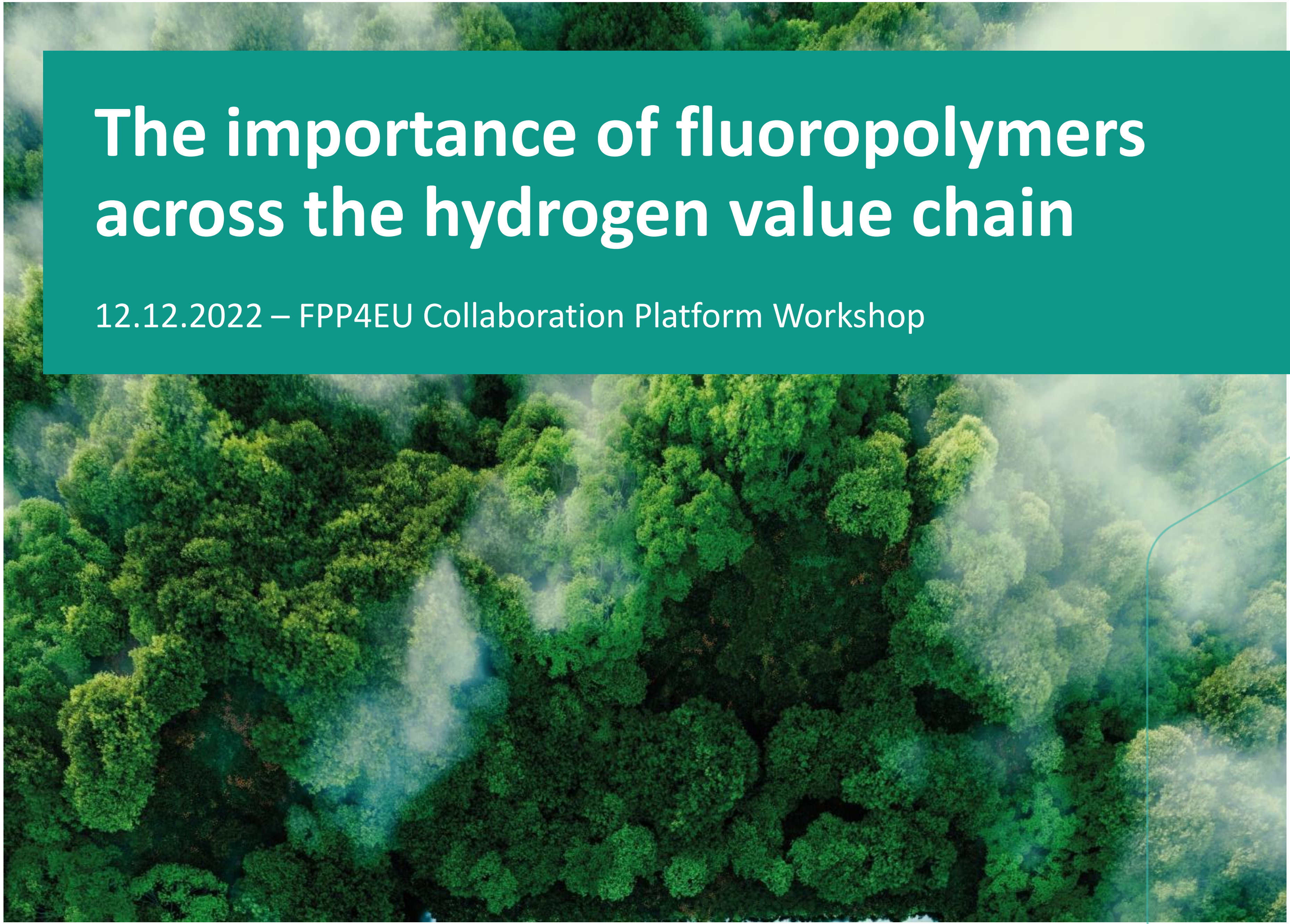
The importance of fluoropolymers across the hydrogen value chain

12.12.2022 – FPP4EU Collaboration Platform Workshop



Hydrogen Europe

Our Vision

Hydrogen Europe is propelling global carbon neutrality by accelerating European hydrogen industry

Our Mission

Hydrogen Europe is the leading organization representing European based companies and stakeholders that are committed to moving towards a (circular) carbon neutral economy

Hydrogen Europe will be the spearhead of hydrogen industry towards policy and decision makers for hydrogen technology and application

Hydrogen Europe effectively supports and facilitates its members in their transition towards (circular) carbon neutral economy while creating and maintaining sustainable jobs

Hydrogen Europe Introduction

Hydrogen Europe

430+ Members

We encompass the entire value chain of the hydrogen ecosystem: from production, distribution to end uses, including Industry, EU regions & H2 National Associations.

