26 May 2021

HYDROGEN EUROPE

Gasdagarna

Sabrine Skiker
EU Policy Manager – land transport

Hydrogen Europe


ABENGOA
Advent
ArcelorMittal
AeH2
SPANISH HYDROGEN ASSOCIATION
AFHYPAC
AFS
AGFA
Air Liquide
AIR PRODUCTS
AIRBUS
ALSTOM
AMF
BAKERY SYSTEMS
AMHYD
Association Marocaine pour l'Hydrogène et le Développement Durable
AngloAmerican
ANSALDO ENERGIA
aperam
APREN
Associação de Energias Renováveis
AsahiKASEI
ASAHI KASEI EUROPE
atawey
ANYTIME, ANYWHERE, ENERGY
AVGUSTA
AVL
aspo
Baker Hughes
BALLARD
BDR THERMEA GROUP
Bioway
Blue World Technologies
BMW Group
bp
Brintbranchen
CaetanoBus
capitalenergy
CCS GLOBAL
CENERGY HOLDINGS
ceres
CHANTIERS DE L'ATLANTIQUE
CHART
Cooler By Design.™
CHEREAU
INNOVATION DRIVES YOU FORWARD
CNH INDUSTRIAL
COLRUYTGROUP
CMB
convion
DAIMLER
DAM GROUP
DEMACO
DEME CONCESSIONS
DENSO
Crafting the Core
DESFA
Hellenic Gas Transmission System Operator S.A.
DKV
DTEK
DWV
Deutscher Wasserstoff- und Brennstoffzellen-Verband
e·on
EATON
Powering Business Worldwide
EDF
EFCF EUROPEAN FUEL CELL FORUM
Fuel cell technology
elcogen
elogen
elringklinger
EMEC
THE EUROPEAN MARINE ENERGY CENTRE LTD
enagas
ENERGINET
ENGIE
equinor
ervia
ESB
Energy for generations
Hydrogen Europe
Estonian Association of Hydrogen Technologies
Everfuel
EVONIK
Leading Beyond Chemistry
EWE
Falck Renewables
PURE POWER TO GROW
faurecia
FiveTHydrogen
fuelcellenergy
FUEL CELL POWERTRAIN
FEV
FINCANTIERI
Finnish Energy
FLUXYS
fortum
FREUDENBERG
INNOVATING TOGETHER
VORWERK
Fronius
FTI CONSULTING
FUSION-FUEL™
Endless energy. Unlimited future.
galp
gasunie
new energy
Garrett
ADVANCING MOTION
GAZ system
GAUSSIN
Be Faster... Safer & Cleaner
GE
GENCELL
GREEN HYDROGEN SYSTEMS
greenGT
GRTgaz
GTT
Technology for a Sustainable World
GUNVOR
H2LV
h2energy
H2B2
H2
H2V
HAFFNER energy
HALDOR TOPSOE
Haskel
An Accudyne Industries Brand
HDF
MASS STORAGE ENERGY
Helion
HYDROGEN POWER
HELLENIC PETROLEUM
HILITE
INTERNATIONAL
Hinicio
HITACHI
Inspire the Next
HOLTHAUSEN
CLEAN TECHNOLOGY
HONDA
Howden
Hungarian Hydrogen and Fuel Cell Association
HY2GEN AG
hydrogenious
LOHC TECHNOLOGIES
H2YDROPOLE
HyET
Hydrogen Efficiency Technologies
HYGEAR
HyMove
hypion
HYSYTECH
Developing Solutions
HYTEP
CZECH HYDROGEN TECHNOLOGY PLATFORM
SINCE 2007
HYUNDAI
IBERDROLA
ÍSLENSK
NYORKA ehf
ICELANDIC NEW ENERGY Ltd.
iht
INDUSTRIE HAUTE TECHNOLOGIE
IMI
INEA
HZwo
Antrieb für Sachsen
Hydrogen Europe
IRD


ITM POWER
Energy Storage | Clean Fuel
JSW SA
John Cockerill
JM Johnson Matthey
Inspiring science, enhancing life
KEPCO
kiwa
Q8 Research
LANDIRENZO GROUP
H2LV
Lhyfe
LIEBHERR
Linde
Lithuanian Hydrogen energy association
Logan Energy limited hydrogen technologies
LUXFER GAS CYLINDERS
LOTOS
MAYFAIRMARINE
McPhy
Mercedes-Benz FuelCell
metacon
CLEAN ENERGY FOR INDEPENDENCE
MYTILINEOS
MICHELIN
MITSUBISHI POWER
MOL
MOTOR OIL (HELLAS)
CORINTH REFINERIES S.A.
MTSA
TECHNOPOWER
MTU Aero Engines
group
m v m
Nedstack
PEM FUEL CELLS
nel
NESTE
NEA GROUP
NORSK HYDROGENFORUM
hydrogen.no
Nouryon
NOVA SWISS
NWBA
OMV
ontras
Open Grid Europe
The Gas Wheel
Ørsted
PAUL WURTH
SMS group
Persee
smarter energies
PGE
Polska Grupa Energetyczna
PGNiG
ORLEN
planetpower
finance
PLASTIC OMNIUM
PLUG POWER
POLENERGIA
KLASTER
TECHNOLOGII WODOROWYCH I CZYSTYCH TECHNOLOGII WĘGLOWYCH
POPPE+POTTHOFF
Port of Antwerp
Port of Rotterdam
POWERCELL
PowiDian
POWER IN ALL MERIDIANS
PRF
PROTON MOTOR
Fuel Cells · Power Systems
REN
REPSOL
Hydrogen Europe
RICARDO
RINA
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BOSCH
Invented for life
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ROLLS ROYCE
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SAFRAN
AEROSPACE · DEFENCE · SECURITY
SAIPEM
SALZGITTER MANNESMANN FORSCHUNG
A Member of the Salzgitter Group
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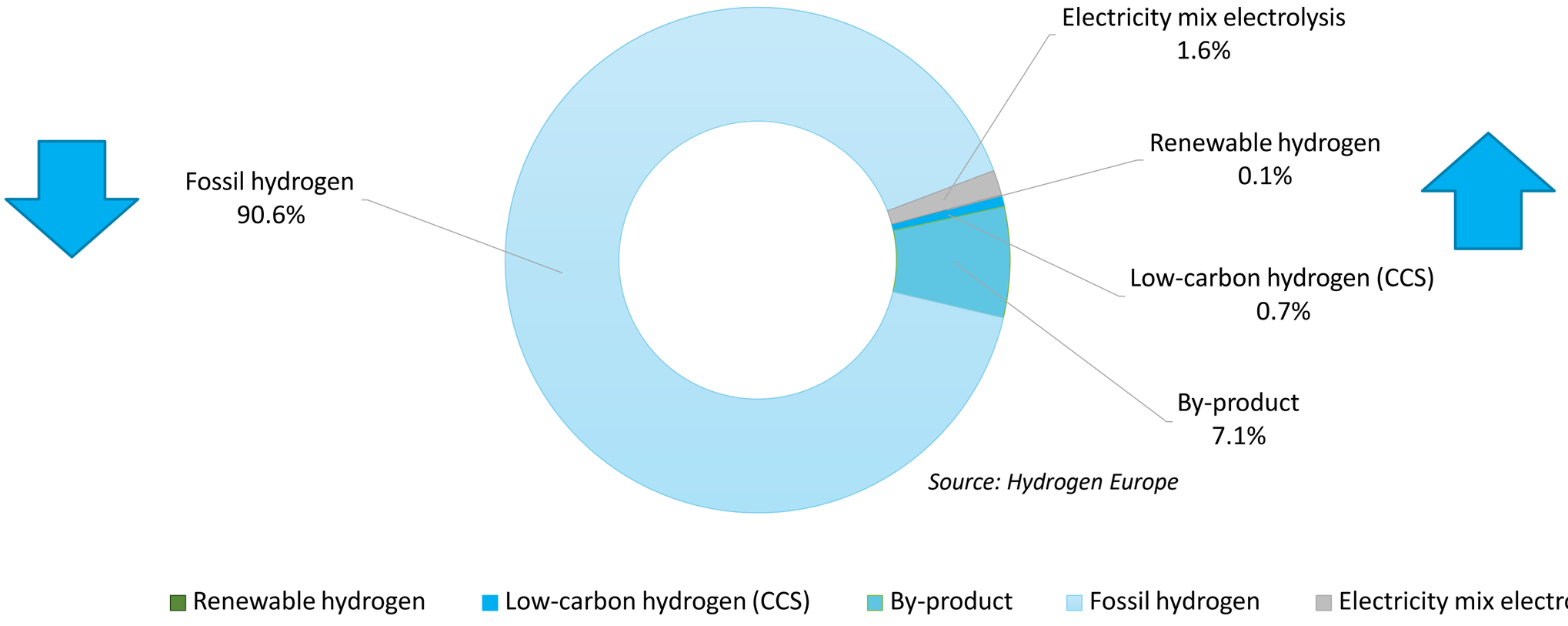
sfice
INNOVATIVE MINDS
SHV ENERGY
SIEMENS
Slovak National Hydrogen Association
SMA
SMARTENERGY
snam
SNCF
SOLARIS
SOLENCO POWER
SOLID POWER
STORAG ETZEL
Energy Storage Solutions
storengy
Sumitomo Benelux s.a./n.v.
sunfire
Swagelok
SYMBIO
A FAURECIA MICHELIN HYDROGEN COMPANY
T.EN
TECHNIP ENERGIES
TECO 2030
TERĒGA
Thyssengas
thyssenkrupp
TOMO GROUP
TORAY
Innovation by Chemistry
TOTAL
TOYOTA
TÜV NORD
TÜV SÜD
Tyczka
UFI
INNOVATION CENTER
UKHFCA
Representing the UK Hydrogen and Fuel Cell Industry
UKRAINIAN HYDROGEN COUNCIL
umicore
uniper
VANHOOL
VÄTGAS SVERIGE
VATTENFALL
VDL
BUS & COACH
Verbund
VIAR VALVOLE
WHATEVER IT FLOWS
VIESMANN
climate of innovation
voestalpine
ONE STEP AHEAD.
VOITH
VOLVO
Vopak
walter tosto
WaterstofNet
WIGA
WOIKOSKI
Worley
energy | chemicals | resources
WORTHINGTON INDUSTRIES
WHITE SUMMIT CAPITAL
Wystrachli
Worldwide art of precision
X-ELIO
YANMAR
ZEG Power
ZE
ZSIS

