



Hydrogen Europe

Renewable Energy:
Global Challenges and Prospects for Ukraine
Jorgo Chatzimarkakis, Secretary General

International Renewable Energy Investment Forum, Kyiv, November 2019





Noé Van Hulst

Hydrogen Envoy –

Ministry of Economic Affairs &
Climate Policy



“Policy makers should now be ready to start putting hydrogen plans into action.”

“Opportunities that could make a crucial difference to our clean energy future are there to be seized”



Sebastian Kurz

Austrian Chancellor



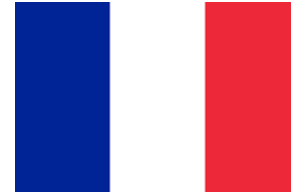
“Hydrogen is the fuel of the Future”

“I want Austria to be the number one Hydrogen nation”

“I want to spend an additional 500 million Euros to speed up the transition to hydrogen”



Emmanuel Macron
President of France



“I want to resolutely engage France in a "transport revolution" by generalizing electric and hydrogen vehicles”

“This is a national strategy we have engaged on. It must also accelerate at the European level”



Angela Merkel

German Chancellor



“Germany should become the center of environmentally friendly aviation.”

“A national hydrogen strategy should be in place by end of the year” [2019]



Giuseppe Conte
Prime Minister of Italy



“I have already started to look at the issue of hydrogen. We have to work on it today!”

“It’s a topic I am passionate about!”

All EU Countries: “Linz Declaration”



“We aim to maximise the great potentials of sustainable hydrogen technology for the decarbonisation of multiple sectors, the energy system and for the long-term energy security of the EU”

2030 FRAMEWORK FOR CLIMATE AND ENERGY AGREED TARGETS

	GREENHOUSE GAS EMISSIONS	RENEWABLE ENERGY	ENERGY EFFICIENCY	INTER-CONNECTION	CLIMATE IN EU-FUNDED PROGRAMMES	CO2 FROM:
2020	-20%	20%	20%	10%	2014-2020 20%	
2030	≤ -40%	≥ 32%	≥ 32.5%	15%	2021-2027 25%	CARS -37.5% Vans -31% Lorries -30%

Upwards revision clause by 2023

Targets to become even more ambitious

“I want Europe to become the first climate-neutral continent in the world by 2050. To make this happen (...)

we must go further. We must strive for more. A two-step approach is needed to **reduce CO₂ emissions by 2030 by 50, if not 55%.**”

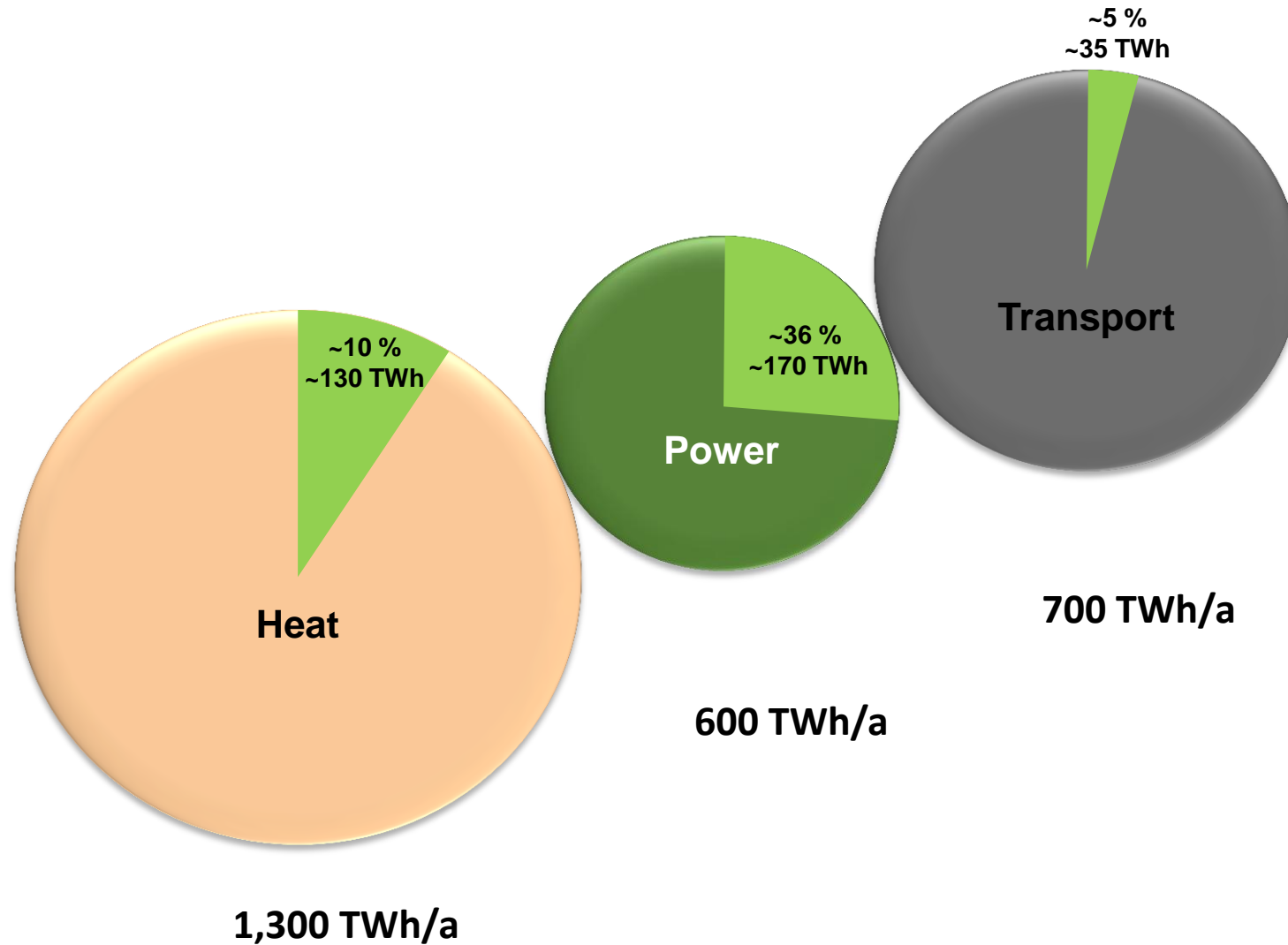
- **Green Deal for Europe** during first 100 days in office.
- First ever **European Climate Law** which will set the 2050 target into law.



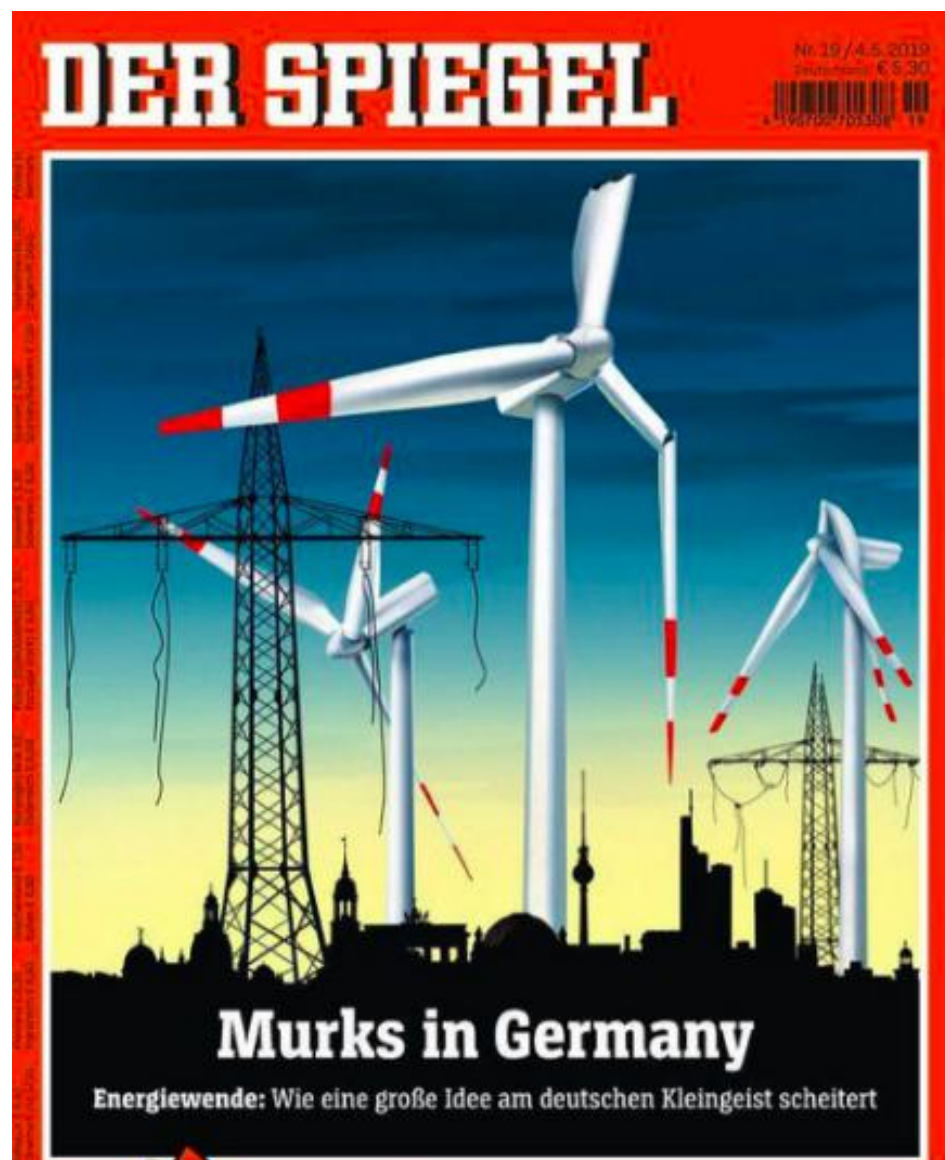
**Statement
in the European Parliament,
16.07.2019**



Can we do it with electricity alone?



