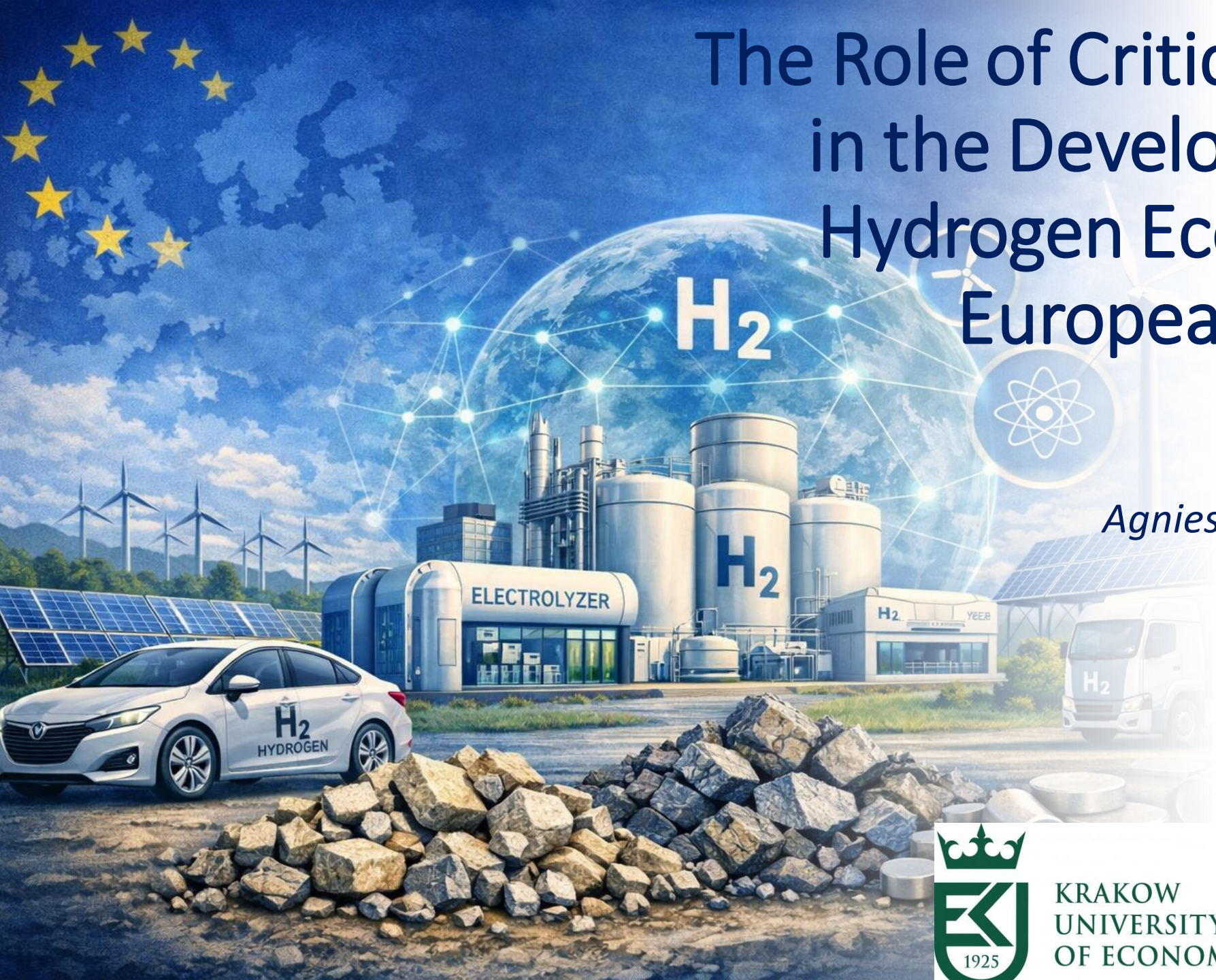
The Role of Critical Raw Materials in the Development of the Hydrogen Economy in the European Union.