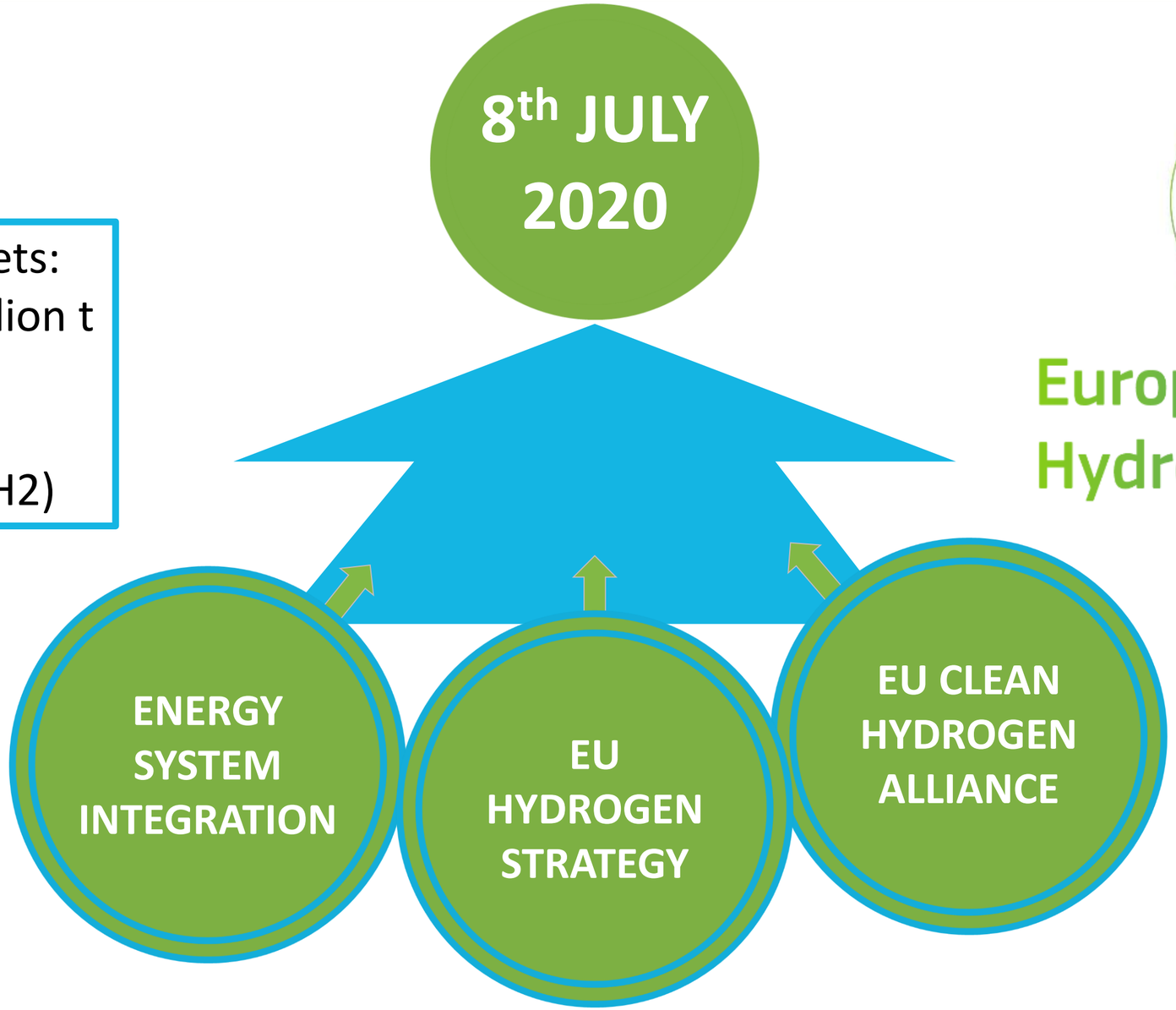
How is hydrogen produced today?



