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EUROPEAN UNION AND GREEN HYDROGEN - OVERVIEW

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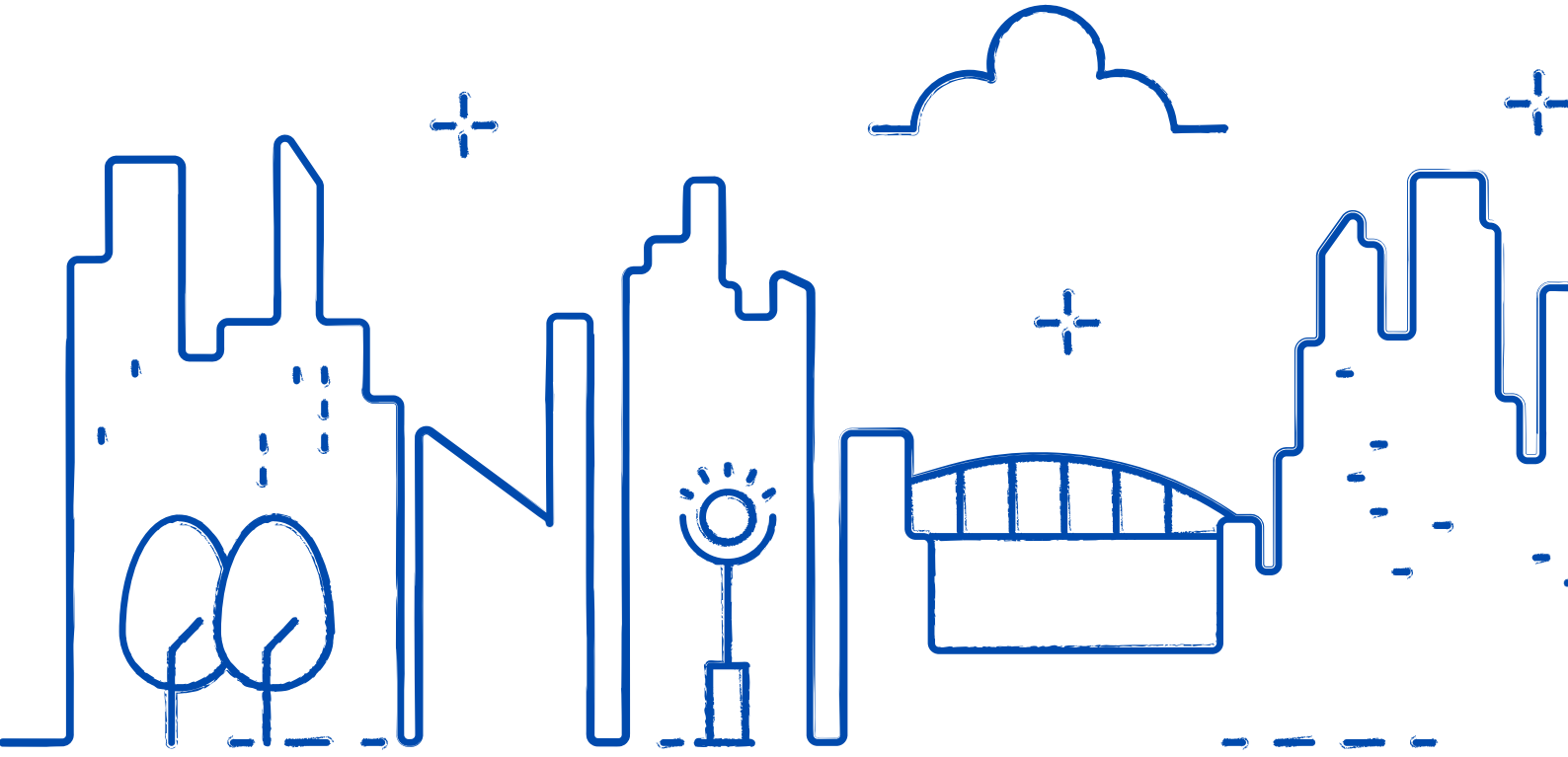