Power grids are efficient – but too small



Germany decided 10 years ago
to build new power grid

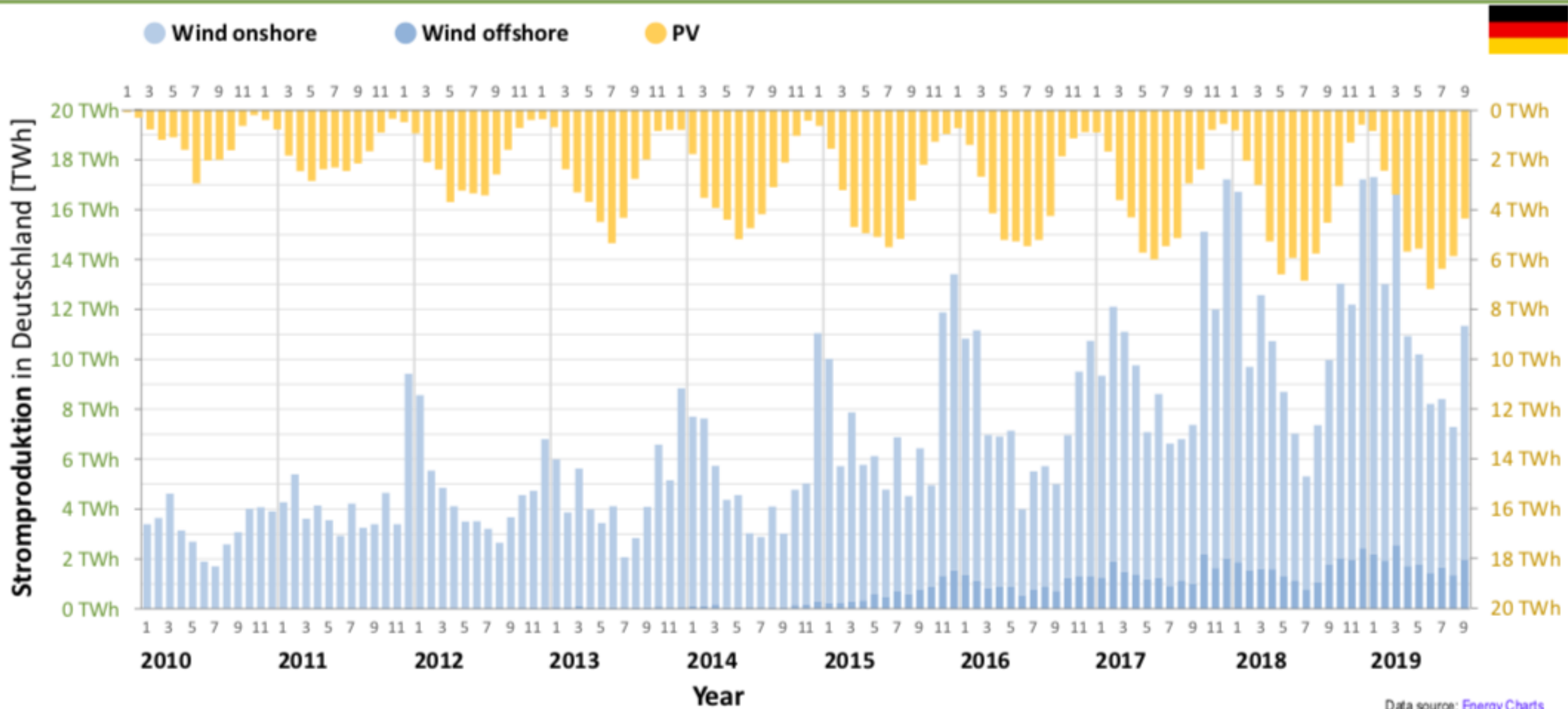
Planned: 7.700 km

Realised: 950 km

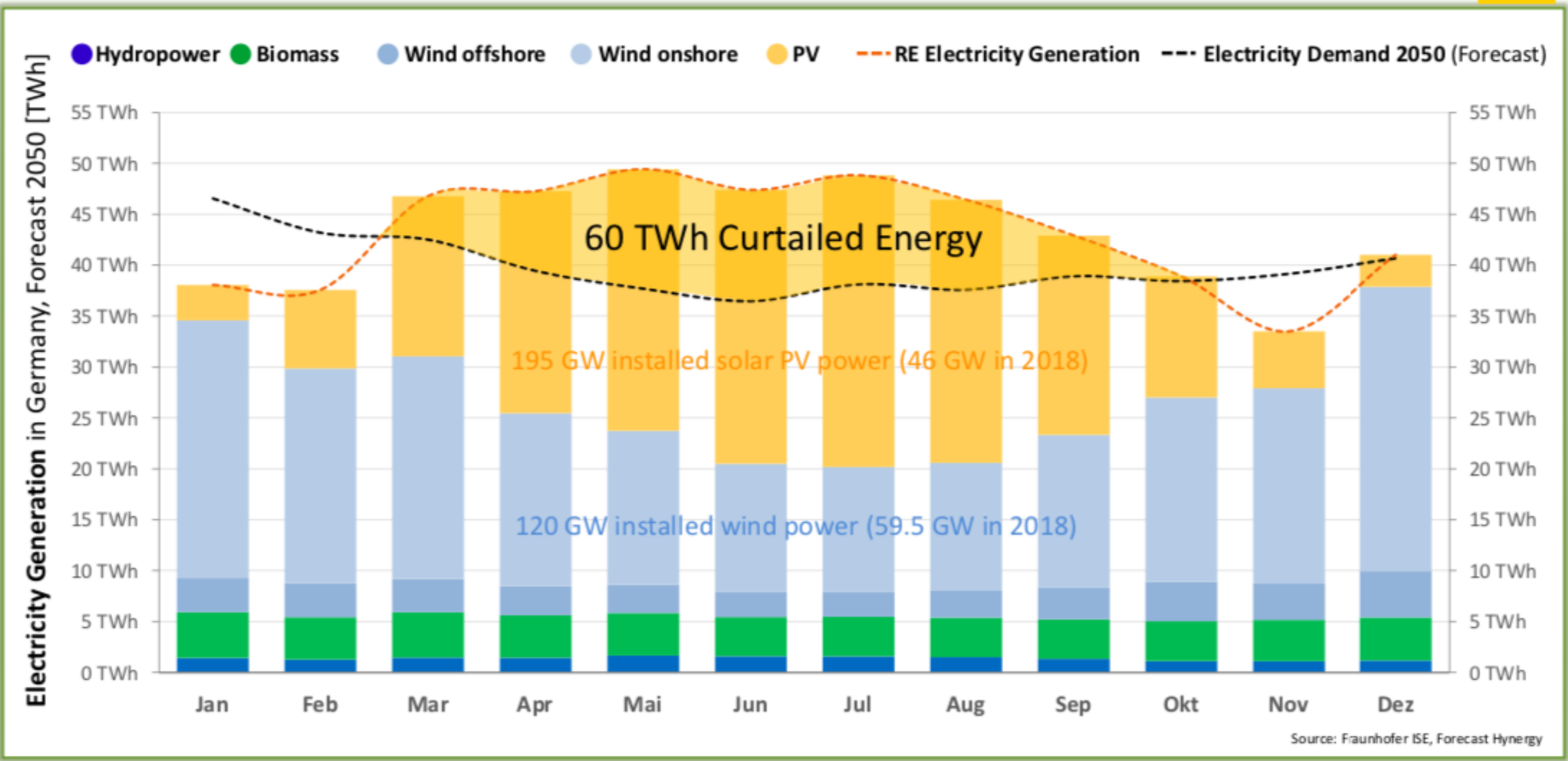
Built in 2017: 30 km

Left: 6.720 km

Renewable power production



Curtailed Energy in 2050



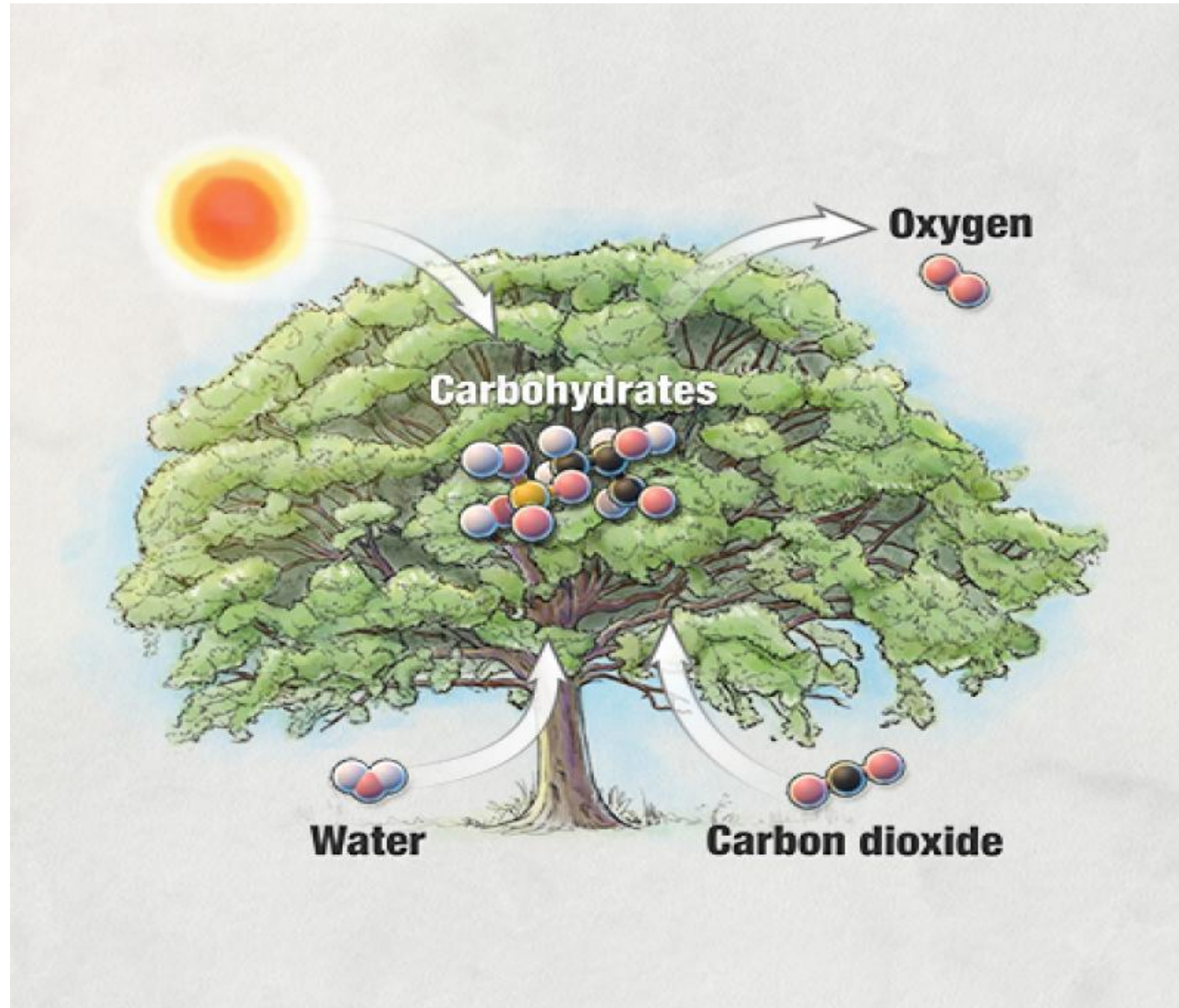
Sector coupling & sector integration



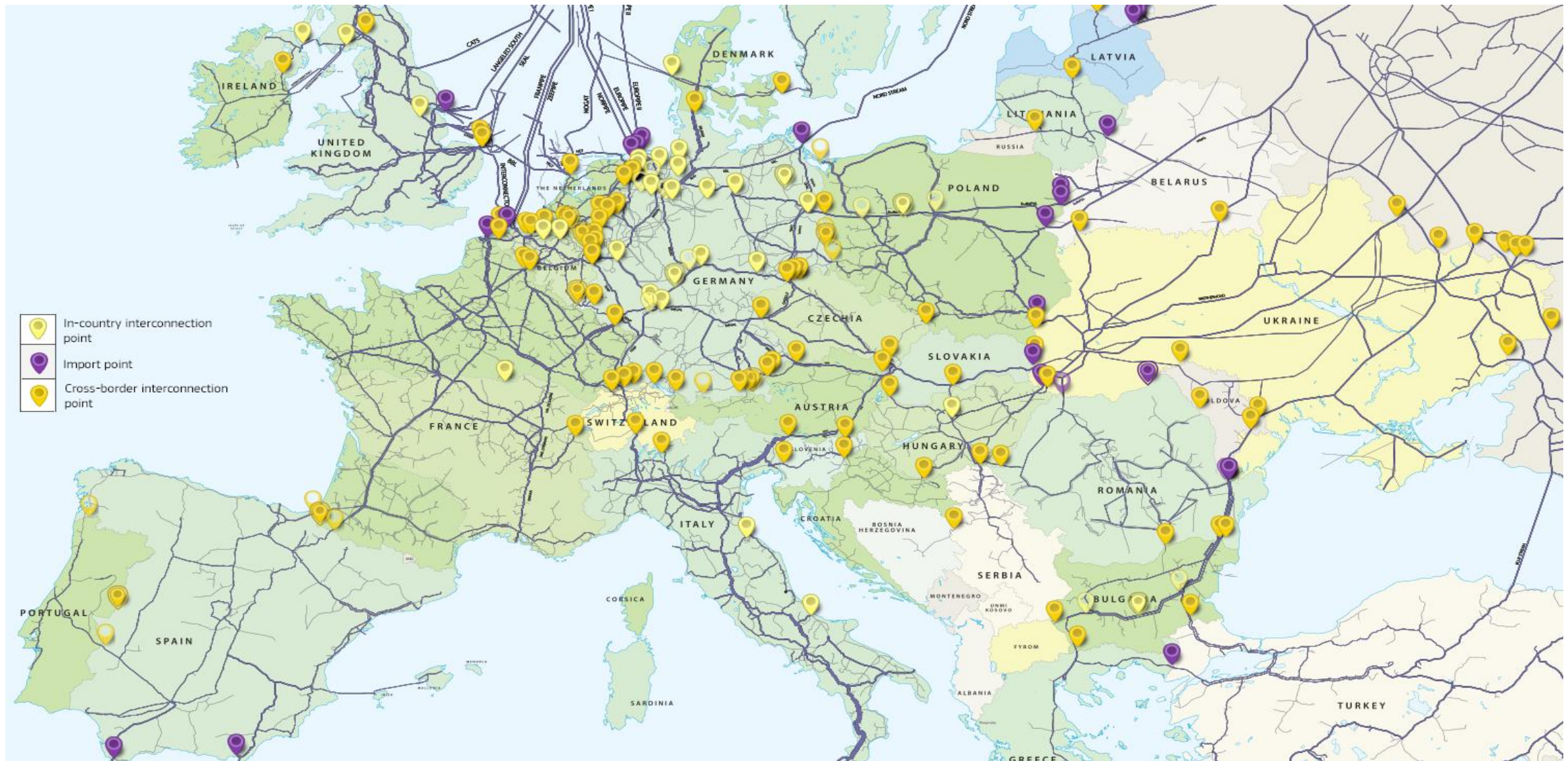
Why Hydrogen for Climate Action?