40+ Employees

120k+ Followers on Social Media

Follow us on:

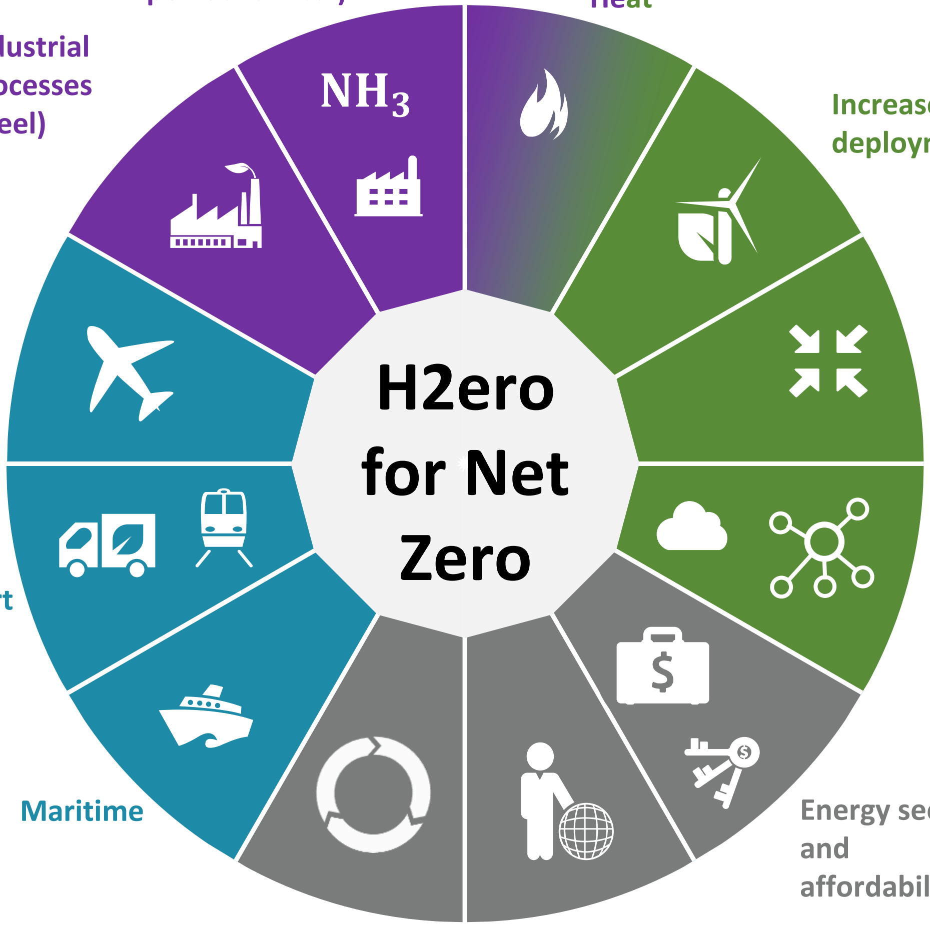
Hydrogen will provide a myriad of benefits in transition to Net Zero

Industry

- Decarbonizing “hard to abate” industrial sectors

Transport

- No transport mode left behind
- No compromise (range, refuel time)
- No consumer segments left behind (fleets, long-distance travelers)