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AGENDA

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1.The European Union as a Leader of the Global Energy Transition

2.The New Geopolitical Context: Balancing Energy Transition and Energy Security

3.The Role of Critical Raw Materials in Hydrogen Technologies

4.Hydrogen Production in the European Union

5.Challenges Associated with Critical Raw Materials in the Development of the EU Hydrogen Economy

6.Conclusions



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1. EU as a Leader of the Global Energy Transition

The European Union has been a **pioneer in global climate and energy policy**

•Commitment to emission reduction dates back to the **Kyoto Protocol**

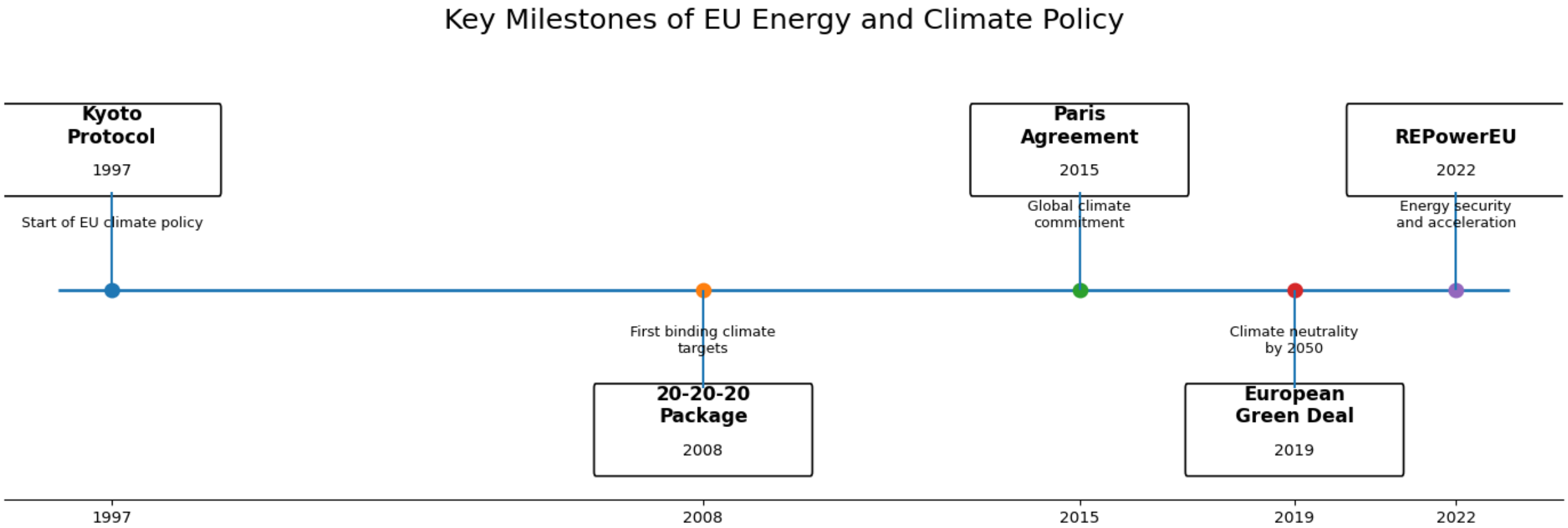
•The **2008 Climate and Energy Package (20-20-20 targets)** set three key goals:
•20% reduction in greenhouse gas emissions
•20% share of renewable energy
•20% improvement in energy efficiency

•Strengthened through the **Paris Agreement**, aiming to limit global warming to well below 2°C

•The **European Green Deal** established a roadmap towards **climate neutrality by 2050**