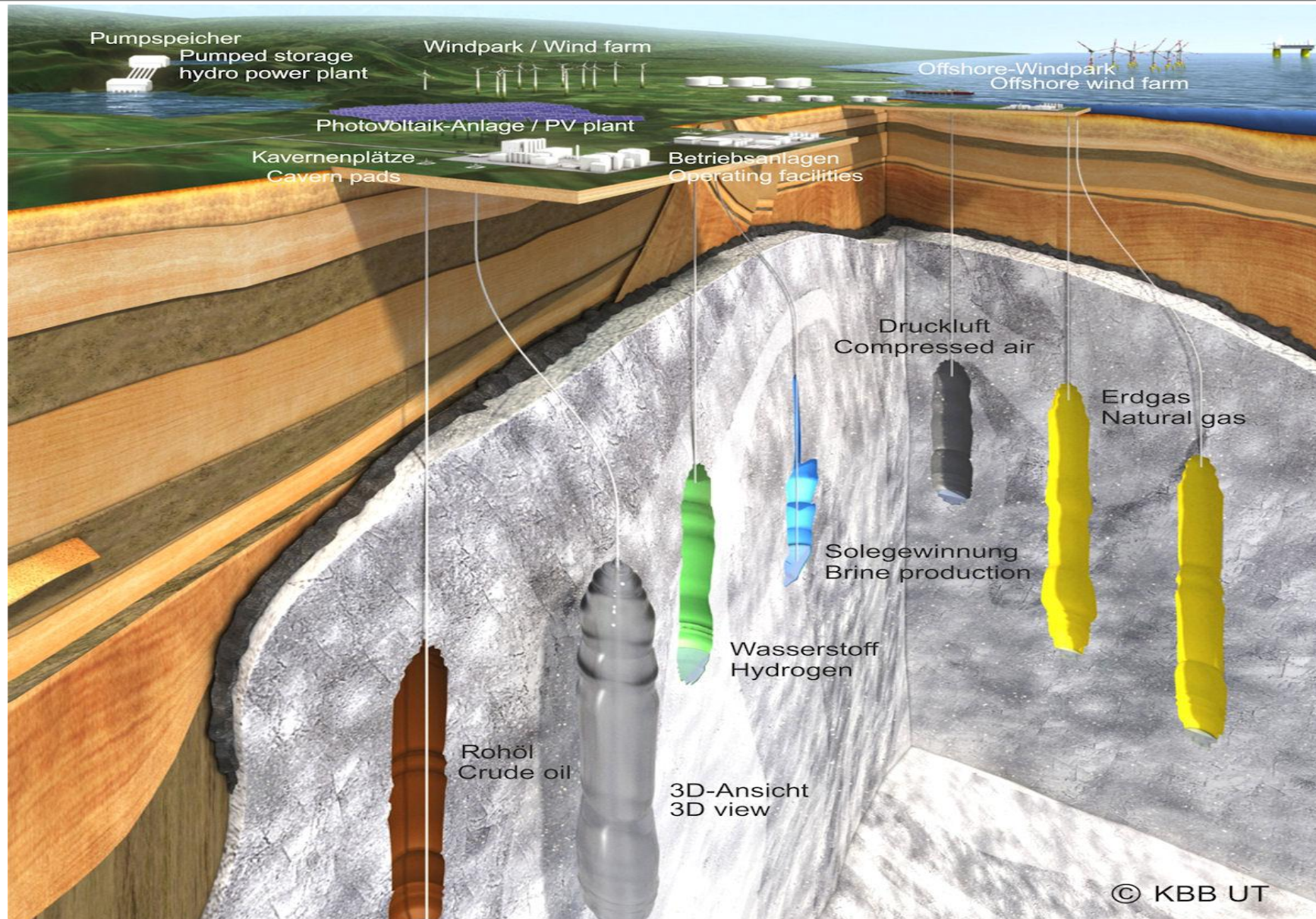
From Anthropocene to Cyclocene!



The European Gas Grid – cheap transport of H₂



Salt Caverns as a huge potential for storage



Storage Capacities



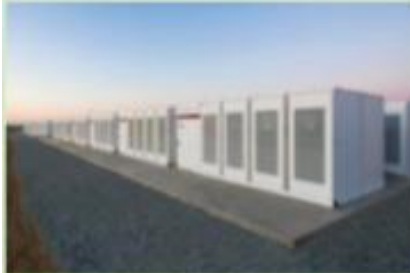
Pumped Hydro Stations in Germany:
Technical Potential

Storage Capacity: **0,04 – 0,06 TWh**



Vehicle to Grid – Battery Electric Vehicles in a Smart Grid:
10 Mio. Battery Electric Vehicles (BEV) with 10 kWh Vehicle to Grid storage

Storage Capacity: **0,1 TWh**



1000 Tesla Mega Batteries
(1000x 100 MW, 129 MWh, 50 Mio € ⇒ Total cost of 50 Billion €)

Storage Capacity: **0.13 TWh**



Hydrogen Gas Storage:
(similar to Natural Gas storage)

Storage Capacity: **> 50 TWh**

Existing infrastructure

Energy Transport capacity – Public Acceptance



1 gas pipeline ($\varnothing 1,20\text{m}$) transports as much energy as **8** power pylons (of 3 GW each)

The Future of Hydrogen

Seizing today's opportunities



Report prepared by the IEA
for the G20, Japan



HYDROGEN: A RENEWABLE ENERGY PERSPECTIVE

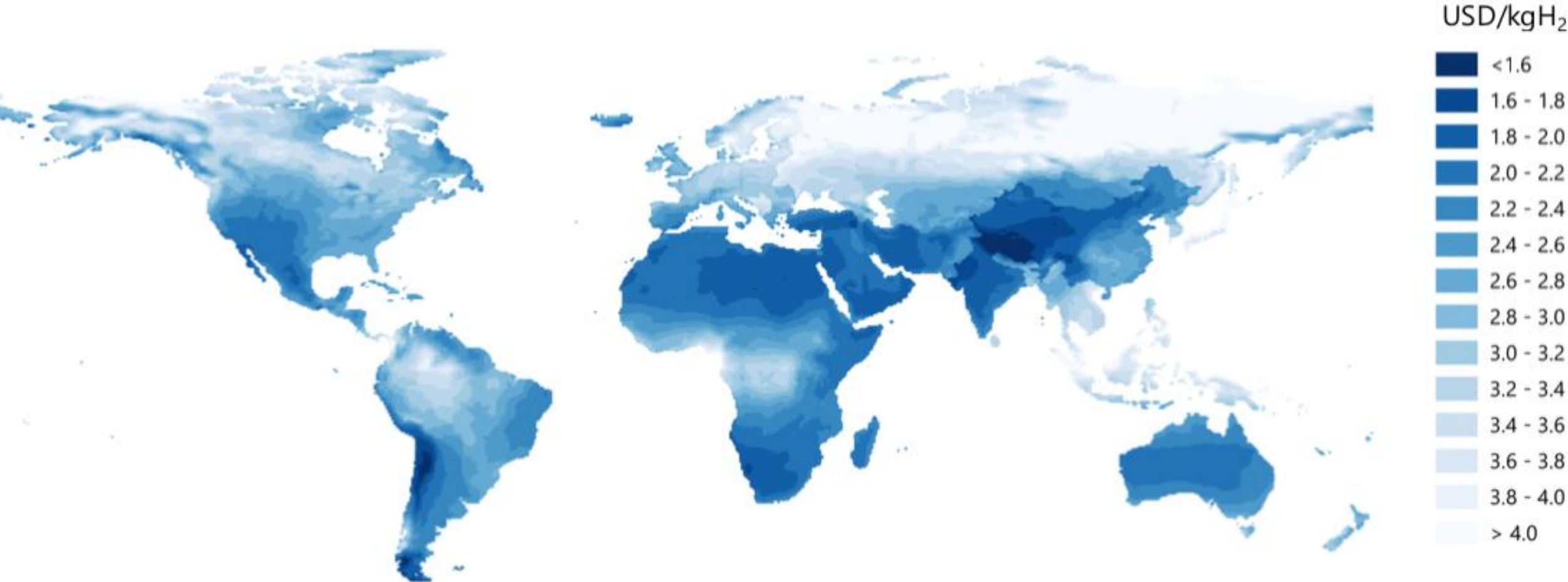
Report prepared for the
2nd Hydrogen Energy Ministerial Meeting
in Tokyo, Japan



Global importance of H2 massive in order to achieve Paris Climate targets

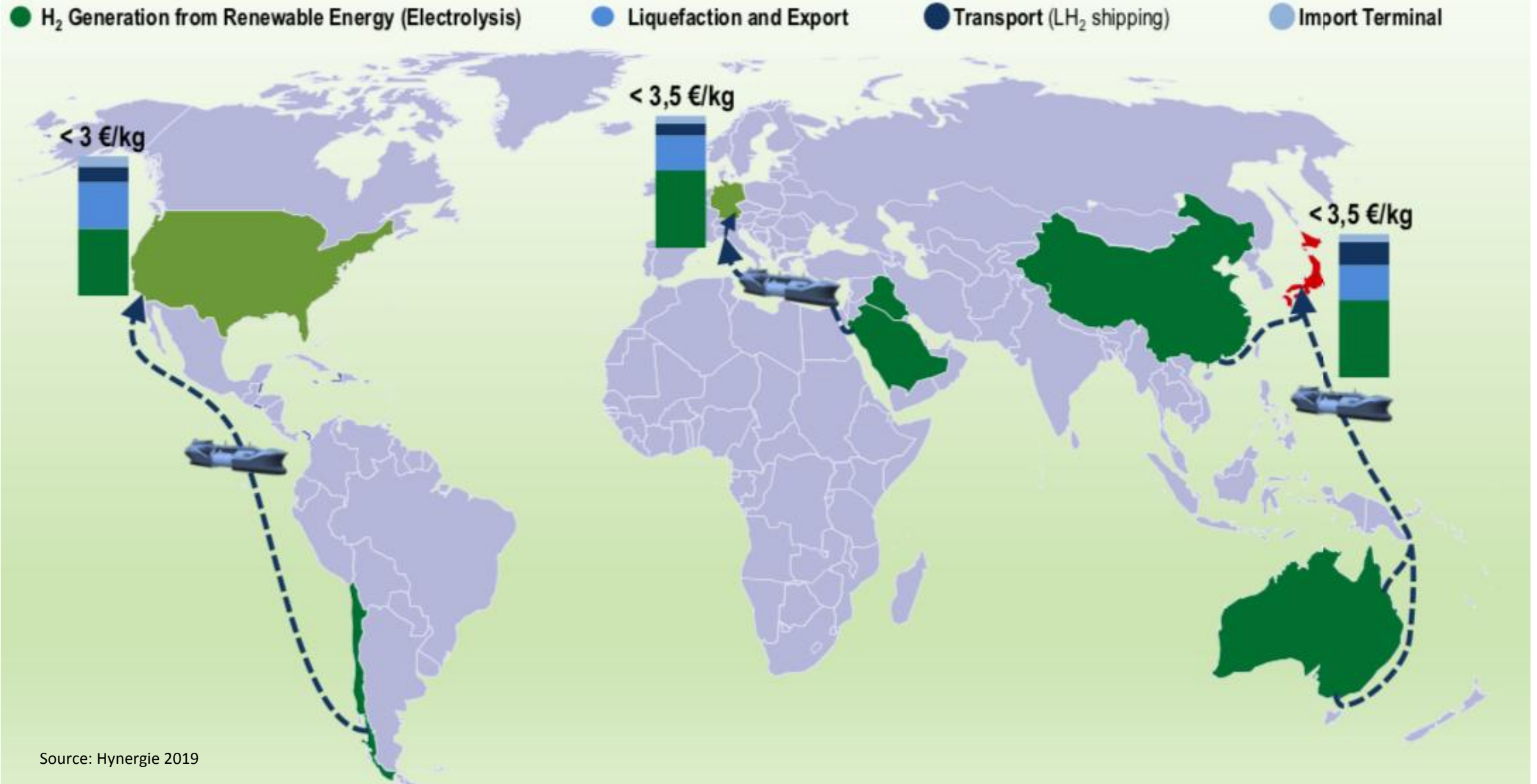
Global Conditions for Renewable Hydrogen

Long-term hydrogen production costs from solar & wind systems



Source: IEA, 2019

How to transport renewable Hydrogen?