Energy

- Making a net-zero energy system possible

Societal

- Ensuring prosperity
- Reducing waste

The Backbone of Hydrogen Europe: Our Working Groups

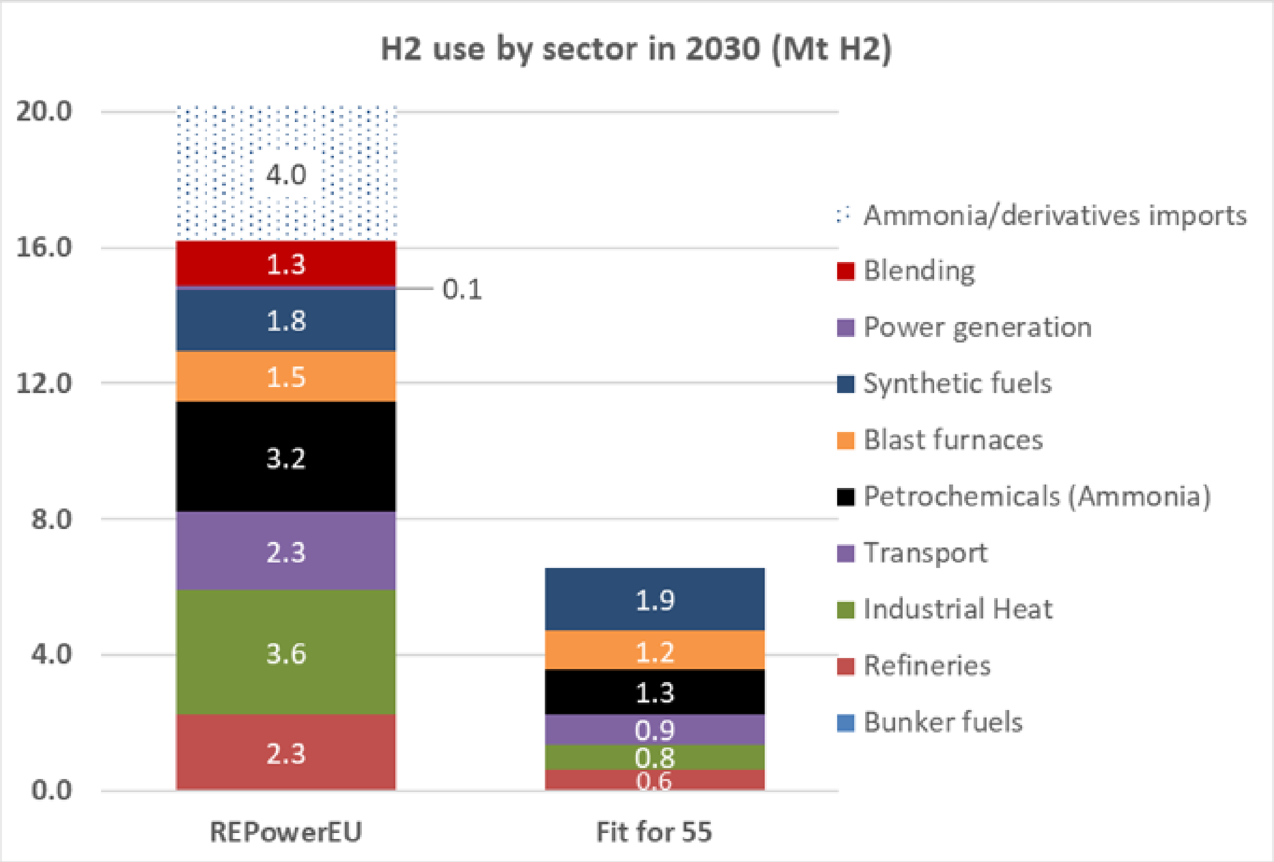
- Buildings
- Infrastructure
- Industry
- The Per- and polyfluorinated alkyl substances (PFAS) Ad Hoc Group
- Carbon market reform Ad Hoc Group
- Energy
- Production
- Regional Pillar
- Skills
- Mobility
- Funding & Finance
- Cars and Vans Subgroup
- Aviation Subgroup
- Water and Transport Subgroup
- Heavy-duty & Non-Road Vehicles Subgroup

Hydrogen, front & centre to the EU's climate & energy security ambitions

Hydrogen Europe

REPowerEU: 20MtH2= 10Mt EU + 10Mt non-EU

EC calls upon Council and EP to align the sub-targets for renewable fuels in RED II



Source: Modelling using PRIMES

RED targets: from 5.6 to 9mt by 2030

75 % for industry (an increase from 50%)