•The **REPowerEU Plan** accelerated the transition due to geopolitical risks

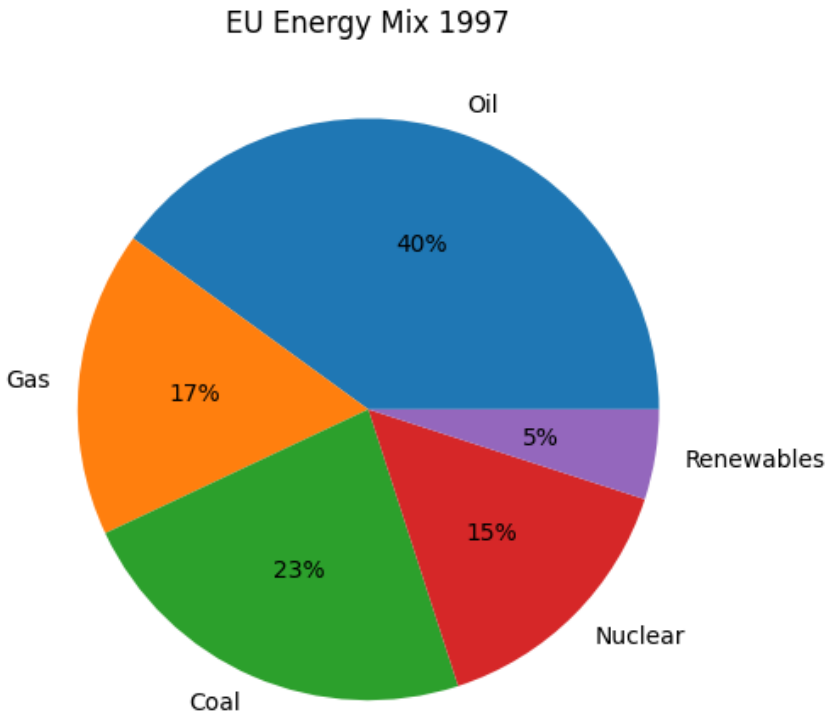
1. EU as a Leader of the Energy Transition