Hydrogen historical day: 3 important EU initiatives

Hydrogen strategy targets:

- 6 GW by 2024 (1 million t renewable H2)
- 40 GW by 2030 (10 million t renewable H2)



European Clean Hydrogen Alliance

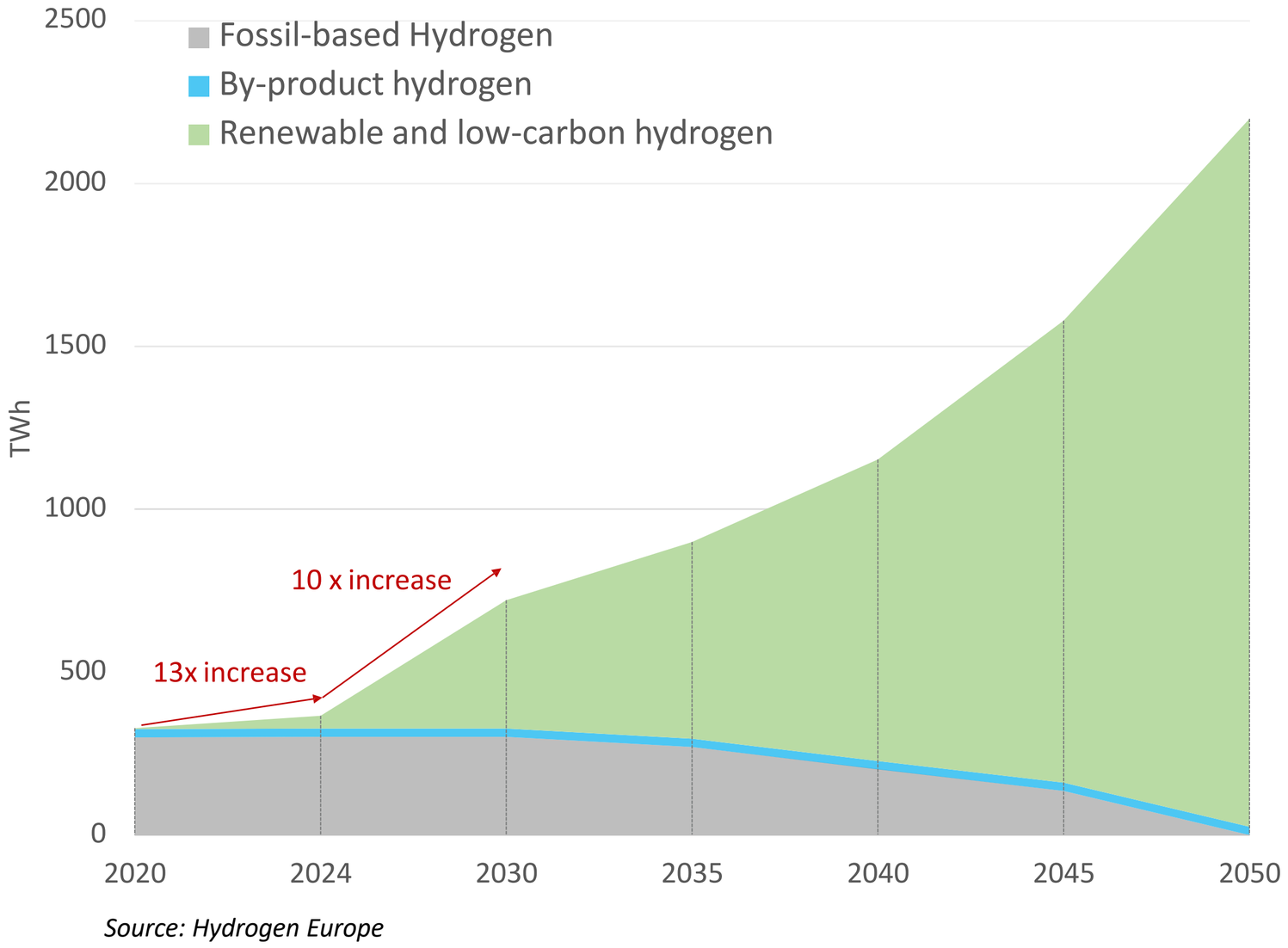
Hydrogen Europe

What we want

Enable clean hydrogen to:

- replace all unabated fossil hydrogen consumption,
- replace fossil fuels and feedstocks in other sectors where hydrogen can play a role – including the transport sector

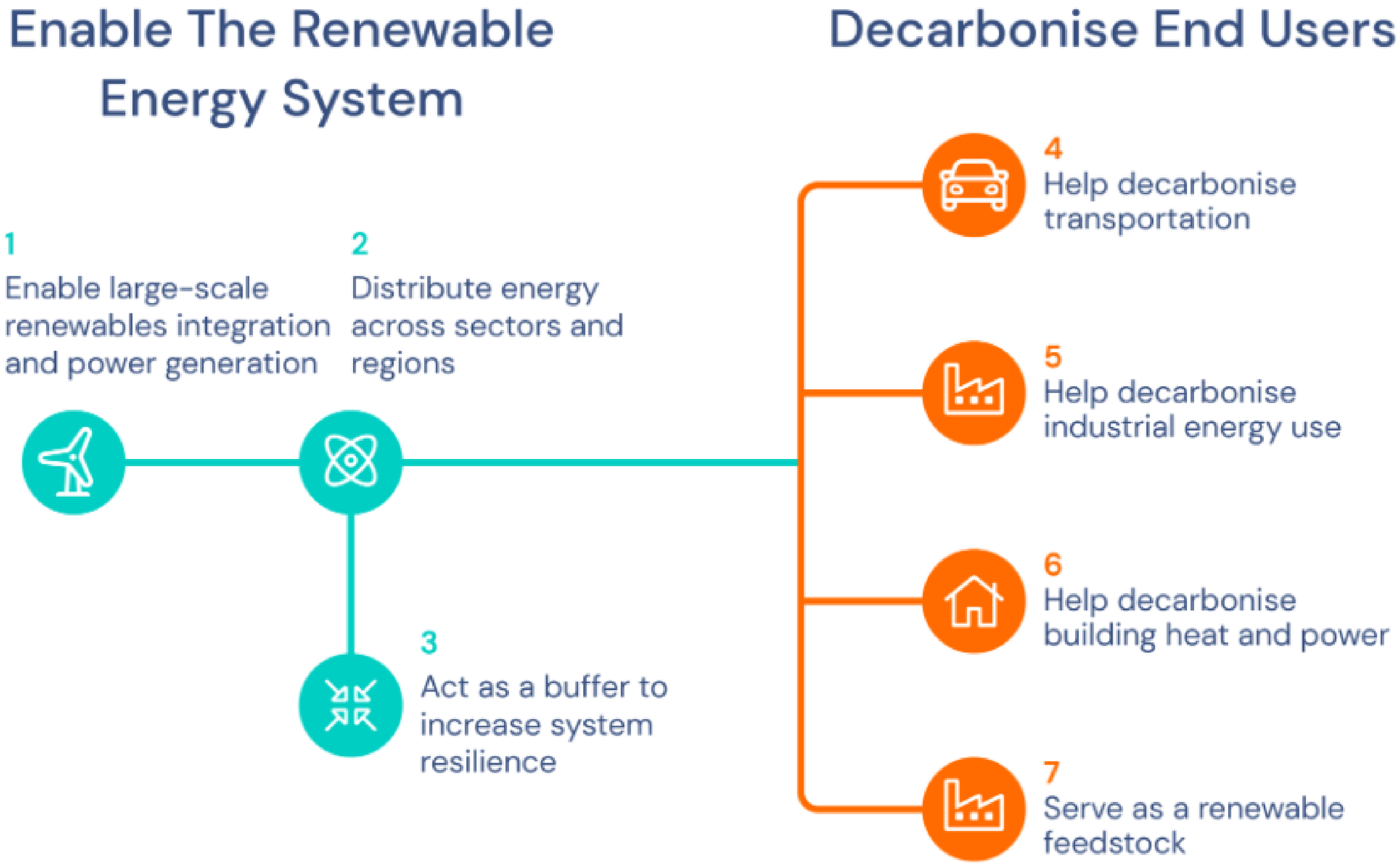
<u>By 2024 Clean Hydrogen Production should be 13x times that of today</u>
<u>By 2030, it should be 130 times larger.</u>