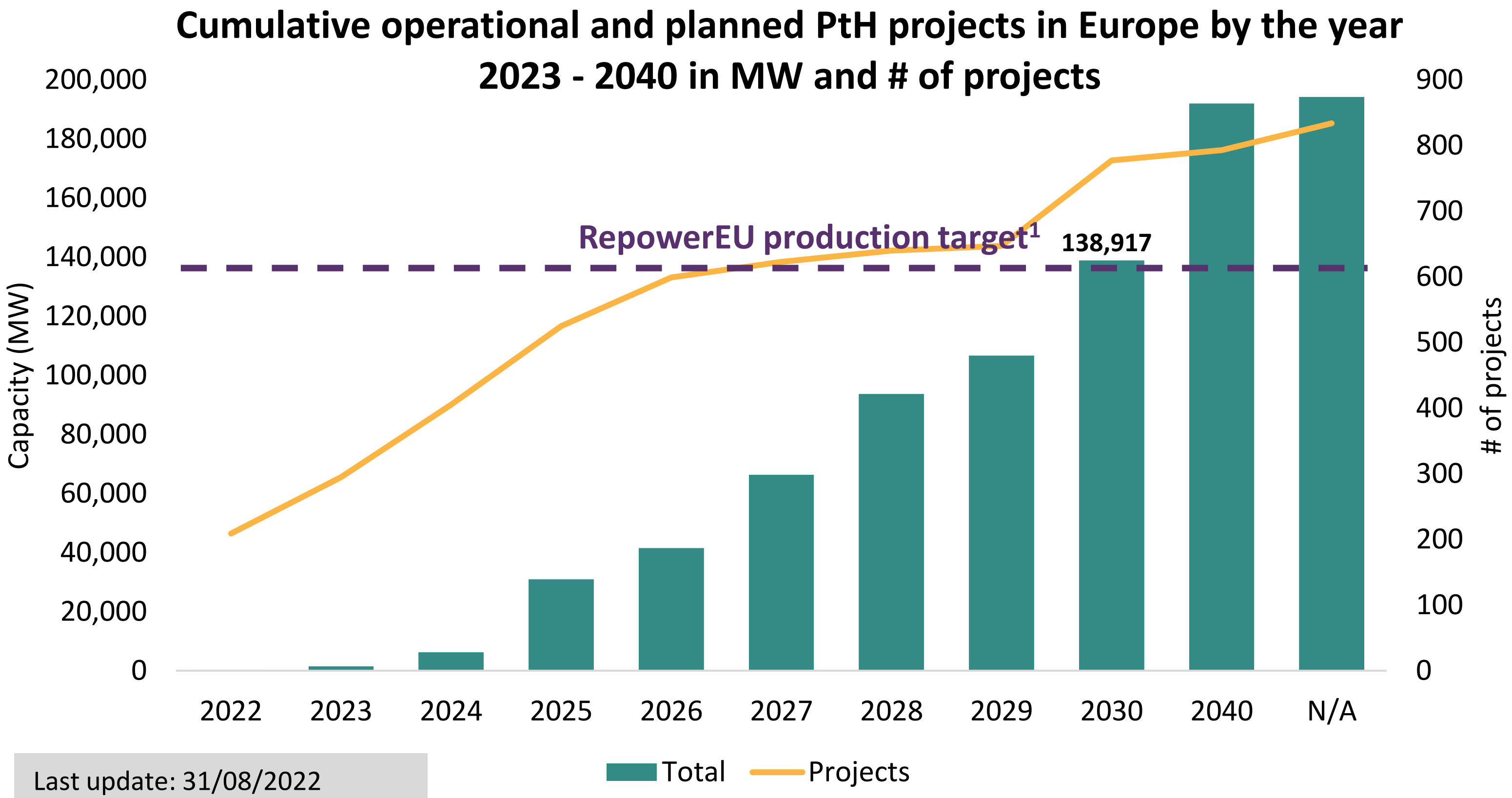
- Estimated demand by 2030: 8.4 mt (excluding refineries)
- 3.6 mt for industrial heat (x4)
- 3.2 mt in chemicals (x2.5)
- 1.5 mt in steelmaking (switch 30% steel production to hydrogen-based DRI-EAF)

5% for transport (an increase from 2.6%)

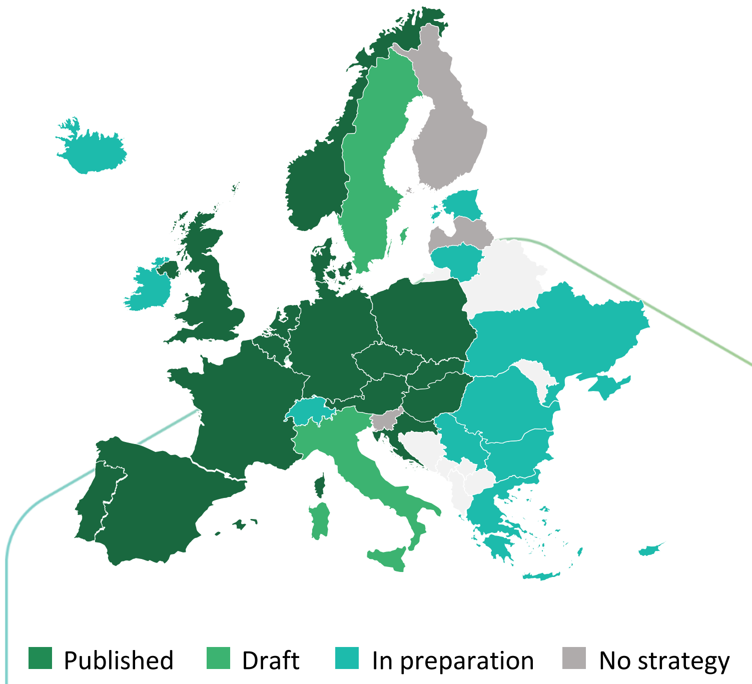
- Estimated demand by 2030: 6.4 mt (including in refineries) (x3)
- Increase the share of zero-emission vehicles
- Adopt proposals on Alternative fuels
- Adopt a legislative package on greening freight transport by 2023