Europe will start a „Green Deal“?



Frans Timmermans

Executive Vice President EU Commission

“Hydrogen could be a huge opportunity for our economy”

“It is not that difficult to use gas infrastructure to import [green] hydrogen using gas infrastructure”

“we need to protect our industries and [...] help them free themselves from fossil fuels, for example when hydrogen is used in the manufacturing of steel”



What's the Green Deal?

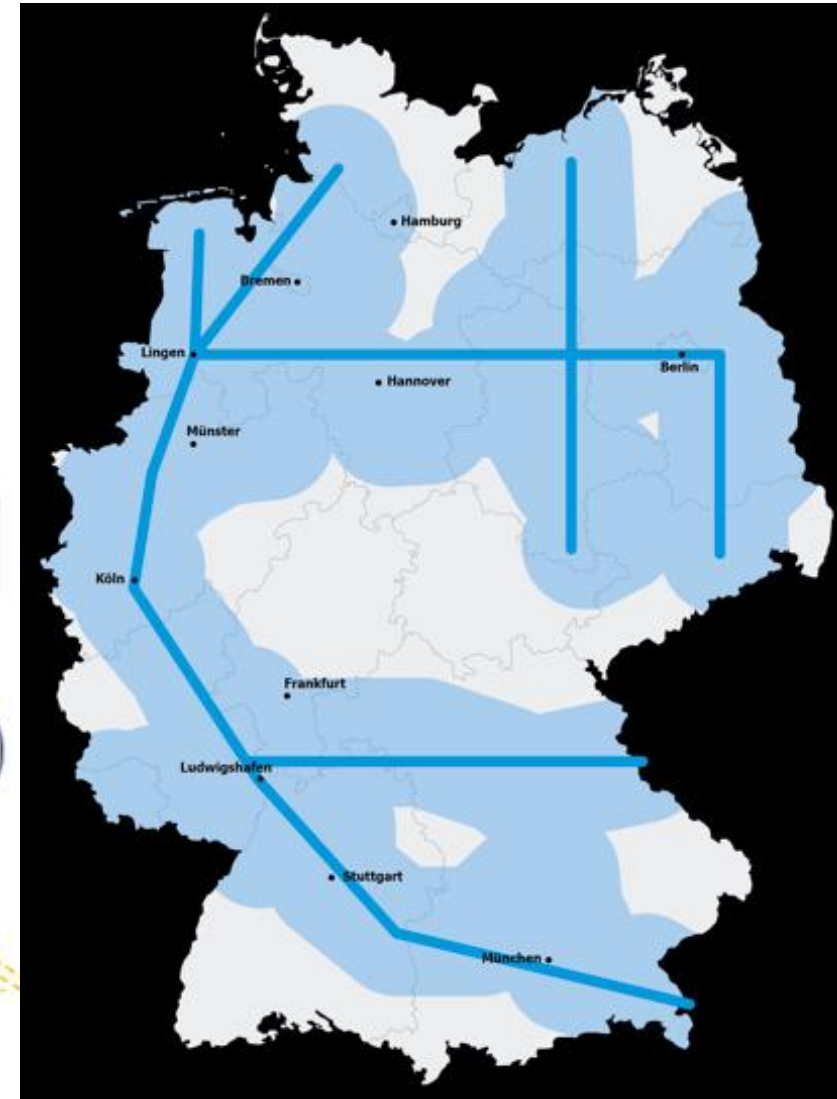
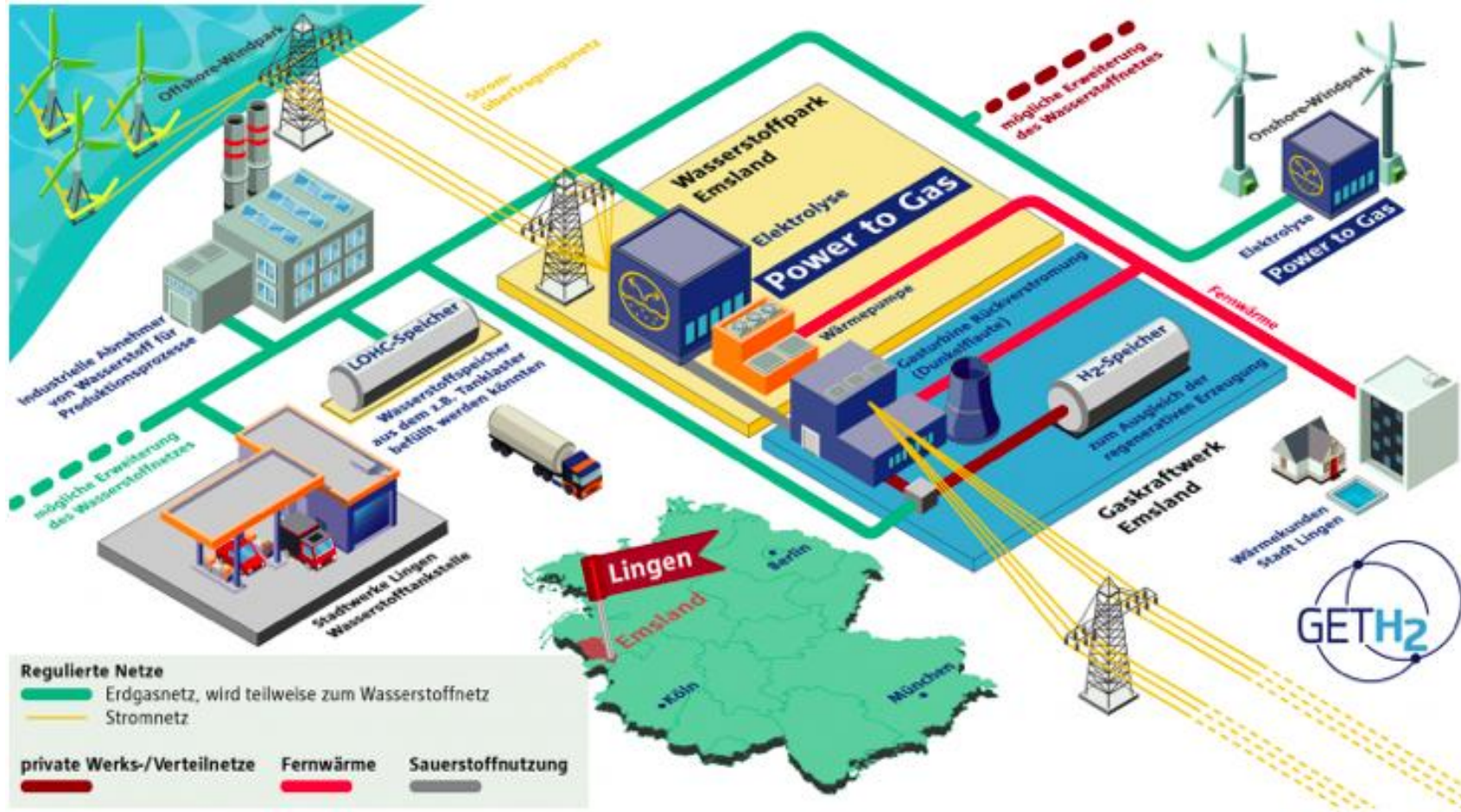


Source: EU Commission

How to do the job?



Example in Germany: GetH2





European Commission

#hydrogen4climate

Hydrogen for Climate Action

How to kick start the EU Hydrogen Industry
to achieve the EU climate goals?

9 October 2019 - Brussels

Hydrogen Europe

www.hydrogen4climateaction.eu

11 Projects presented

Hydrogen for Climate Action

How to kick start the EU Hydrogen Industry to achieve the EU climate goals?

Green Octopus

PURPOSE: Creating a backbone of clean hydrogen between France - Belgium - The Netherlands - Germany, serving hydrogen supply and demand, facilitated by the ports and industrial clusters. Integrating energy systems and coupling sectors.

BENEFITS: Maximizing implementation of offshore wind energy, transforming natural gas pipelines to hydrogen pipelines, replacing fossil fuels in ports by green hydrogen. Making hydrogen endusers more sustainable (industry/mobility)

COUNTRIES:

20 companies

9.700M investment

PV+Wind

6,0 GW

2000 km

20 HRS

250 HDV

25 ships

Steel/Ref/Chem

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hydrogen4climateaction.eu

Hydrogen for Climate Action

How to kick start the EU Hydrogen Industry to achieve the EU climate goals?

Green Hydrogen @ Blue Danube

PURPOSE:

- Produce green hydrogen on a large scale in South-East Europe using off-grid wind and solar energy
- Transport hydrogen via the River Danube to hydrogen users in countries of the Interreg Danube Transnational region
- Set up the necessary infrastructure in the involved member states

BENEFITS: Establishing this trans-European value chain will:

- Reduce dependence on fossil energy imports: renewables made in Europe
- Increase security of energy supply: increased flexibility and resilience
- Contribute to reach climate objectives of Member States
- Strengthen key European industry sectors

COUNTRIES:

12 companies

5.850M investment

Solar+Wind

2,0 GW

40 barges

Steel/Ref/Chem

100 HRS

500 HDV

5.000 new + 50.000 secured

80.000 t/year

CO₂ - 3.200.000 t/year

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Green Octopus

PURPOSE: Create a backbone of clean hydrogen between France - Belgium - The Netherlands - Germany, covering hydrogen supply and demand, factored by the ports and industrial clusters, integrating energy systems and existing sectors.

BENEFITS: Maximising implementation of offshore wind energy, transforming natural gas pipelines to hydrogen pipelines, replacing fossil fuels in ports to green hydrogen. Making hydrogen endusers more sustainable (industry/mobility)



COUNTRIES:



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Green Hydrogen @ Blue Danube

PURPOSE: Produce green hydrogen on a large scale in South-East Europe using off-grid wind and solar energy
- Transport hydrogen via the River Danube to hydrogen users in countries of the Rhine-Danube Transnational region
- Set-up the necessary infrastructure in the involved member states

BENEFITS: Establishing the trans-European value chain will:
- Reduce dependence on fossil energy imports, renewables made in Europe
- Increase security of energy supply, increased flexibility and resilience
- Contribute to reach climate objectives of Member States
- Strengthen the European hydrogen sector.



COUNTRIES:



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Hydrogen for Climate Action

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Green Spider

PURPOSE: Development of a large scale green hydrogen production and its associated value chain by using renewables energies and distribution across Spain and into central Europe.