Source: Hydrogen Europe

Hydrogen Europe

7 roles for hydrogen



Hydrogen Europe

European Hydrogen Backbone: snapshot

Welcome & Introduction

Highlights of the new report

Dedicated hydrogen pipeline infrastructure is needed to help **integrate large amounts of renewable energy** and to create a **liquid, cross-border market for renewable and low-carbon hydrogen**

European Hydrogen Backbone demonstrates a **technically and economically plausible vision** for such a dedicated hydrogen infrastructure

Twelve European gas TSOs from eleven European countries have joined the European Hydrogen Backbone initiative and the **2040 backbone has almost doubled in length** compared to last year's report

The European Hydrogen Backbone can be created at an **affordable cost**

The report published today shows a vision for a

39,700 km hydrogen pipeline infrastructure

In **21** countries by 2040

almost **70%** of which is based on repurposed existing natural gas pipelines

Hydrogen Europe

Source: European Hydrogen Backbone

Gradual creation of a dedicated hydrogen infrastructure

Connecting industrial clusters to an emerging infrastructure in 2030

In addition to what was presented in the previous report….

- **In the UK,** four of the country's five major industrial clusters could be connected through the phased repurposing of existing gas pipelines to form an initial hydrogen backbone.
- **In Finland,** first stretches emerge around industrial hydrogen valleys in the south and along the west coast, where large amounts of onshore wind will be deployed.
- **In Hungary,** a first industrial cluster can be connected, while an interconnection to Ukraine could also emerge
- **In Italy,** a south-north connection already emerges, and alongside domestic production, imports from North Africa could be possible, by repurposing one of the five subsea pipelines

Source: European Hydrogen Backbone

Gradual creation of a dedicated hydrogen infrastructure

Growing network covers more countries and reaches large potential import regions of green hydrogen in 2035

In addition to what was presented in the previous report….

- **In central and eastern Europe,** a route from the east to the west of Europe could emerge, passing through the networks in **Slovakia** and the **Czech Republic.**
- Through **Spain and France,** a corridor towards Germany emerge
- **In Sweden, Finland and Estonia,** the network will support the increased need to balance the future decarbonised energy system.
- **In Central Europe,** the network of Slovenia, Hungary and Italy matures and interconnects with Austria, and southeast Europe
- In the **Baltic Sea**, green hydrogen is used to integrate and store large amounts of intermittent (offshore) wind energy

Source: European Hydrogen Backbone

26,100 km

Gradual creation of a dedicated hydrogen infrastructure

Mature infrastructure stretching towards all directions by 2040

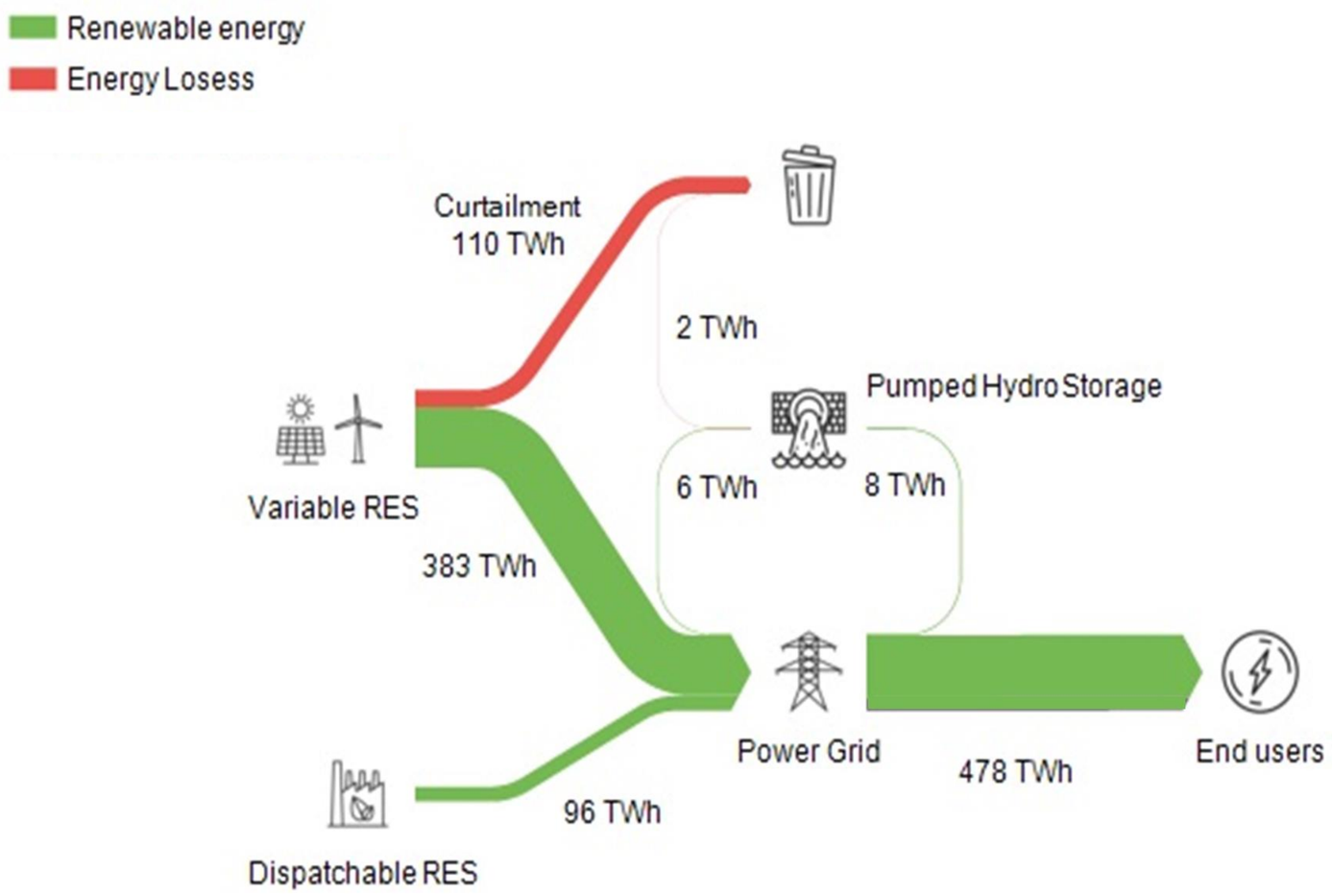
In addition to what was presented in the previous report….