Hydrogen, front & centre to the EU's climate & energy security ambitions

1. Realising all planned projects would result in 139 GW of PtH by 2030



2. Quasi all EU countries have – or are working on – their hydrogen strategy



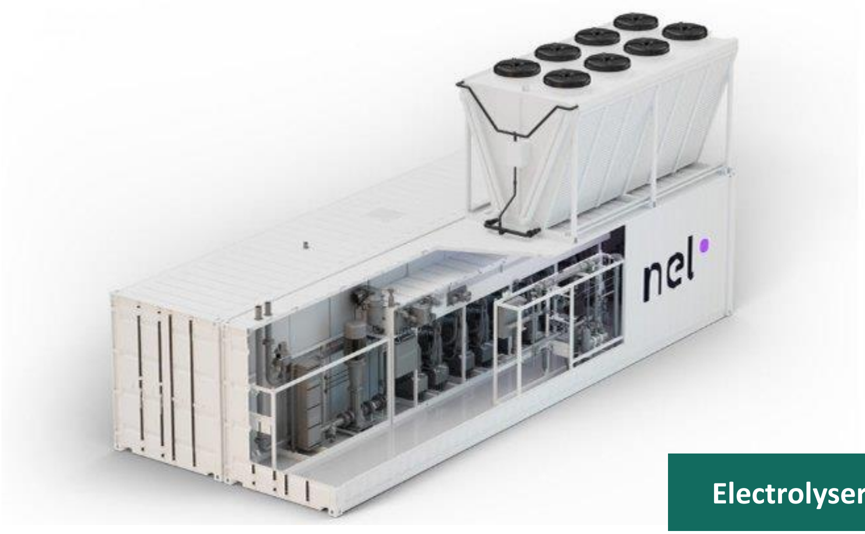
Last update: 31/08/2022

Notes: Individual phases with separate FIDs are counted as separate projects

1. Translating 10 Mt of European renewable hydrogen production into installed electrolysis capacity depends on utilization and efficiency assumptions. For PtH projects connected to the electricity grid, an electrolyser capacity factor of 68% was assumed. Country-specific utilisation factors for different electricity sources have been used to calculate expected production for directly connected projects. The values can be underestimated as they do not consider increasing electrolysis efficiency up to 2030, increasing renewable generation utilisation up to 2030, and oversizing renewables directly connected to electrolysers, which are expected to constitute almost 62% of the current planned capacity by 2030.