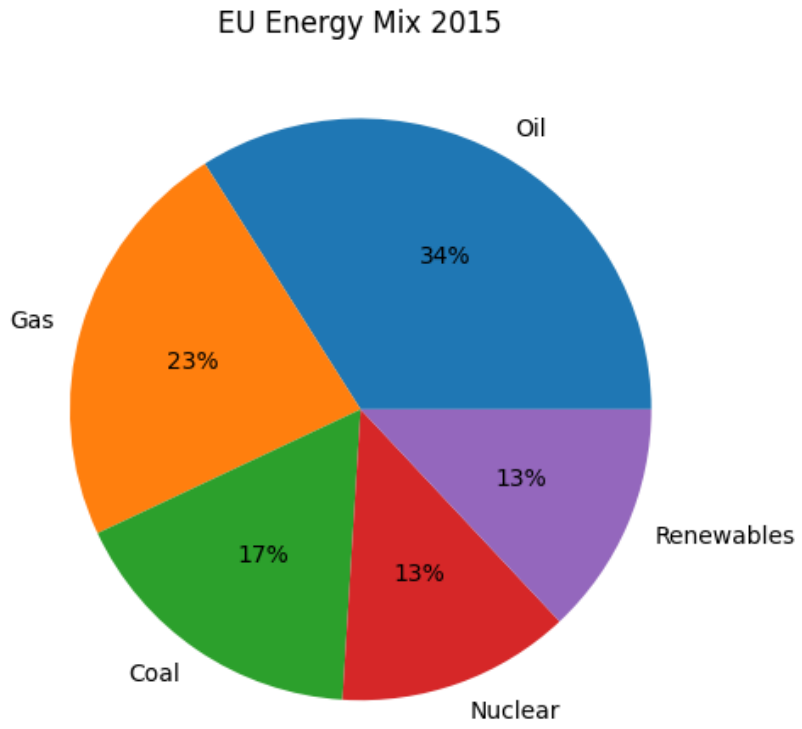


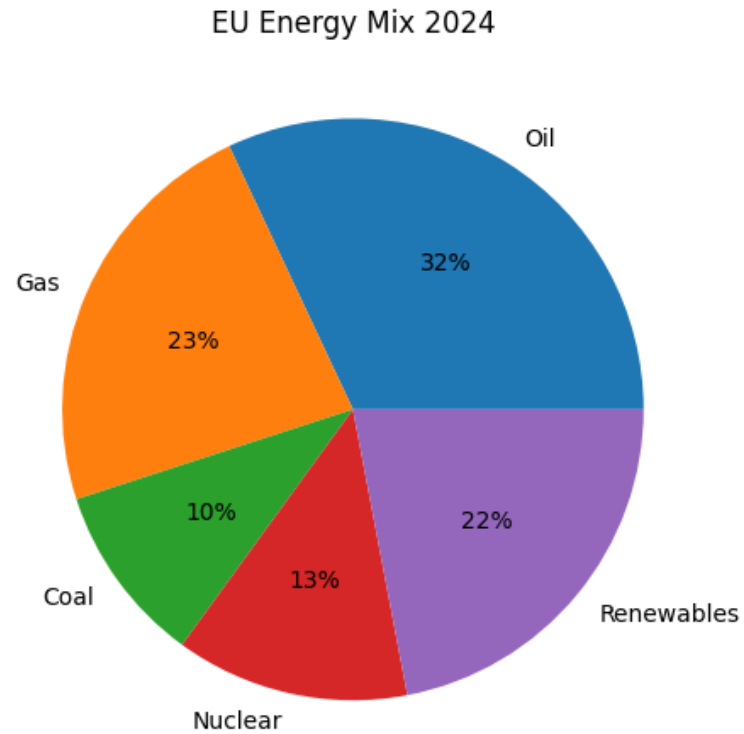
Source: own eleboration

1.EU as a Leader of the Global Energy Transition

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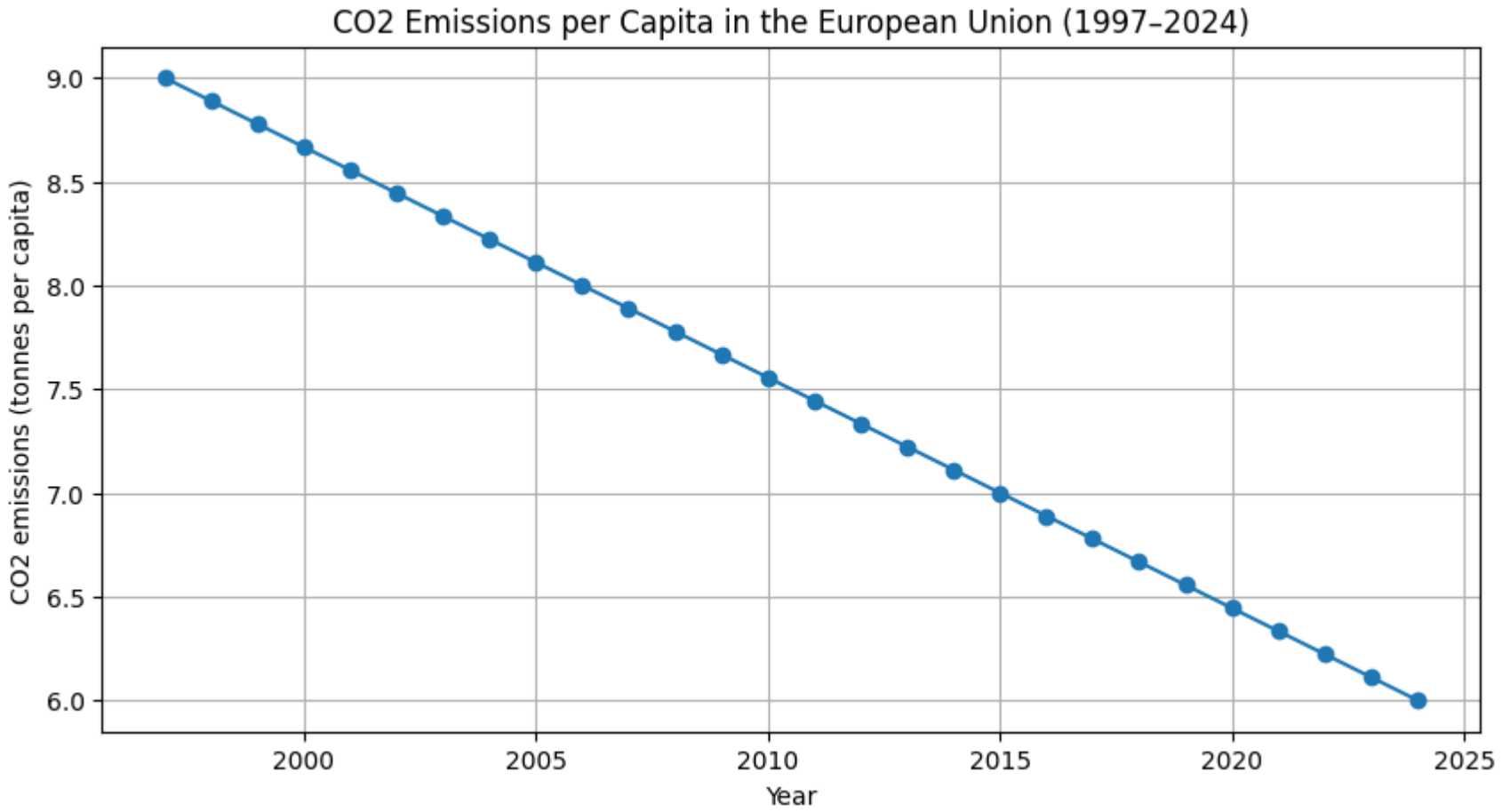




Source: Eurostat (Energy Balances Database), International Energy Agency, based on gross available energy (primary energy mix), own calculations.