- **In the North Sea,** energy islands, offshore and coastal hydrogen production help integrate energy and complement the power grid
- **In Poland,** a matured backbone creates a highway connecting renewable production in the north with industry in the south
- In **Central and Eastern Europe**, multiple interconnections enhance security of supply and a liquid hydrogen market
- **In Austria,** the backbone now connects Slovakia with Germany, providing for an alternative east-west route
- **In Ireland and the UK**, the repurposed subsea interconnectors connect the mature UK network and Dublin with the EU mainland

Source: European Hydrogen Backbone

39,700 km

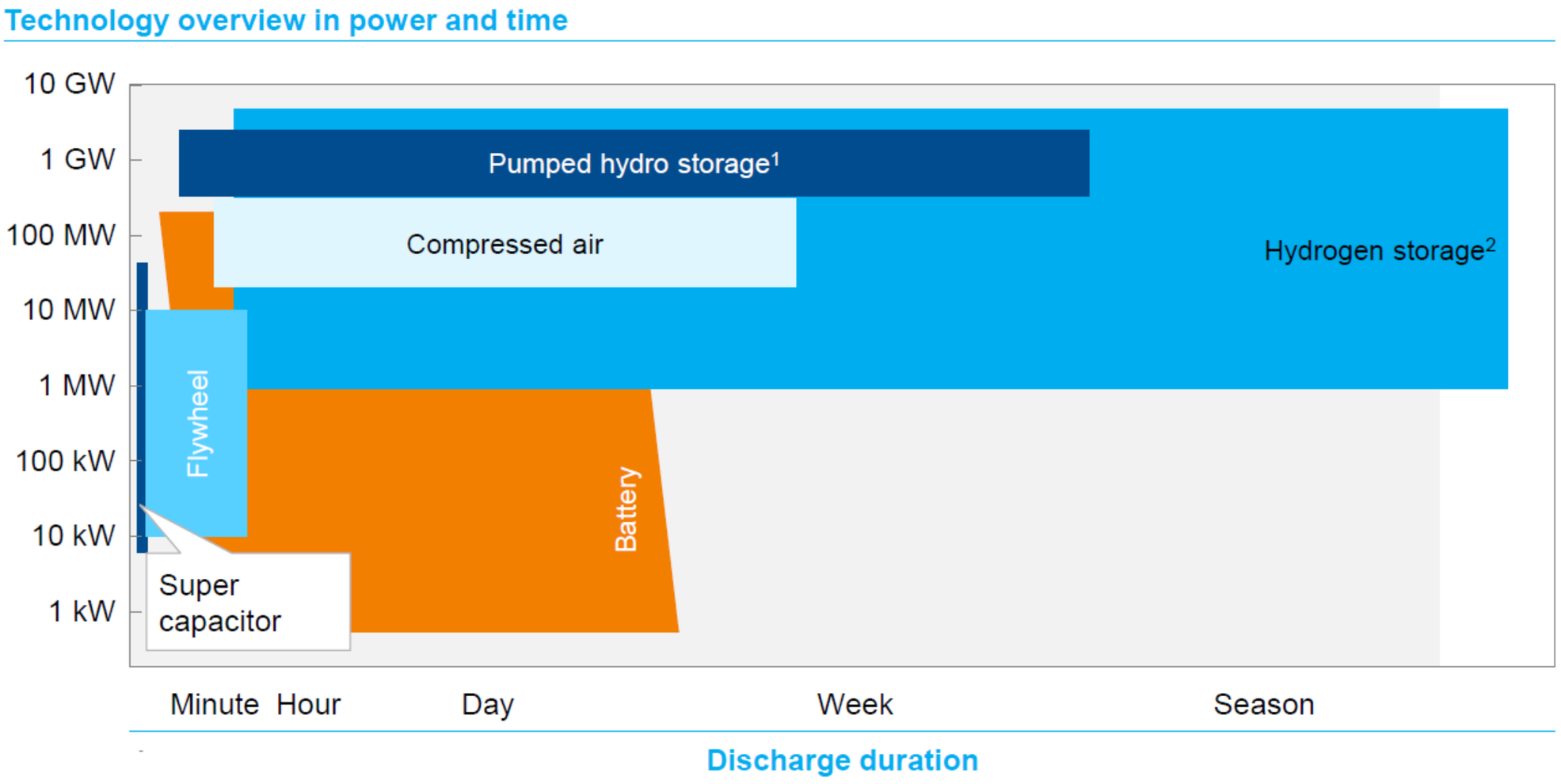
Energy efficiency first principle...



- Scenario: Germany electric grid 100% renewable with no additional energy storage
- Result: curtailed electricity amounting to 1.5 Mt H2 = 10 million FCEVs
- Doesn't include heating electrification
- Doesn't include industry electrification
- Doesn't include mobility electrification
- Doesn't include grid congestion

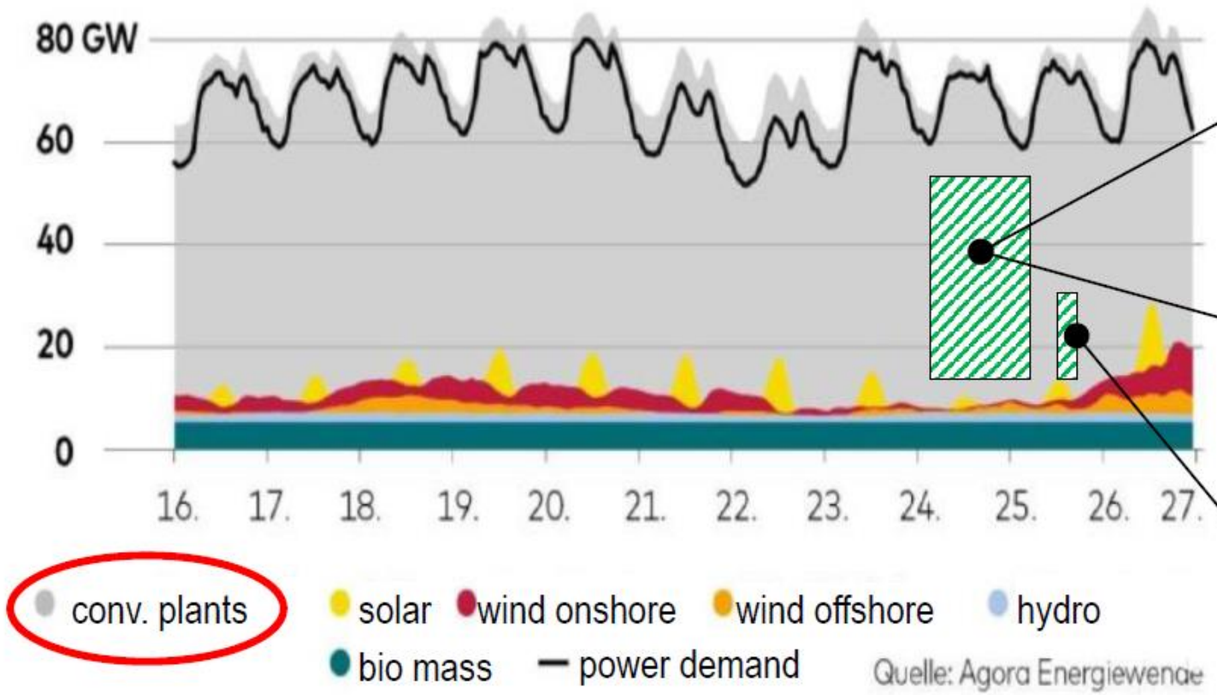
Hydrogen Europe

Hydrogen is ideally suited for long term storage due to its long discharge duration and high discharge power