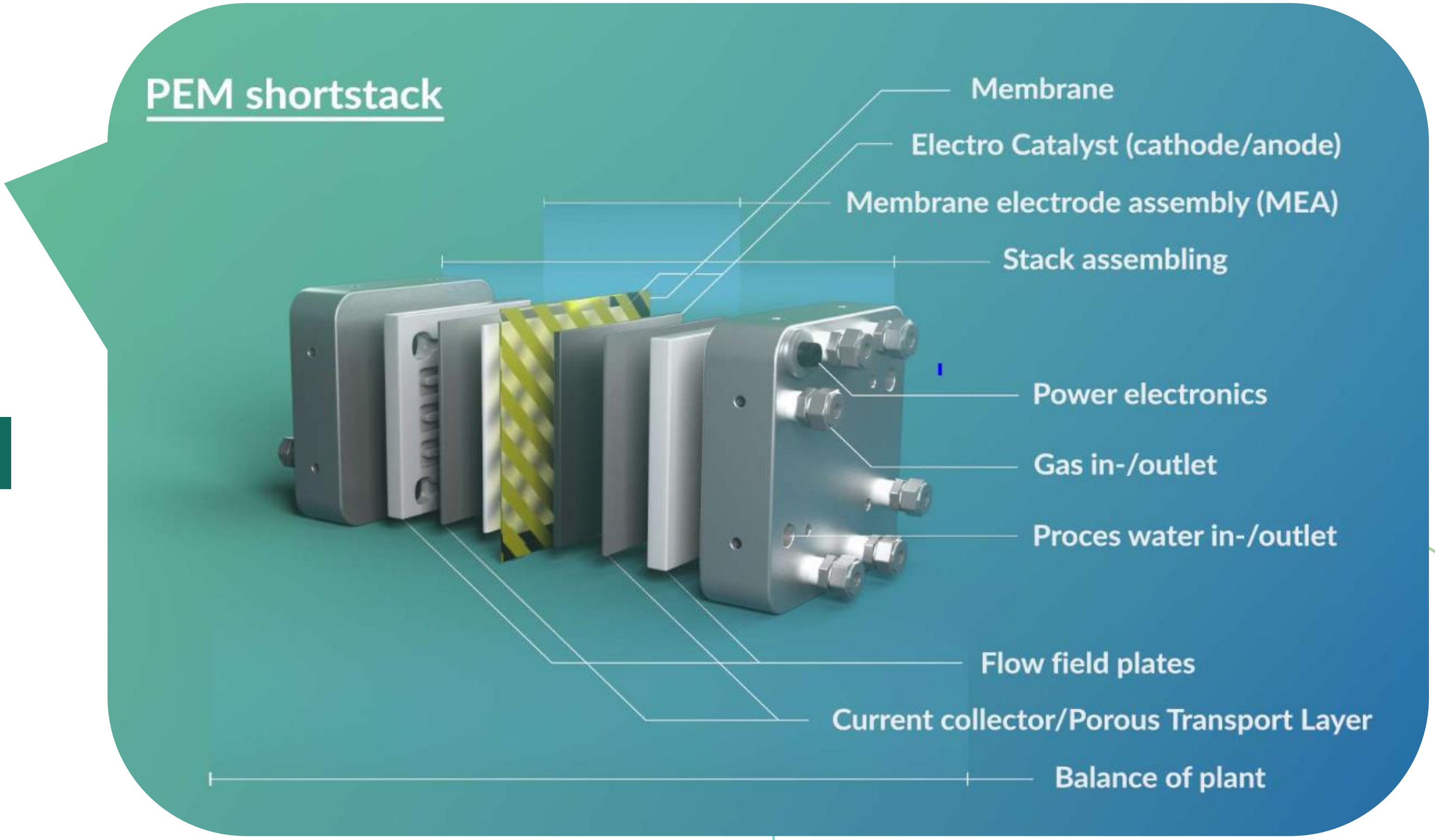
Source: Hydrogen Europe

What are PFAS used for in the H2 and fuel cell industry



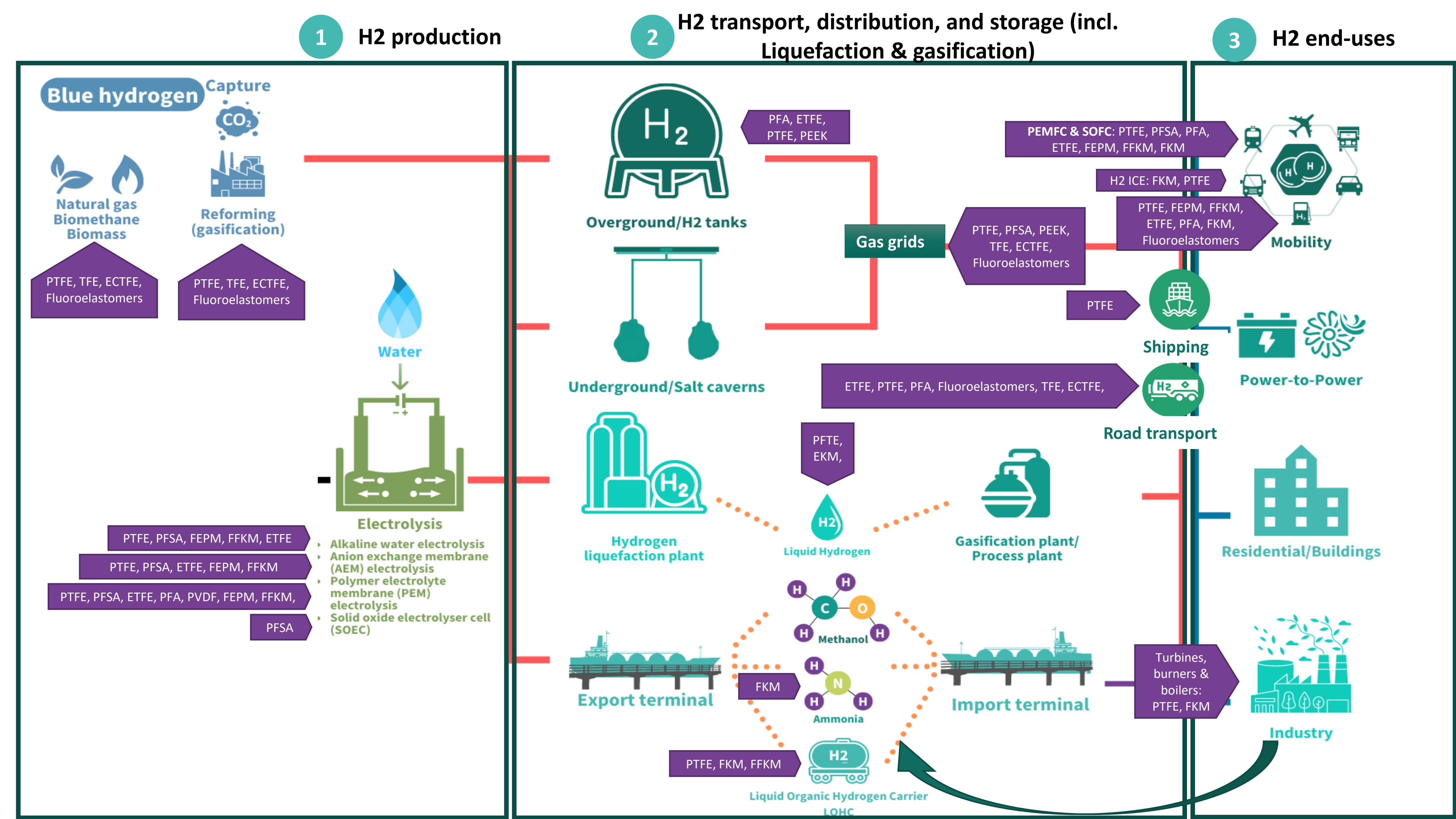
Electrolyser

SOEC | AEM | ALK | PEMWE



Fuel cell module

PEMFC | DMFC | AFC | PAFC | MCFC | SOFC



1 H2 production
2 H2 transport, distribution, and storage (incl. Liquefaction & gasification)
3 H2 end-uses
Blue hydrogen
Capture
CO_2
Natural gas
Biomethane
Biomass
Reforming (gasification)
PTFE, TFE, ECTFE, Fluoroelastomers
PTFE, TFE, ECTFE, Fluoroelastomers
Water
Electrolysis
PTFE, PFSA, FEPM, FFKM, ETFE
PTFE, PFSA, ETFE, FEPM, FFKM
PTFE, PFSA, ETFE, PFA, PVDF, FEPM, FFKM,
PFSA
Alkaline water electrolysis
Anion exchange membrane (AEM) electrolysis
Polymer electrolyte membrane (PEM) electrolysis
Solid oxide electrolyser cell (SOEC)
H_2
Overground/H2 tanks
PFA, ETFE, PTFE, PEEK
Underground/Salt caverns
Gas grids
PTFE, PFSA, PEEK, TFE, ECTFE, Fluoroelastomers
Hydrogen liquefaction plant
PFTE, EKM,
H2
Liquid Hydrogen