BENEFITS: Green hydrogen production from more than 1,000 of renewable energies, considering wind, solar and hydro, that will be locally consumed and also exported to Europe by using LHC technology.
Establishing the first large scale green hydrogen production and the first European transport chain to decentralize all sectors and strengthening the European energy network.



COUNTRIES:



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Hydrogen for Climate Action

How to kick start the EU Hydrogen Industry to achieve the EU climate goal?



Black Horse

PURPOSE: Lower CO2 emissions in the heavy duty transport sector
- Help reach the GHG objective for 2035
- Make hydrogen trucks commercially viable for transportation companies
- Shift from diesel to green hydrogen

BENEFITS: Construction of renewable power plants
- Production of green hydrogen for transport sector
- Build-up of large scale, state-of-the-art hydrogen refueling trails
- Build HFC infrastructure for HDV, but also for passenger cars and buses



COUNTRIES:



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Hydrogen for Climate Action

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Silver Frog

PURPOSE: Build EU gigawatt manufacturing for cutting-edge solar PV and water electrolysis technologies
- Produce large quantities of renewable hydrogen, transported to large scale industrial and urban use gas pipelines
- Roll-out integrated and replicable solutions in several EU countries

BENEFITS: Foster significant CO2 emissions reductions in hard-to-abate industrial sectors
- Upgrade the gas infrastructure for renewable hydrogen transport
- Capture EU energy security via domestic production of hydrogen and clean technologies made in Europe
- Obtain EU industrial leadership supporting Europe's "Green Deal" by creating long-term industrial jobs in transitioning regions



COUNTRIES:



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Hydrogen for Climate Action

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Zero Emission Urban Delivery @ Rainbow Unhycorn

PURPOSE: Offer delivery companies a specific zero emission solution for urban delivery allowing extensive use of vehicle and high payload capacity
- Deliver green hydrogen partly zero with local to allow CO2 equivalent TCO for environmental costs
- Offer approach to urban and suburban areas of 20 major European cities with HDV other transporting 70% palette or producing it locally with major solar electrolyzers

BENEFITS: Allow full-range zero emission alternative for urban and suburban delivery
- Improve air quality and drastically reduce CO2 emissions in major European cities
- Facilitate transition of logistic freight operation and commercial activity towards zero emission
- Facilitate the deployment of H2 goods' transportation at regional and international scale




COUNTRIES:



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Hydrogen for Climate Action

How to kick start the EU Hydrogen Industry to achieve the EU climate goal?



White Dragon

PURPOSE: Produce green hydrogen by photoelectrolysis, membrane water electrolysis producing hydrogen, power, and heat
- Feed-in hydrogen into the existing district heating system
- Store hydrogen using technologies for liquid, LOHC and compressed hydrogen
- Transporting water hydrogen through the steam by Transatlantic Gas Pipeline for further use
- Using active fuel cell power (combined electrolyser and fuel cell)

BENEFITS: Make the heavy-duty logistic sector more sustainable
- Establish a green hydrogen economy competitive with diesel
- Green hydrogen will contribute to reach climate objectives of Member States
- Support the European value chain leadership in heavy logistics



COUNTRIES:



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Hydrogen for Climate Action

How to kick start the EU Hydrogen Industry to achieve the EU climate goal?



The Orange Camel

PURPOSE: 2000 zero emission hydrogen trucks for steel distribution
- Develop a balanced network of hydrogen refueling stations
- Create leverage for the hydrogen car and bus market

BENEFITS: Make the heavy-duty logistic sector more sustainable
- Establish a green hydrogen economy competitive with diesel
- Green hydrogen will contribute to reach climate objectives of Member States
- Support the European value chain leadership in heavy logistics

COUNTRIES:



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Hydrogen for Climate Action

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Hybrit

PURPOSE: Decarbonising the energy-intensive steel value chain by replacing fossil fuels and using low-carbon materials used in the steel production with hydrogen made from fossil free electricity

BENEFITS: The technology has a potential to drastically reduce CO2 emissions and contribute to achieve the Paris agreement
- Large scale CO2 generation and storage, not only support the transition towards a low-carbon energy system, but can also play an important role in the renewable energy system
- The decarbonisation of hydrogen sector (steel-making, steel reduction) by CO2, is an average carbon, which gives the steel industry flexibility to transport energy in the form of CO2 to the carbon rich sectors to electric steel (Duisenberg) or to use on steel transport, rather than to import and use carbon ore in steel furnaces.

COUNTRIES:



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Hydrogen for Climate Action

How to kick start the EU Hydrogen Industry to achieve the EU climate goal?



H2Go

PURPOSE: Demonstrate the potential of hydrogen powered steel transport from Northwest to Southeast transport through a systems integration of production, storage, storage, storage, logistics operators, O&M, filling stations, home and mobile heating

BENEFITS: Offer a zero emission and well-coordinated large-scale investments along the entire value chain will
- Build-up the elements of the value chain already developed (operational approach)
- Integrate and access HFC technology (storage, logistics and station operators) of large-scale transportation facts as part of the hydrogen value chain in Europe
- Provide valuable technological and operational insights for further systematic efforts to decarbonise European mobility system



COUNTRIES:



Hydrogen Europe [#hydrogen4climate hydrogen4climateaction.eu](https://hydrogen4climate.hydrogen4climateaction.eu)

Hydrogen for Climate Action

How to kick start the EU Hydrogen Industry to achieve the EU climate goal?



Blue Dolphin

PURPOSE: Produce a green gasification system for steel based on hydrogen
- Build gas pipes for liquid hydrogen
- Build gasification plant based on hydrogen production
- Roll-out solutions for hydrogen management
- Stop pollution of the sea

BENEFITS: Enable zero emission-implications of very large ships in harbor zones
- Ability to bring hydrogen to where it is needed without pipelines
- Stop pollution of the sea

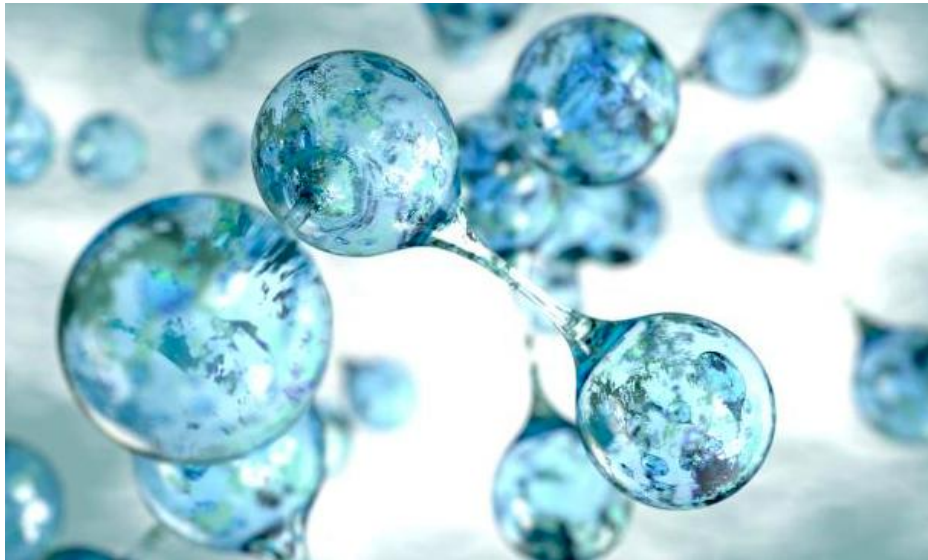


COUNTRIES:

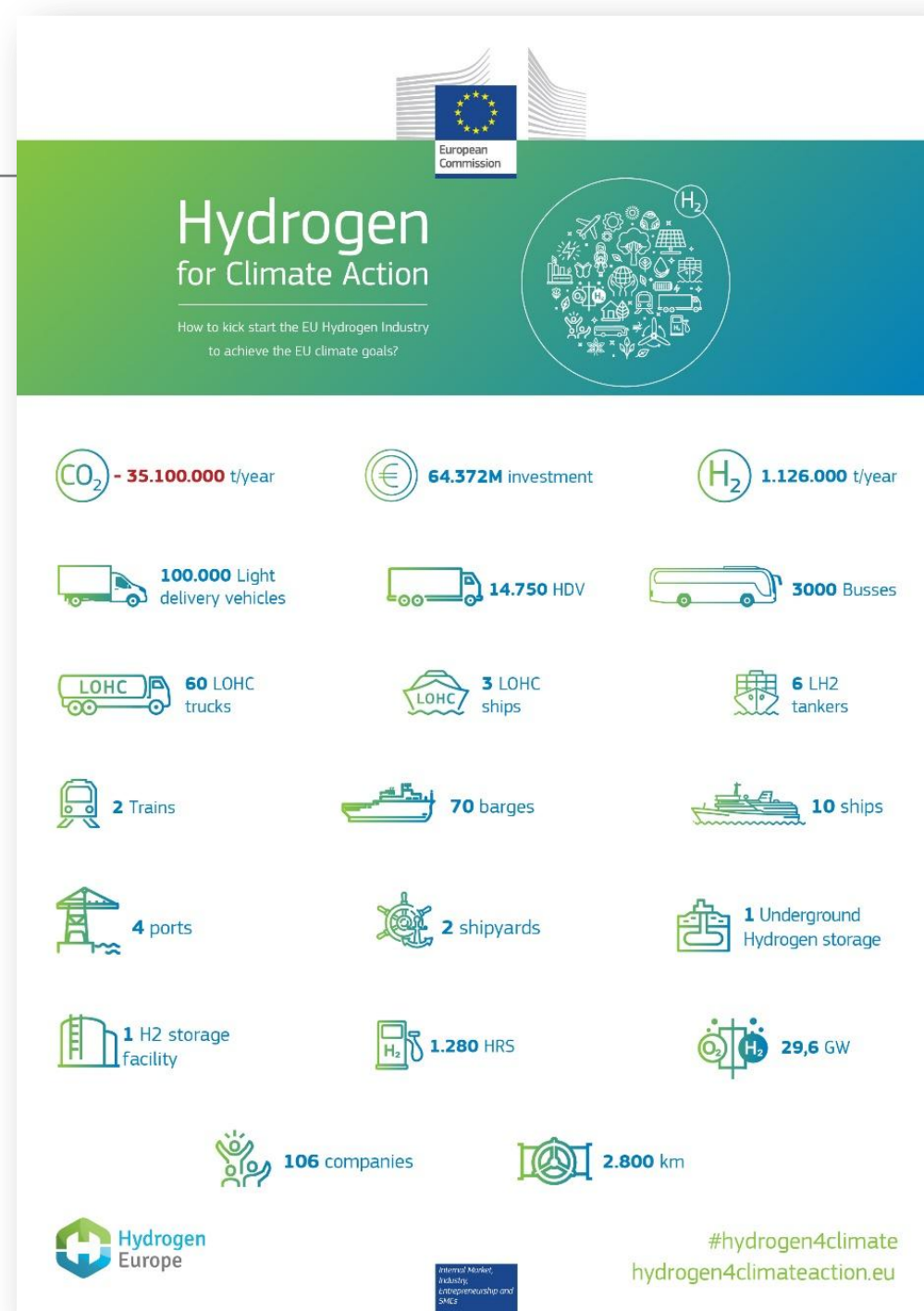


Hydrogen Europe [#hydrogen4climate hydrogen4climateaction.eu](https://hydrogen4climate.hydrogen4climateaction.eu)