Security of Supply vs non-conventional dispatchable power

Residual load demand: 11 days x 24h/day x 60 GW ~ 16 TWh



Installed Wind/Solar capacity (Dec. 2018): 45.0 GW wind
39.2 GW solar

⇒ assessment of storage solutions

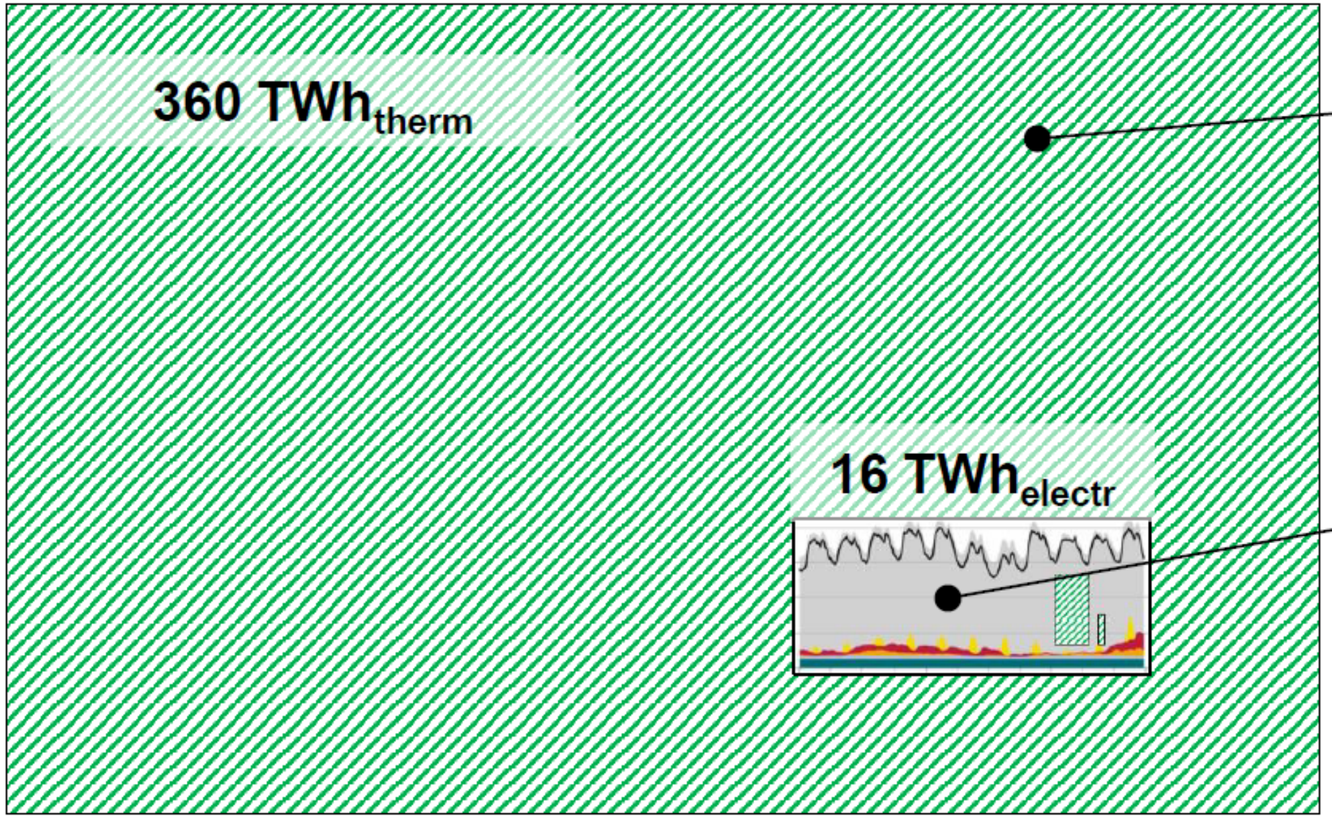
Assumed 100% E-mobility: ~ 1.32 TWh
(44 Mill. Cars, 20kWh/100km, capacity 300km, 100% charged, discharge down to 50% cap. level)

Li Ion batteries with 1.3 TWh
= 10200 x Tesla batteries Parks
(Australia 129MWh)

German pump storage capacity: ~ 0.04 TWh

Hydrogen Europe

Security of Supply vs non-conventional dispatchable power



Gas system capacity: ~360 TWh$_{thermal}$

- 230 TWh storage (caverns)
- plus 130 TWh gas grid (500.000 km)

(Basis: Methane)

Residual load (Jan. 2017):

~16 TWh$_{electr}$

⇒ ~9% of gas system capacity (with η=0,5)

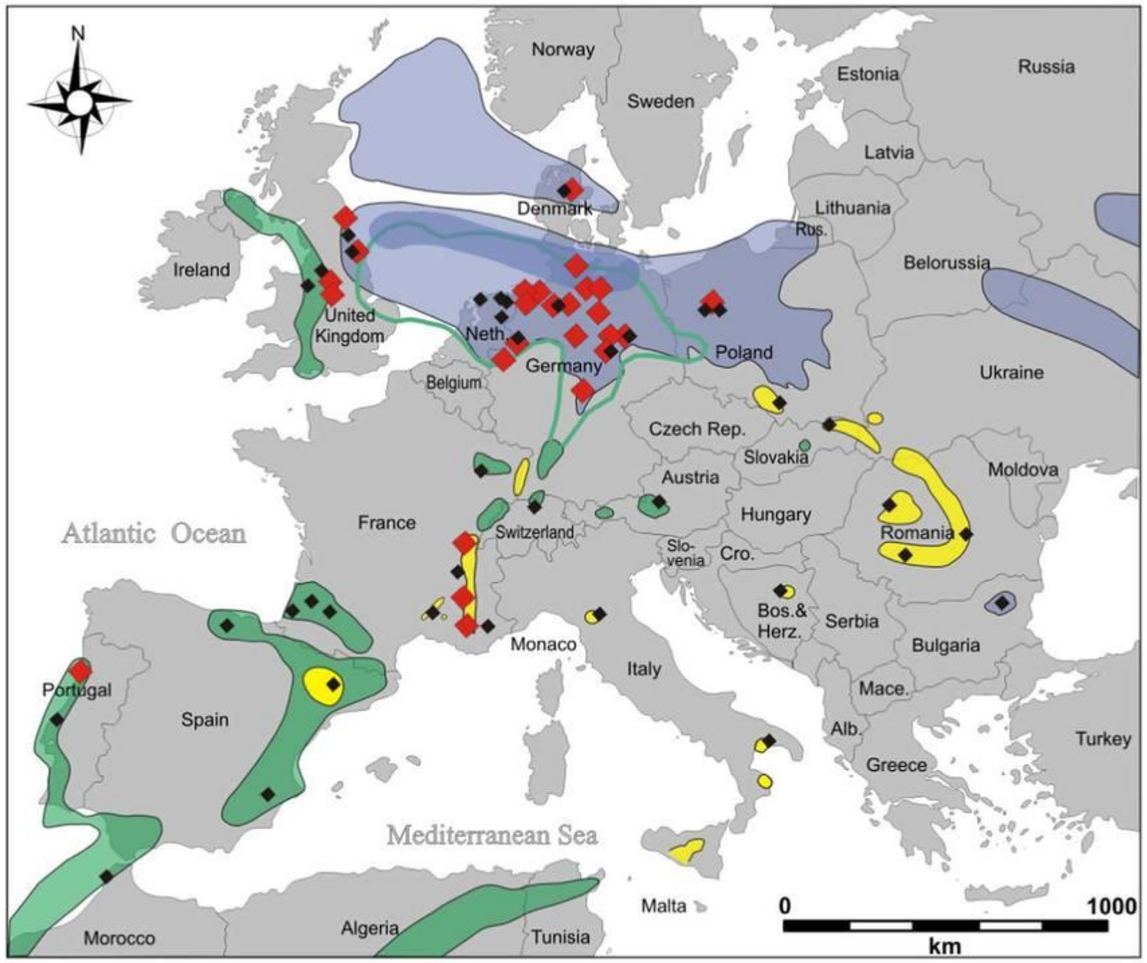
⇒ Gas system offers potential for green Hydrogen.

