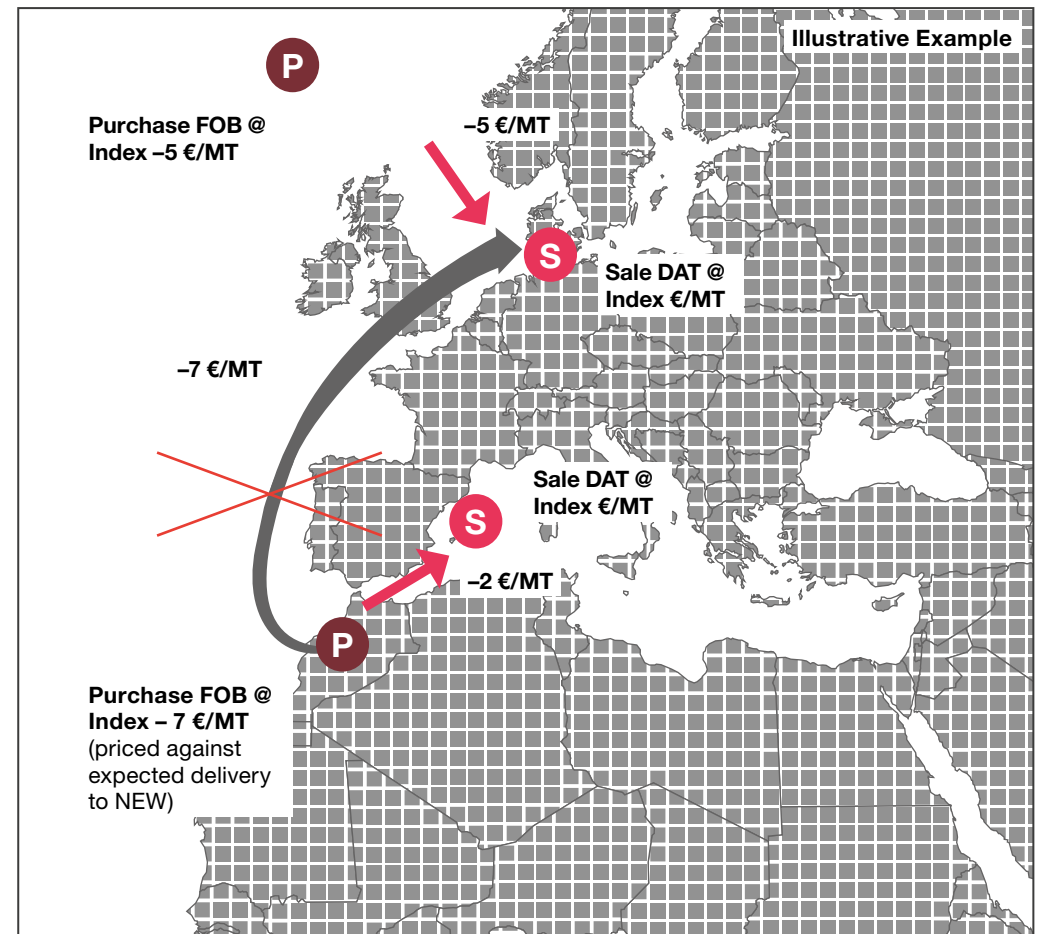


Exploitable pricing differentials/„net backs“ between semi-/illiquid „fringes“ and the liquid „core“ of the „European Hydrogen Backbone“ driven by