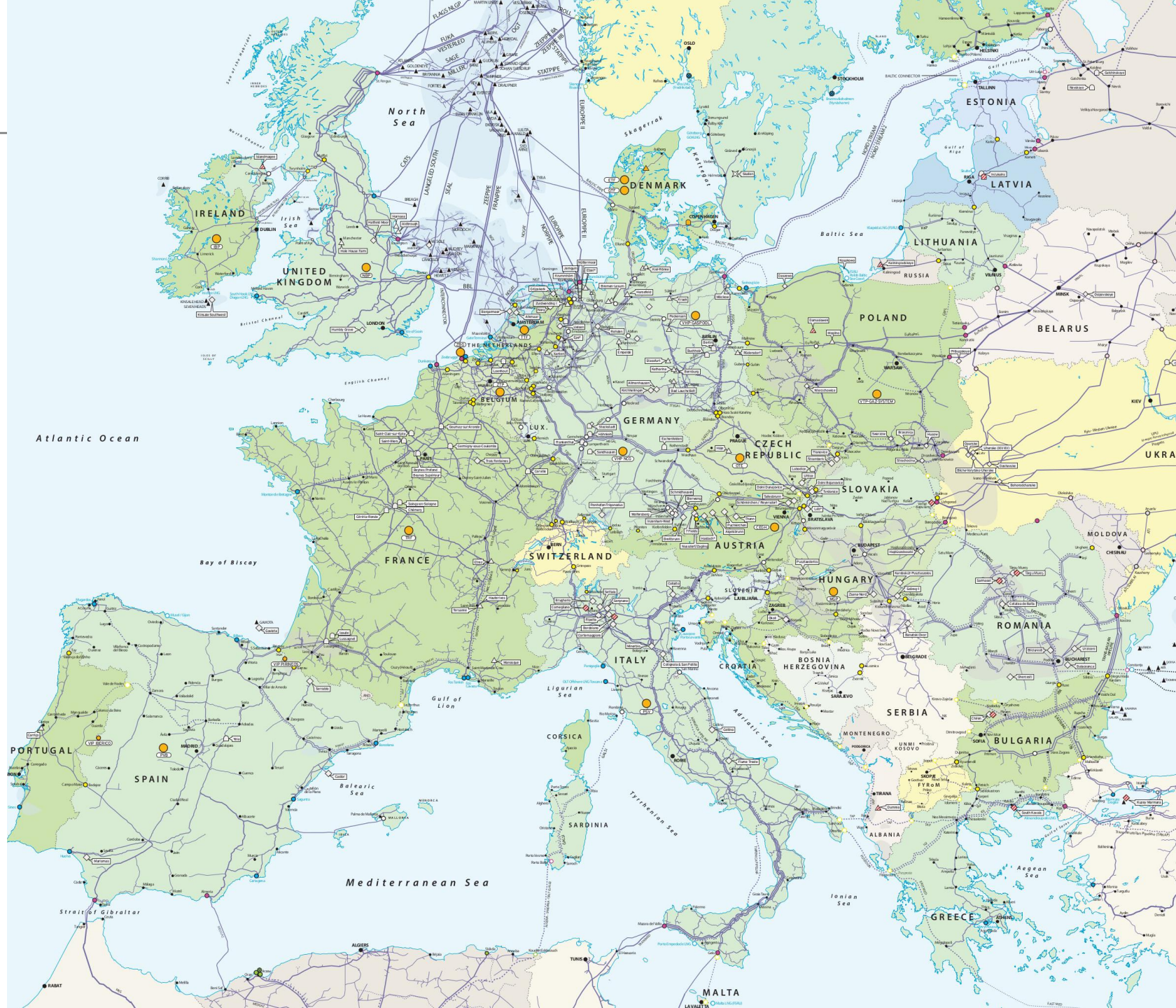
Accumulated capacity



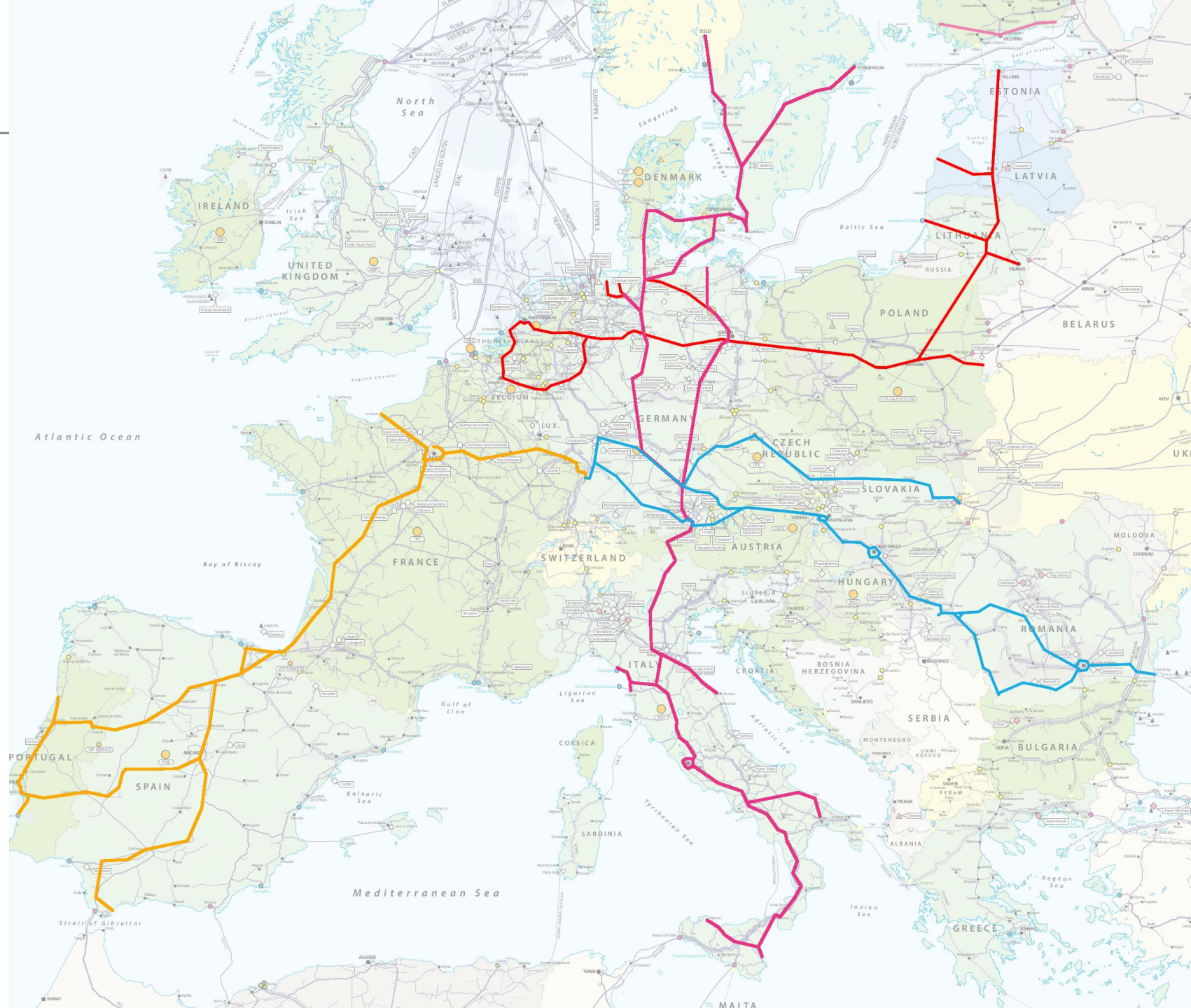
www.hydrogen4climateaction.eu



EU Gas Grid



TEN-T Corridors



IPCEI (1)

H2-DEMAND:

150 Trains
1000 Trucks
5000 City Bus
10.000 LDV

1 Fertiliser
2 Refinery
2 Steel

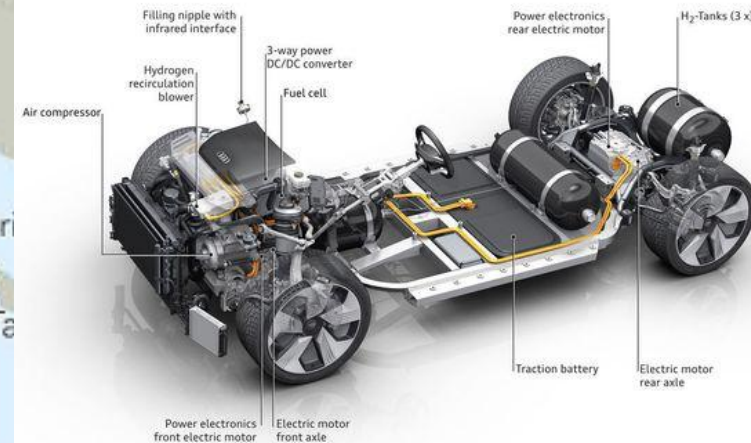
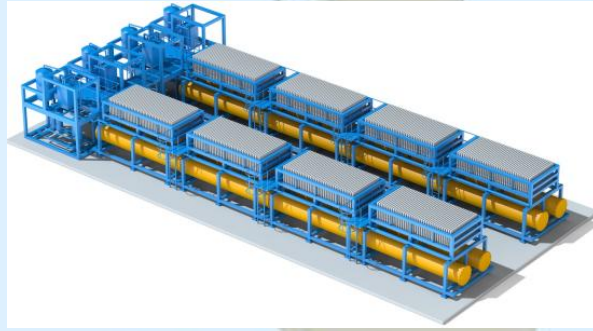


IPCEI (1)

STRATEGIC H2-EQUIPMENT:

1 Liquefaction
1000 H2 Stations
20 GW Electrolyser

FC Stacks
H2 Tanks
Mobility Platform



Power-to-Gas



Salt caverns for H₂ storage



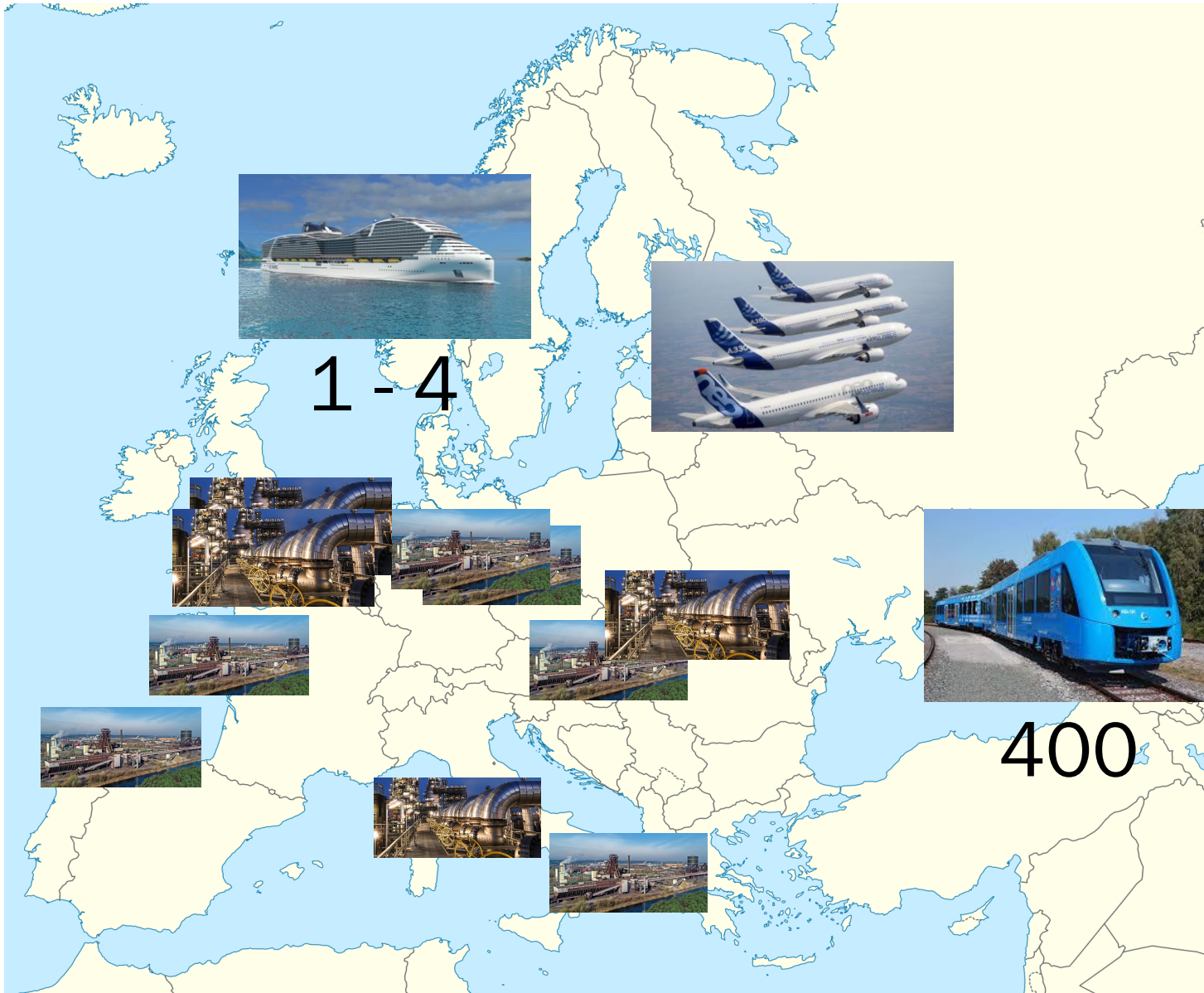
H₂ fit pipelines



LOHC storage



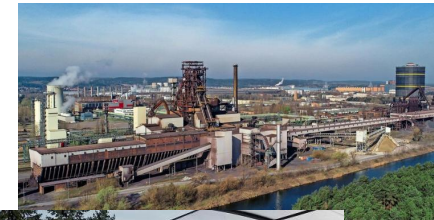
Possible H2 demand in Europe



4 Steel



4 Refineries



2 Fertiliser



100.000



20.000



25.000

Possible production capacities in Europe



H2 Refuelling stations



H2 Tanks



Fuel Cell Stacks



H2 Auto Platform



Electrolyser factory



Power-to-Gas

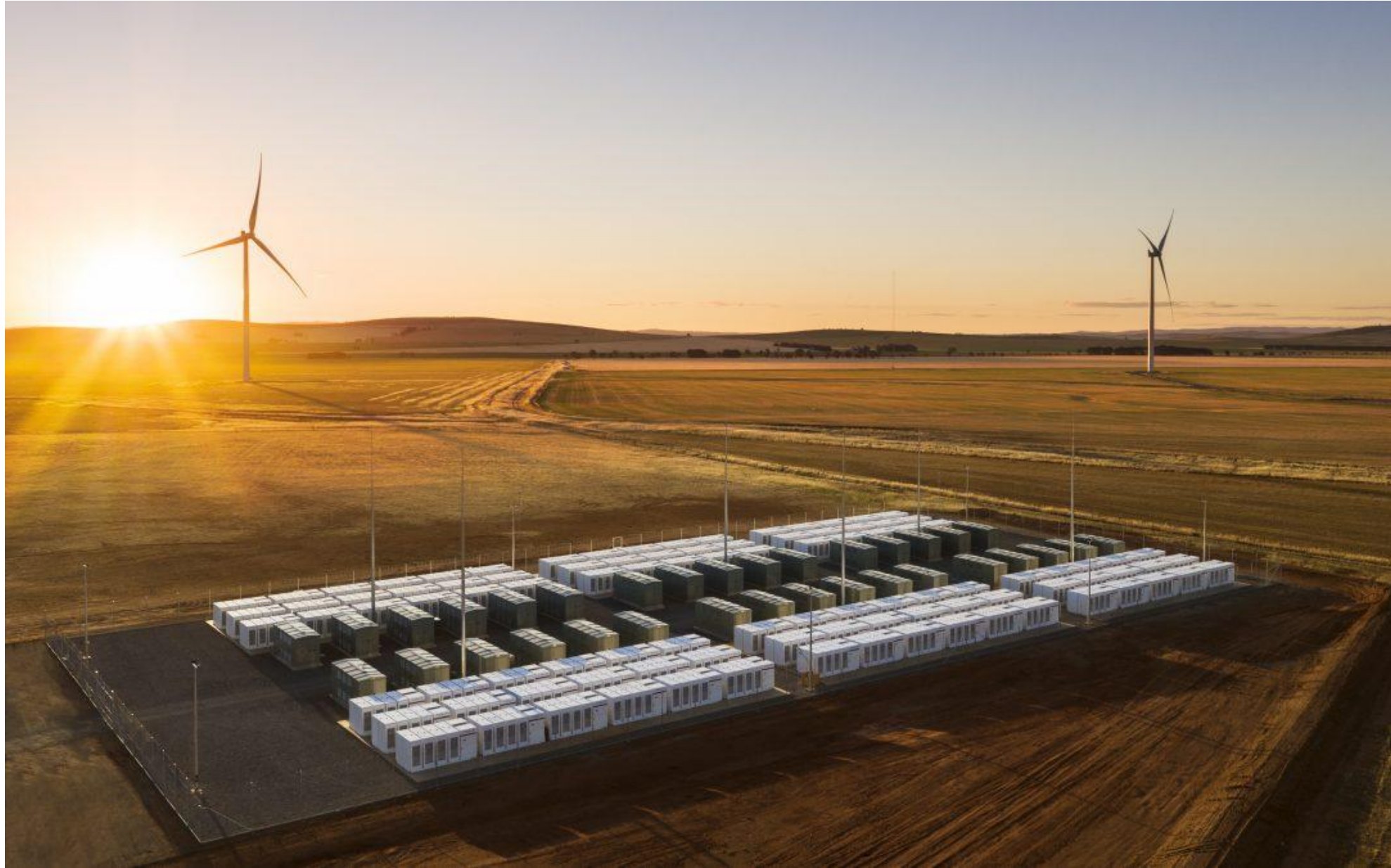


LOHC

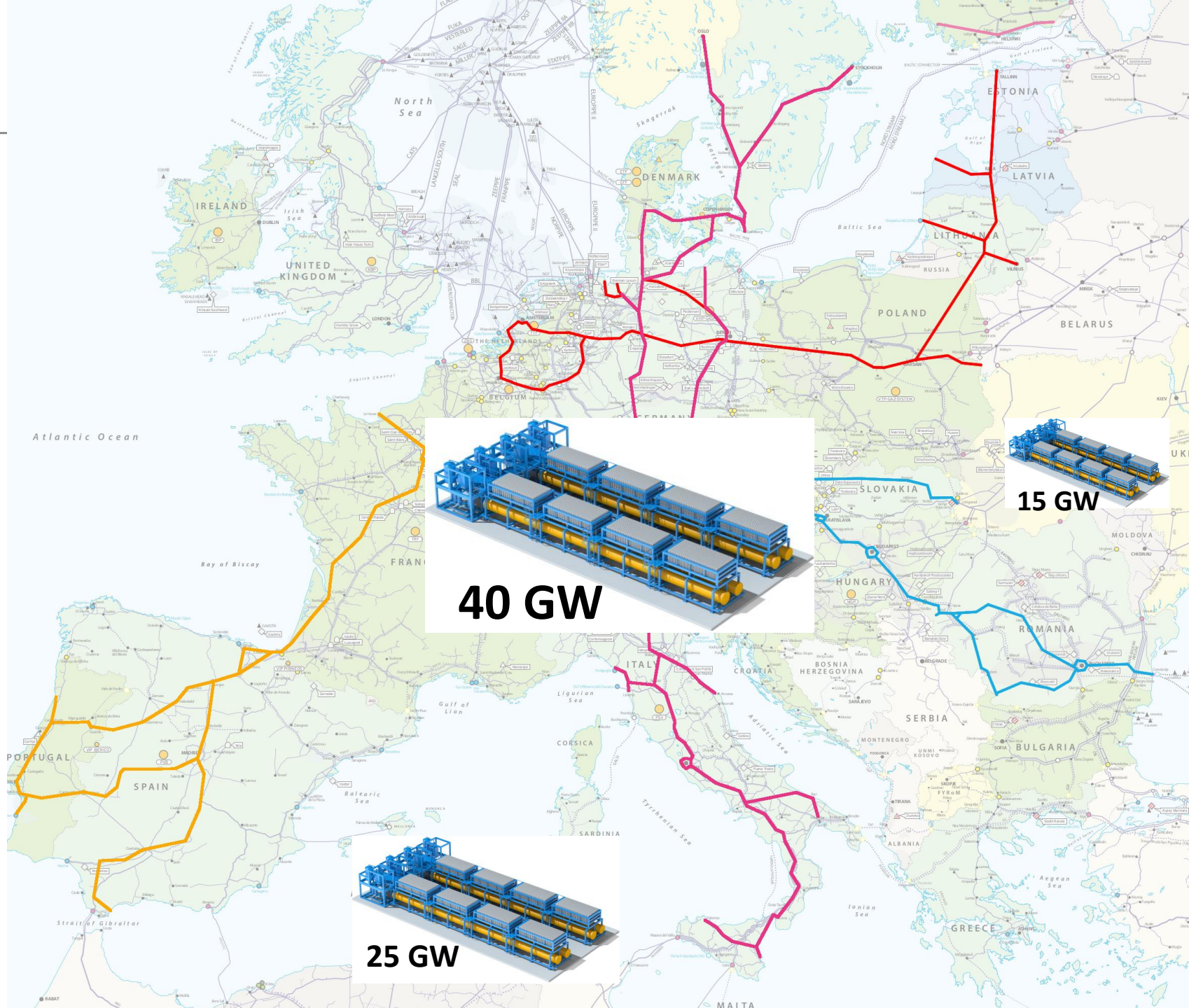


H2 Liquefaction

2x40 GW Green Hydrogen Alliance



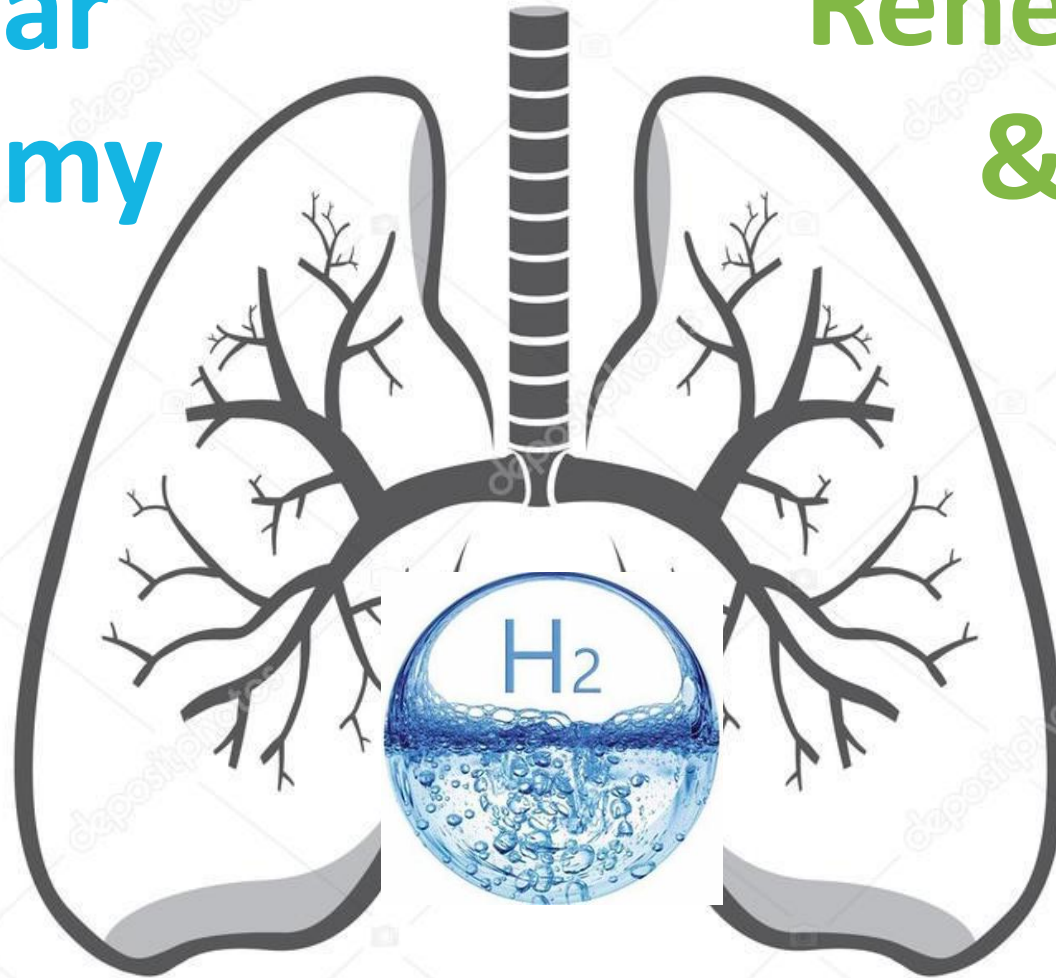