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Hydrogen in the EU

The European Union (EU) prioritises the development of renewable hydrogen as a key element in its energy transition, net-zero goals, and sustainable development strategy. The European Commission introduced the hydrogen policy framework in 2021 which sets binding targets for the adoption of renewable hydrogen in industry and transport by 2030: these have been incorporated into the revised Renewable Energy Directive effective since 2023. As of 2022, hydrogen represented less than 2% of Europe's energy consumption. Out of this 2%, 96% of hydrogen was derived from natural gas, contributing to CO_2 emissions (European Commission, 2023).

The 2022 REPowerEU Strategy outlined a goal to produce and import 10 million tonnes of renewable hydrogen by 2030 in the EU. The anticipated rise in hydrogen demand is driven by not only regulation and strategy but also its potential applications across various sectors, in terms of decarbonisation and energy storage. This includes (Jacquemin, Thiran and Quoilin, 2025):

- **Power sector:** energy storage and grid balancing using electrolysers and fuel cells.
- **Steel industry:** transition from basic oxygen furnaces (BOFs) to hydrogen direct reduction (H-DR) in the steel production process.
- **Aviation sector:** medium-range flights could be powered by hydrogen by 2050
- **Maritime shipping:** Hydrogen propulsion.

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Types of hydrogen

Grey hydrogen: Grey hydrogen is the most common form and is generated from natural gas, or methane, through a process called "steam reforming" (Marchant, 2021). In 2023, around 70% of hydrogen was derived from methane (McGregor, Young and Hildebrandt, 2025).

Black and brown hydrogen: Black or brown hydrogen is obtained from coal: bituminous (black) or lignite (brown) It is the most environmentally damaging due to the generation and lack of capture of greenhouse gasses (CO2 and carbon monoxide) (Marchant, 2021).

Blue hydrogen: When carbon generated from steam reforming is captured and stored underground through carbon capture storage systems, it is termed blue hydrogen (Marchant, 2021).

Green hydrogen: Hydrogen which is created electrolytically using renewable electricity is termed green hydrogen. It does not emit greenhouse gases during electrolysis (European Commission, 2023).

Challenges of green hydrogen adoption

"To meet Europe's 2030 targets, a 250-fold increase in electrolyser capacity is required, necessitating an investment of €170-240 billion. This involves constructing 20–40 pioneering megaprojects, each with a 1–5 GW capacity."
(McGregor, Young and Hildebrandt, 2025).

Historically, pioneering energy projects have seen capital costs double or triple from initial estimates, with over half failing to meet production goals. Projects which cost more than €1 billion are termed 'megaprojects' and are often over budget and anticipated time scale due to underestimation of costs and risks. Furthermore, overtime as these projects develop, technology related to it can quickly go obsolete due to quick advancements in the sector.

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Some nations are fortunate to have abundant renewable energy resources. In 2023, the renewable energy share for EU27 was 24.5%. Sweden had an over 65% share as the frontrunner, followed by Finland and Denmark at over 45 and 40% respectively, and 19 out of the 27 countries had under 30% share in 2023 (EEA, 2023). Seasonal variations and geography of the country can also impact on the type of renewable energy it can specialise in (McGregor, Young and Hildebrandt, 2025).

Low population density areas can utilise renewable energy more easily, however high population density countries can exceed the renewable energy sources' capacities (McGregor, Young and Hildebrandt, 2025). Jobs and skills are also key as the construction, operation, and maintenance of renewable energy systems and its development. There is a certain level of technical, as well as management expertise required. This may be particularly limited in remote areas.

There is a diverse and unique set of risks associated with production, distribution, and utilisation of green hydrogen, which can impact a variety of stakeholders. Green hydrogen in particular faces market risks, due to posing a small market share at the moment, competition in the industry, and high costs of production compared to other hydrogen types. McGregor, Young and Hildebrandt (2025) proposed the following risk categories: project execution, technology, market and supply chain, business, and political risks.

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