Gasification plant/ Process plant
Methanol
Ammonia
FKM
Export terminal
Import terminal
PTFE, FKM, FFKM
H2
Liquid Organic Hydrogen Carrier LOHC
PEMFC & SOFC: PTFE, PFSA, PFA, ETFE, FEPM, FFKM, FKM
H2 ICE: FKM, PTFE
PTFE, FEPM, FFKM, ETFE, PFA, FKM, Fluoroelastomers
Mobility
PTFE
Shipping
Power-to-Power
ETFE, PTFE, PFA, Fluoroelastomers, TFE, ECTFE,
Road transport
Residential/Buildings
Turbines, burners & boilers: PTFE, FKM
Industry

Why are PFAS relevant for the H2 industry: PEM fuel cell example

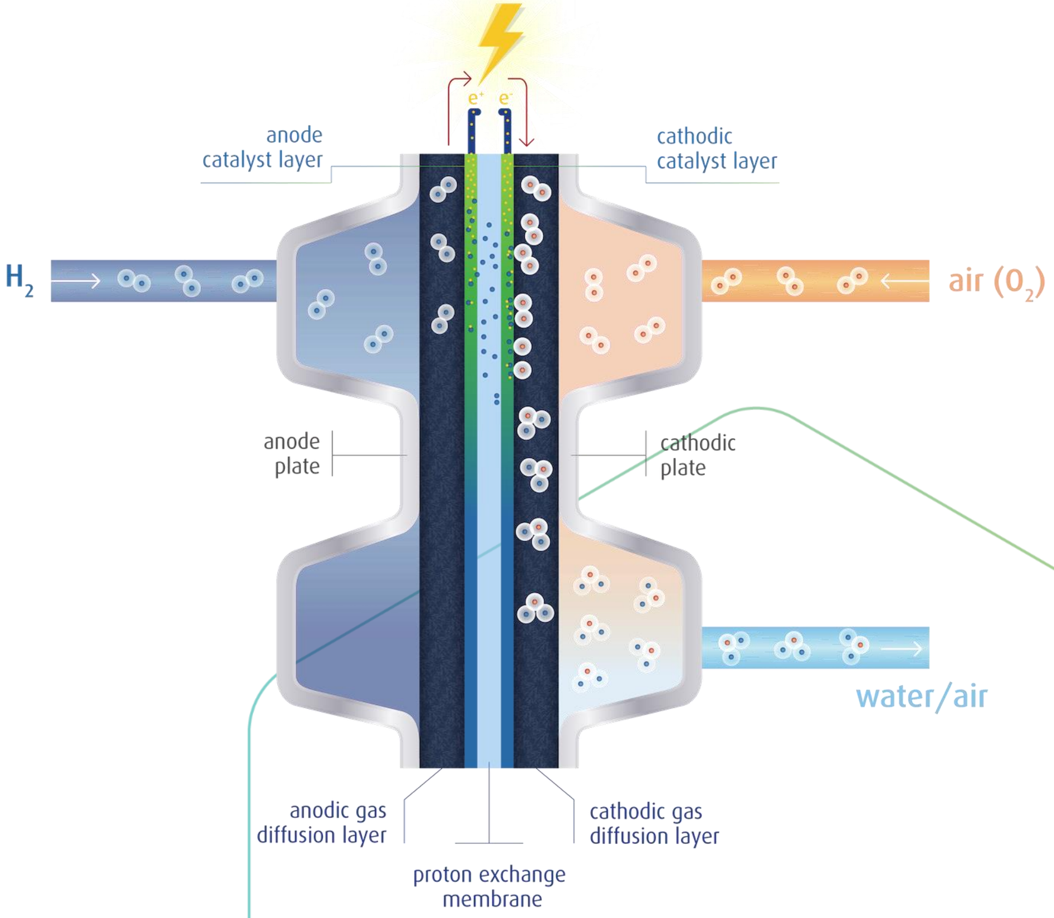
- <u>Membrane</u>
  - **PFSA ionomers**: perfluorinated copolymers that carry sulfonic acid groups (SO3H); most commonly **reinforced by PTFE** (therefore, fluoropolymers) → it separates protons and electrons and provides the proton conductivity (thereby producing electric current) while separating the reactants: hydrogen and air (oxygen), in the case of a fuel cell
  - Examples: Nafion; 3M ionomer, Solvay Aquivion ionomer...
  - In PEM FC and EL, DMFC, chloralkali EL...