2x40 GW
Green
H2
Alliance



Hydrogen = „Lung of the Green Deal“

**Circular
Economy**

**Renewable Energy
& Hydrogen**



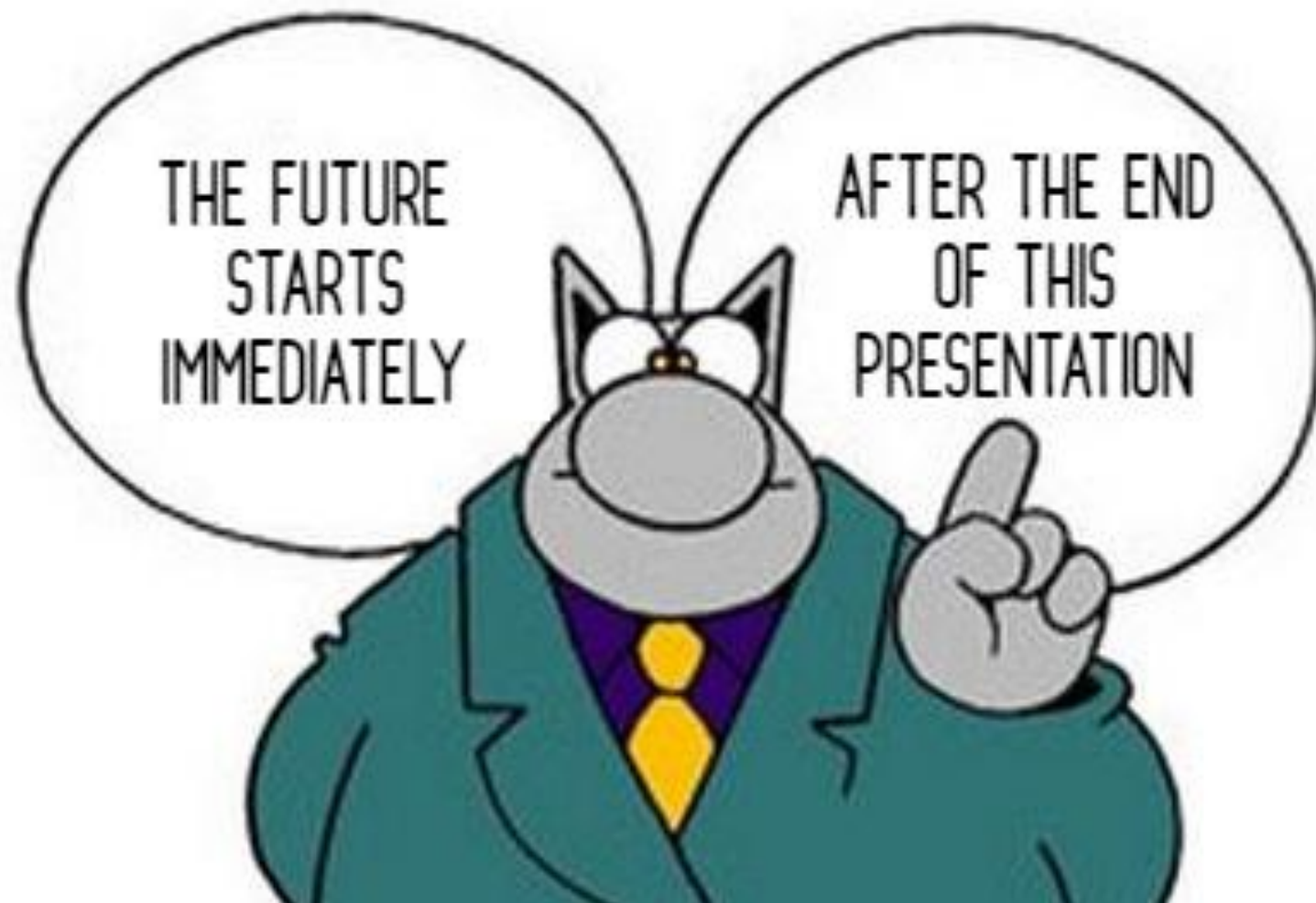


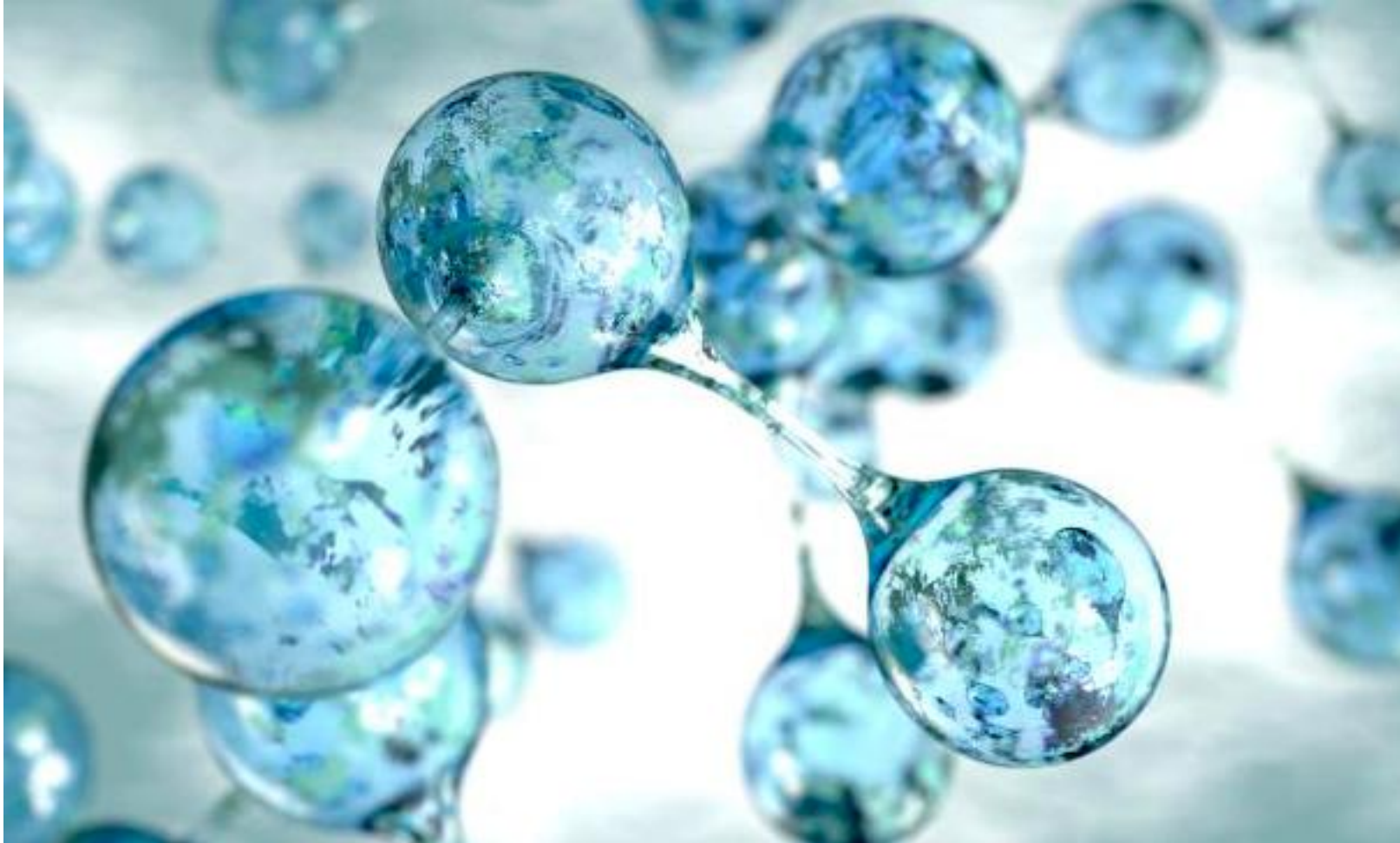
Contacts

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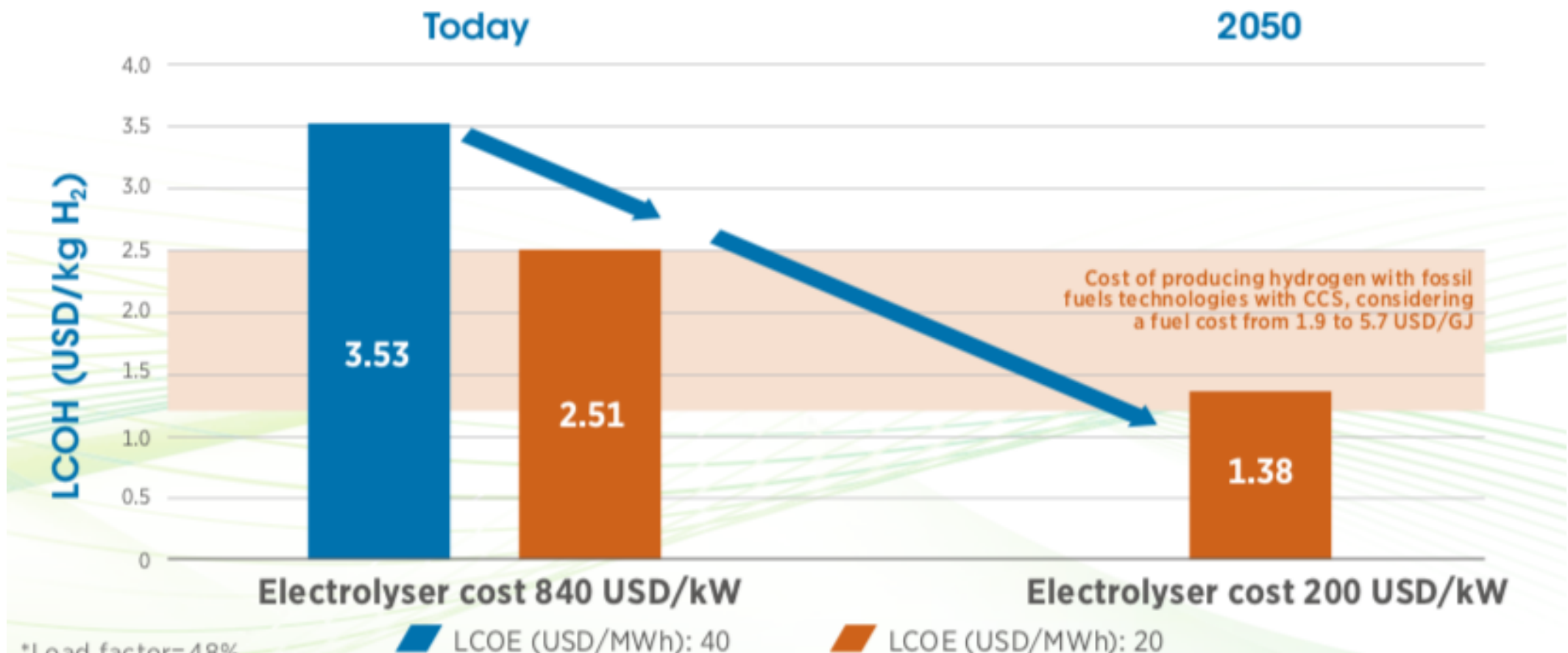




Electrolyser costs will fall

Falling renewable electricity and electrolyser prices make green hydrogen the economic supply option.

Figure 9: Hydrogen costs at different electricity prices and electrolyser Capex*



*Load factor=48%
Source: IRENA, 2018a

Renewable Hydrogen becomes competitive

Figure 14: Hydrogen production costs from solar and wind vs. fossil fuels