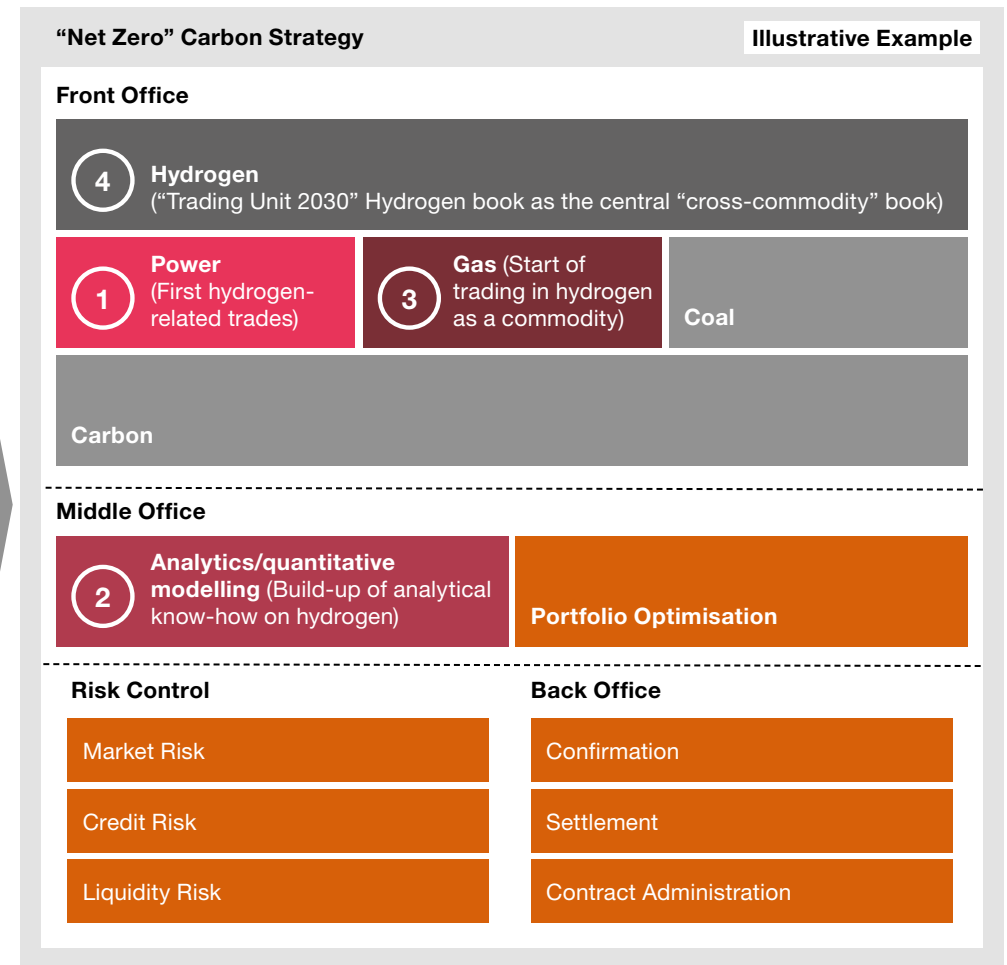
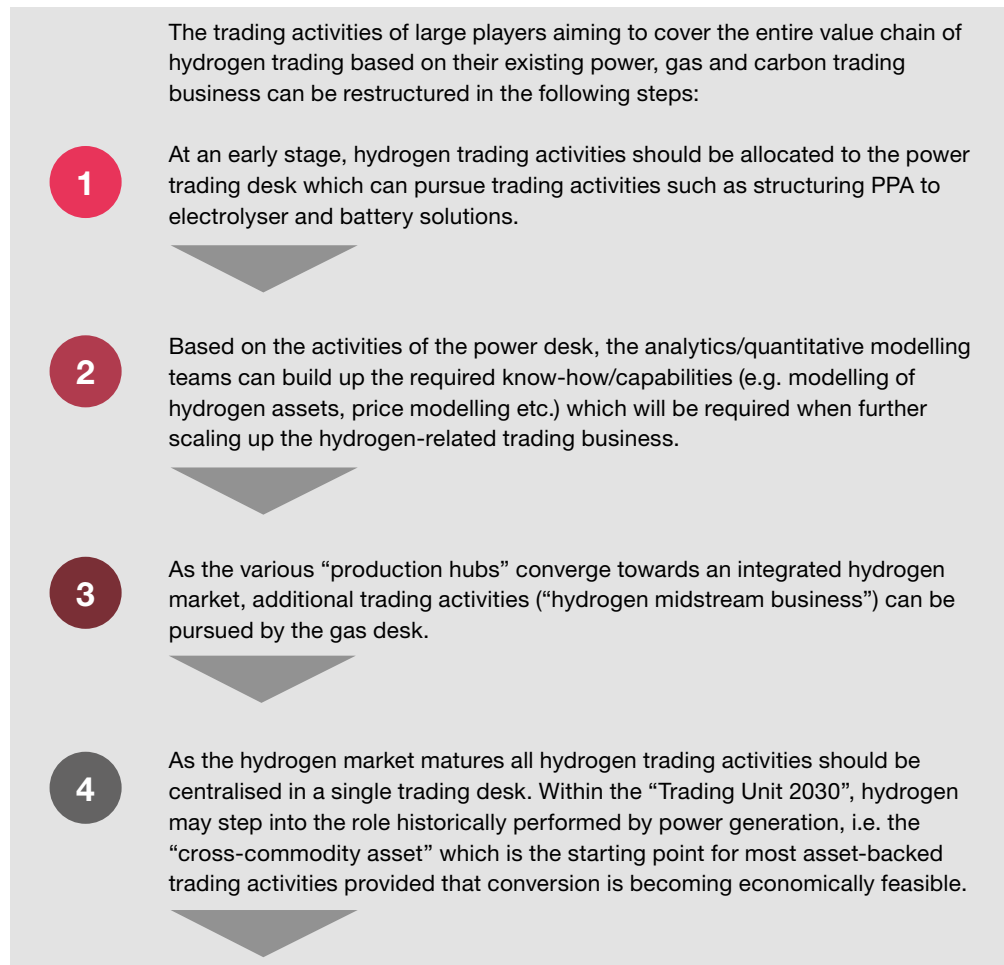
- Downstream transportation costs
- Pricing impact of local excess (surplus/deficit) quantities which cannot be covered in the local market