Hydrogen Europe

Salt cavern formations in Europe

- Total energy (hydrogen) storage capacity in salt caverns (both onshore and offshore) in Europe is 84,800 TWh_{H2} with about ¼ of than in onshore formations*

- Total EU electricity generation is around 2,800 TWh



Tertiary salt deposit

Mesozoic salt deposit

Range of Mesozoic salt above Permian

Paleozoic salt deposit (Permian), Zechstein

Paleozoic salt deposit (Permian), Rotliegend below Zechstein

Salt cavern fields

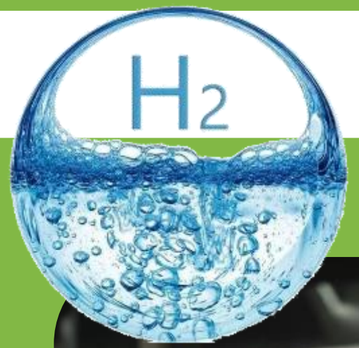
Gas Storage

Storage of Crude Oil & LPG, Brine Production

- Source: D. G. Caglayan, N. Weber, H. Heinrichs, J. Linßen, M. Robinius, P. A. Kukla, D. Stolten, *Technical potential of salt caverns for hydrogen storage in Europe*, International Journal of Hydrogen Energy, Volume 45, Issue 11, 28 February 2020, Pages 6793-6805

Hydrogen Europe

At EU level – Green Deal leaders & hydrogen



“Next Generation EU should invest in Hydrogen.”
Ursula von der Leyen @State of Union speech, September 2020

“H2 rocks, and I am committed to making it a success!”
Frans Timmermans- Executive Vice-President for the European Green Deal

Since them: Climate law: minimum 55% emission reduction by 2030
Fit for 55 package out on July 14th

National Hydrogen Strategies

H2 strategy adoption

Adopted H2 strategy Planned H2 strategy

- Six countries have officially adopted an H2 strategy
- Those are The Netherlands, Germany, France, Spain, Portugal, and Norway
- 13 countries are currently working on their national H2 strategies

EUROPE		
	€ 7 bn	for hydrogen technology
	€ 2 bn	for international cooperation
	€ 8.9 bn	estimated mobilised investment
	€ 5.7 bn	public support
	€ 1.5 bn	for an IPCEI project
	€ 7 bn-€ 9 bn	estimated mobilised investment (public funds around €1bn)
	€ 2 bn	*public support by 2030 (€1bn by 2024)*
	€ 10 bn	*estimated mobilised investment*

DRAFTS

Notes: 1. Illustrative as exact number of policies continues to change
Source: Hydrogen Europe, Fuel Cells and Hydrogen Observatory

Hydrogen Europe

EU mobility targets: national and regional

France

Category	*National targets*	*Regional targets*
HRS	100 (2023), 400-1.000(2028)	99 (2030)
HDV	200 (2023), 800-2.000(2028)	19.550 (2030, incl. LDV)
LCV	5.000 (2023), 20.000-50.000 (2028, incl. FCEV)	

Occitanie, Bretagne, Pay de la Loire, Normandie, Rhone Alpes, Nouvelle Aquitaine

Spain

Category	*National targets*
HRS	100-150 (2030)
HDV	5.000-7.500 (2030) incl. LDV
Buses	150-200 (2030)
Trains	2

Portugal

Category	*National targets*
HRS	50-100 (2030)
H2: 5% road transport, 3-5% maritime sector (2030)	

Netherlands

Category	*National targets*	*Regional targets*
HRS	50 (2025)	100 (2030)
HDV	3.000 (2025)	-
LCV	15.000 (2025), 300.000 (2030, incl. FCEV)	12.000 (2030, incl. FCEV)
Buses	-	1.300 (2030)
Trains	-	50 (2030)

North Netherlands

Germany

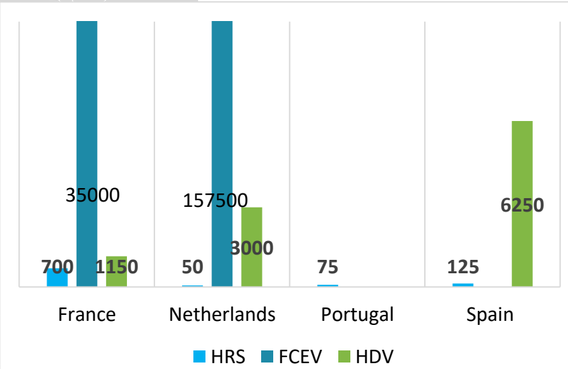
Category	*Regional targets*
HRS	200 (NRW), 400 (BV) (2030)
HDV	11.000 (NRW) (2030), 3.000 (BV) incl. buses
FCEV	6.000 (NRW), 80.000 (BV) (2030)
Buses	3.800 (NRW)

North-Rhine Westphalia, Bavaria

Poland (draft)

Category	*National targets*
HRS	32 (2025), 150 (2030)
Trains	1 (2030)
Buses	500 (2025), 2.000 (2030)