- <u>Gas Diffusion Layers (GDL)</u>
  - These consists of carbon fibre paper or felt. The GDL substrate currently contains **PTFE**. It is used as hydrophobic agent and – depending on the GDL type – also as binder.

- <u>Microporous layers (MPL)</u>
  - GDL are often equipped with an additional layer at the interface to the electrode, an MPL, made of **PTFE** due to its hydrophobic properties It equalizes the GDL surface and, therefore, prevents damage of the membrane and improves electrical and thermal contact between GDL and the electrode.

- Some typical <u>sealing materials</u>, such as gaskets, in fuel cells, as well as in equipment in the distribution network (regulator membranes, meters, etc.)

Figure 2: Schematic representation of a fuel cell's Membrane Electrode Assembly (MEA)



Source: Umicore's website

What is the potential for alternatives and research?

- **Material properties of perfluorinated polymers are unique and technically impossible to replace in the near future.**
- **Restrictions on fluoropolymers** (including PFSA ionomers and PTFE) **would render several critical applications** from water electrolysis, fuel cells, to H2 transport technologies **unfeasible**, or would dramatically reduce their service life and increase the probability of malfunction.
- **Performance of alternative such as hydrocarbon membranes, is still very low because they suffer from reduced thermal and chemical stability and extremely short durability**, lasting only dozens of hours against lifetime requirements (at the very least) of >25,000 hours.
- **There is a potential for research in fluoride-free materials (e.g. Hydrocarbon membranes...), but they need to take the same KPIs of today's technologies as a benchmark.**
- **If the ban were to enter into force before any alternative is proven to be ready, it would result in a significant timeline inconsistency with the H2 Strategy's and climate goals for 2030.**

Socio-economic impacts of a ban

Due to 1) essentiality of fluoropolymers for the H2 value chain and 2) the absence of alternatives.... a precipitous PFAS ban without granting any derogation for applications in the hydrogen sector would have destructive effects on the industry, jeopardising...

2030

- **€30-billion worth of investment** in a decade (only including electrolysers & fuel cells),
- up to **200k direct jobs and over 260k indirect jobs** within 10 years, and
- **2030 climate target** (-55% GHG + renewable H2 targets in industry & transport) and **phasing out Russian gas** (REPowerEU)

2050

- A market with a potential **value of €820 billion**...
- ...**employing 5.4 million workers** by the middle of the century, and
- The EU's climate-neutrality target, energy security, strong industrial base.

Key messages from the hydrogen industry

Hydrogen Europe

1. The proper **functioning of electrolysers, fuel cells** and other technologies across the H2 value chain **rests on the essential use of fluoropolymers** (often classified as a PFAS category).

2. **No alternative** to fluoropolymers today comes close to the same KPIs in the H2 sector – research can play a role but no fluorine-free breakthrough is foreseen in the near future.

3. **Environmental and human health risks** of fluoropolymers (considered by OECD as 'polymers of low concern') are **extremely limited** across the hydrogen value chain (both in terms of environmental and human exposure; also B2B products).

4. **Best practices and incentivisation** can and should be set up to both **limit emissions and foster recovery of materials** at EoL to a maximum (and inherent economic incentive to recover PGM + fluorine).

5. **Not exempting** the use of fluoropolymers in the H2 sector would **threaten the whole European hydrogen industry** and its global competitiveness, as well as **jeopardise the achievement of the EU's climate, energy security, and industrial objectives.**

Thank You

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