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1.EU as a Leader of the Global Energy Transition



Source: own elaboration based on the https://databank.worldbank.org/source/world-development-indicators#

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2.New Geopolitical Context of EU Energy Transition - In Search of a Balance between Energy Transition and Energy Security



3. The Importance of Critical Raw Materials for Hydrogen Technologies

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•**REPowerEU Strategy (2022):** A plan for secure, green gas and hydrogen development.

•**IPCEI** (ang. *Important Projects of Common European Interest*) **programs:** Support investments in hydrogen and critical raw materials.

•**Critical Raw Materials Act (2023):** Establishes a list of critical materials, promotes recycling, and strengthens sourcing within the EU.

•**Integrated Polish hydrogen policy:** Aims at a low-emission economy (e.g., 5 GW of electrolyzer capacity by 2030).

The EU framework for hydrogen development is based on REPowerEU, which assumes, among other goals, the production of 10 million tonnes of green hydrogen by 2030. Critical raw materials are highlighted in the new Critical Raw Materials Act, with the EU emphasizing domestic extraction and recycling. Particular importance is attached to IPCEI (Important Projects of Common European Interest) programs, which support strategic investments in hydrogen technologies and critical raw materials, thereby strengthening the European Union’s industrial base and technological sovereignty.

3. The Importance of Critical Raw Materials for Hydrogen Technologies

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•In Poland, the IPCEI “Hydrogen” initiative accelerates the development of infrastructure, including electrolyzers and hydrogen-based heating plants.

•Importantly, the development of the hydrogen economy is directly dependent on access to critical raw materials, which are essential for key technologies such as electrolyzers, fuel cells, and renewable energy systems.

In this context, the availability and security of supply of critical raw materials become a decisive factor for the successful and scalable development of the European hydrogen economy.

4. The Importance of Critical Raw Materials for Hydrogen Technologies

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➢ Critical raw materials for electrolysers (PEM technology)

An electrolyser is an electrochemical device that enables the decomposition of water (H_2O) into hydrogen (H_2) and oxygen (O_2) using electrical energy. This process, known as water electrolysis, occurs as a result of an electric current passing through an electrolyte and the use of appropriate electrodes and a membrane/separator.

- **Main structural material: nickel** (electrolyser piping and components, approx. 30% of electrolyser cost).
- **Other metals: copper** (wiring, 20%), **cobalt** (membranes, ~15%), **rare earth elements** (e.g. cerium in catalysts).
- **Supporting materials: graphite and rare metals used in control components.**

- Most of the cost of a PEM electrolyser comes from structural materials—primarily nickel and cobalt. For example, nickel accounts for around 30% of the cost, while copper and cobalt represent additional significant shares. This means that shortages of nickel and cobalt have a substantial impact on electrolyser prices.

4. The Importance of Critical Raw Materials for Hydrogen Technologies

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➢ Critical raw materials for fuel cell

PEM fuel cell is a type of fuel cell that uses a polymer (proton) membrane to generate electrical energy from hydrogen.

•**PEM fuel cells** require **platinum and iridium as catalysts** (the most expensive components).

Unlike electrolysers, fuel cells primarily require **platinum and iridium. Platinum** is a critical raw material (the EU imports over 80% of its supply), which poses a significant risk.

The EU is experimenting with anion exchange membrane fuel cells to reduce **platinum** usage, but this technology is still under development. A shortage of platinum could limit the large-scale deployment of hydrogen fuel cells.

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4. The Importance of Critical Raw Materials for Hydrogen Technologies

➢ Critical Raw Materials for hydrogen storage:

•**Solid oxide electrolysers (SOEC):** use cerium, vanadium, magnesium, and aluminium in oxide structures (CRMs: cerium, vanadium).

•**Chemical storage:** e.g. metal hydrides (magnesium, aluminium, manganese – limited data available).

•**Supporting system batteries:** lithium, cobalt, nickel (part of the supporting infrastructure chain, but treated separately).