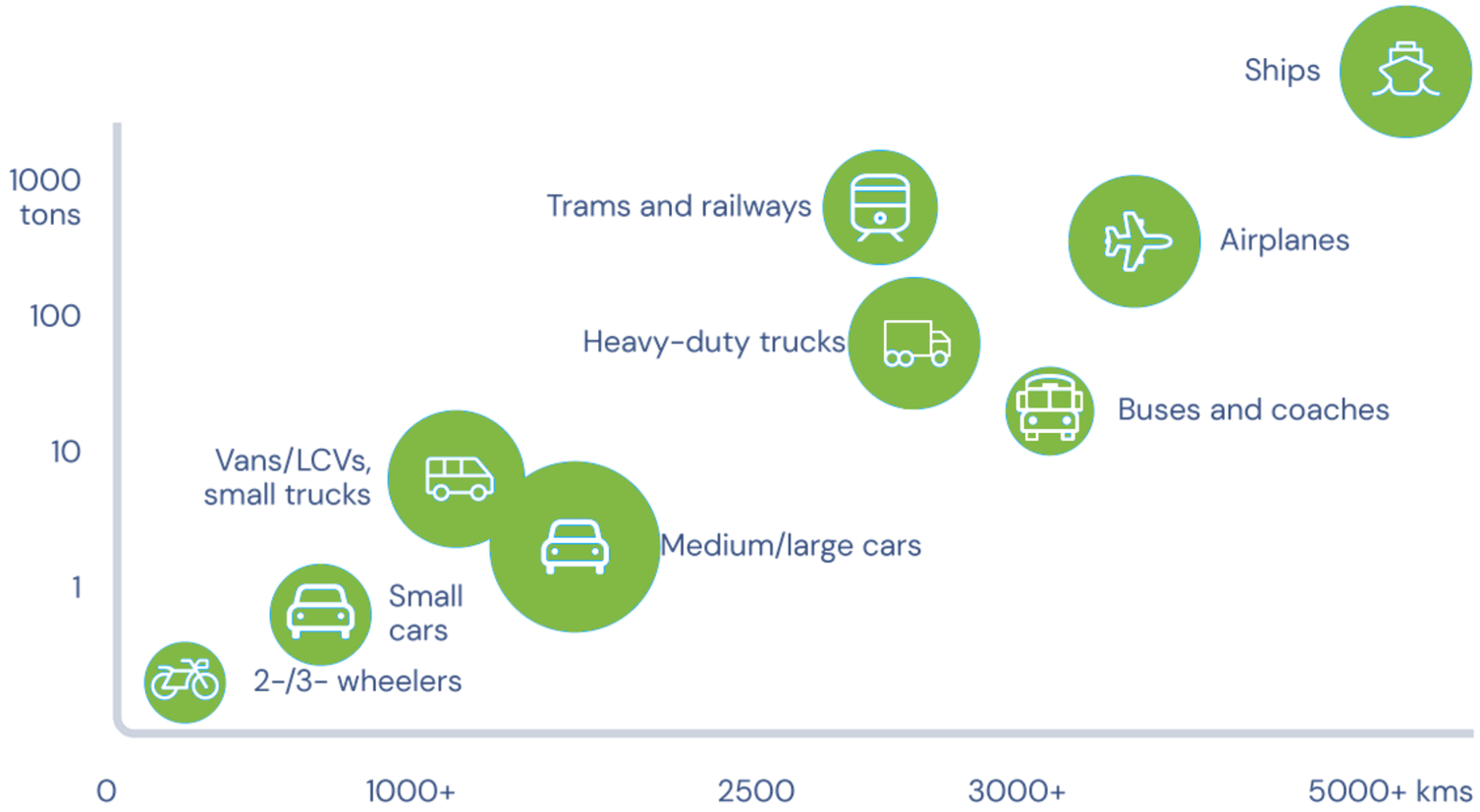
National targets



(average between high-low estimates)

FCEVs and BEVs as complementary options

Comparison of range, payload, and preferred technology



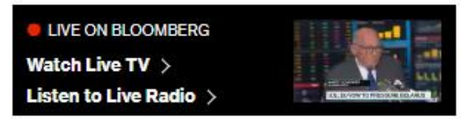
- BEV and FCEVs offer complementary solutions depending on the use
- Hydrogen is particularly well suited for heavy load, high energy use and harsh operational conditions.
- The vehicles can operate 24/7 in all climate conditions without energy loss.
- Efficiency: look at the whole system efficiency - and not just at vehicle efficiency

→ Study referring to synthetic fuels - and NOT FCEVs

Daimler Disagrees With Tesla and VW's Batteries-or-Bust View

By Christoph Rauwald
May 21, 2021, 3:30 PM GMT+2

- ▶ Truck chief says fuel cells are needed to reach climate goals
- ▶ CEOs Musk and Diess have argued hydrogen is a lost cause



"We cannot afford to bank on just one technology to reach the climate goals," Daum said. "The focus until 2025 will be 100% on battery-electric vehicles. Between 2025 and 2035, we're going to need both battery-electric and fuel cell vehicles because the massively growing infrastructure requirements require a two-legged approach."

Hydrogen Europe

Thank you for your attention!

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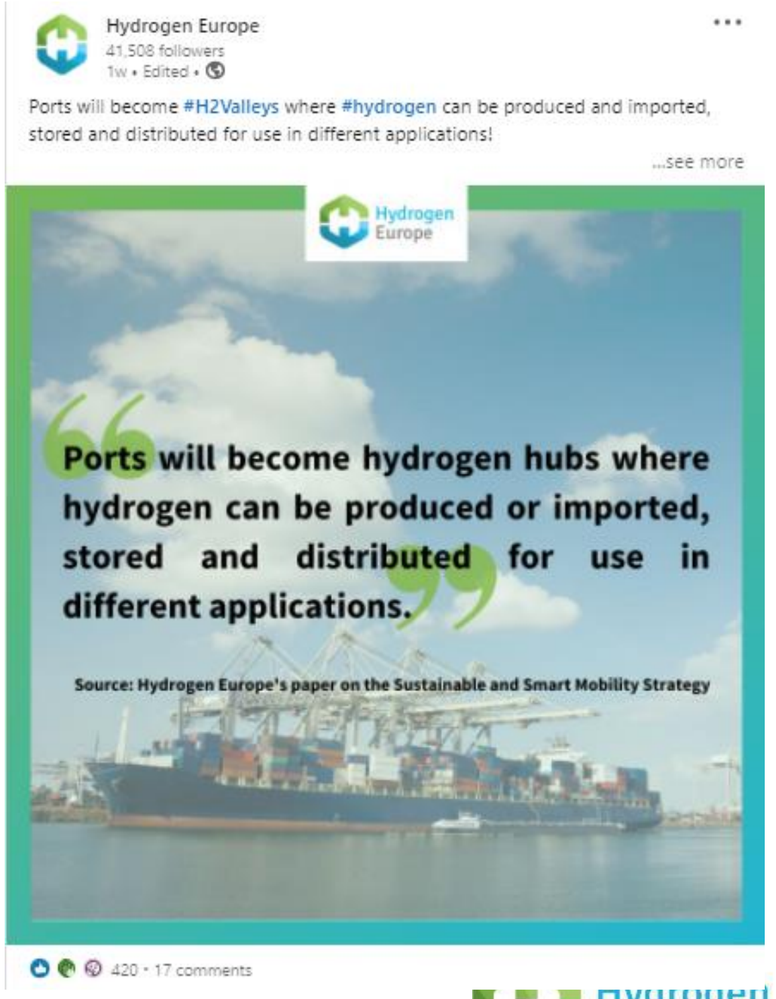
Sustainable and Smart Mobility Strategy- HE’s position paper



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