# Case Study – Geographical Arbitrage & Freight Optimisation

<b>Underlying asset base</b>	<ul style="list-style-type: none"> <li>Long-term offtake &amp; marketing agreement with Moroccan counterparty that includes flexibilities regarding number of ships and nomination rights</li> <li>Market transparency on supply side (access to producers) and sales side (e.g. midstream players and large users)</li> <li>Access to transportation assets (ships, terminals etc.)</li> </ul>
<b>Capturing of margins driven by “market structure”</b>	<p><b>Optimisation of Transport Costs</b> (see example)</p> <ul style="list-style-type: none"> <li>Allocate cargos from long-term supply contract to “demand sink” area</li> <li>Re-optimize cargo delivery plan (e.g. divert / cancel cargos) once additional “spot cargos” become available on the market.</li> </ul> <p>Capitalise on <b>local supply/demand imbalances</b> leading to hydrogen cargos trading at a premium/discount at specific delivery points.</p> <ul style="list-style-type: none"> <li>Excess volumes relative to storage available at export terminals</li> <li>Insufficient inventory levels in downstream markets</li> </ul>
<b>Further Optimisation Potentials</b>	<ul style="list-style-type: none"> <li>Trading “sea-borne” hydrogen cargos against deliveries by pipeline (“Backfilling” of liquified hydrogen with pipeline hydrogen)</li> <li>“In-tank” trading against local hydrogen market using import terminals as storage assets</li> <li>Downstream trades in destination markets (including electrolyzers)</li> <li>...</li> </ul>



# The organisational integration of hydrogen trading activities should adapt to the evolving market structure



Note: For small- and mid-sized trading organisations, the target organisational structure may be different (e.g. split between long-term financial “cross-commodity” hedging & trading and short-term physical optimisation at the level of individual assets/pools of assets).

# Steps to be taken today already

Despite high levels of uncertainty, major international trading companies such as Vitol and Trafigura are taking first steps which enable them to build up the know-how and relationships which are required to quickly enter the market once first trading opportunities emerge (e.g. invest in physical assets along the hydrogen value chain, (re-)build their power and gas trading activities).

## **1 Build-Up of required capabilities**

- Know-How build up regarding physical value chain
- Understand topography of supply and demand to see where bottlenecks may develop

## **2 Build up relationships with key players/participate in emerging industry initiatives**

- Grid operators
- Providers of infrastructure
- Potential users

## **3 Targeting of potential customers/counterparties**

- External business: Identify target client sectors who need trading services and liaise with key stakeholders
- Internal business: Link into group-wide hydrogen strategy

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