•**Key conclusion:** metals used in SOEC dominate, with CRMs required for solid membranes and high-temperature structural components.

Hydrogen storage can take place in high-pressure tanks (steel, carbon fibres – generally not considered critical raw materials) or through chemical methods (metal hydrides). In the case of SOEC (high-temperature electrolysers), the main components contain **cerium and vanadium**, which are on the CRM list. It is also important to note that demand for batteries supporting hydrogen infrastructure (e.g. **lithium-ion batteries**) introduces additional raw material challenges.

3. The Importance of Critical Raw Materials for Hydrogen Technologies

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▨ **Green Hydrogen**

- Hydrogen produced via **electrolysis of water** (typically “water electrolysis” in datasets)
- In the EU regulatory framework, **renewable hydrogen** is defined based on:
  - origin of electricity (renewable sources)
  - lifecycle emission reduction criteria

▨ **Blue Hydrogen**

- Hydrogen produced from **fossil fuels with CO_2 capture (CCS)**

■ **Grey Hydrogen**

- Hydrogen produced from **fossil fuels without CCS**

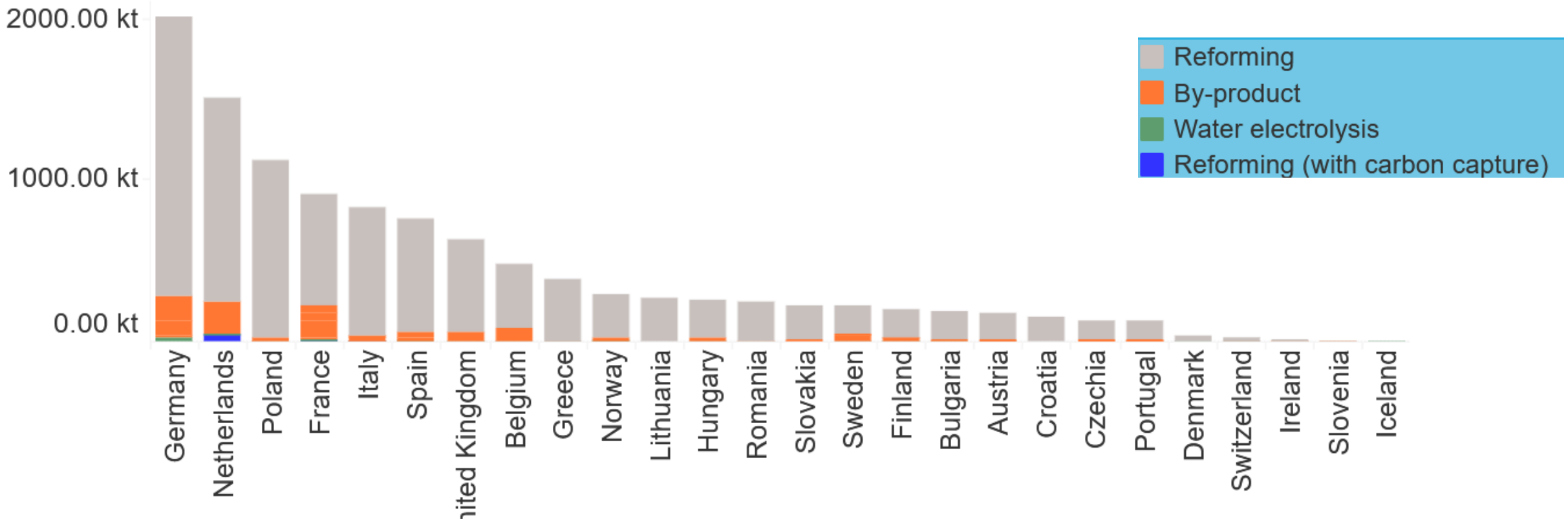
◯ **Other (By-product Hydrogen)**

- Auxiliary category covering **hydrogen as a by-product**
- Color classification depends on:
  - emission allocation between main and by-product outputs
  - system boundaries applied in analysis
- In energy statistics, by-product hydrogen is reported as hydrogen, but its “color” is **not automatically determined**

5.EU Hydrogen Production

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Hydrogen production is becoming a central element of the European Union's energy transition strategy. In particular, the focus is on the development of low-carbon and renewable hydrogen, often referred to as green hydrogen.

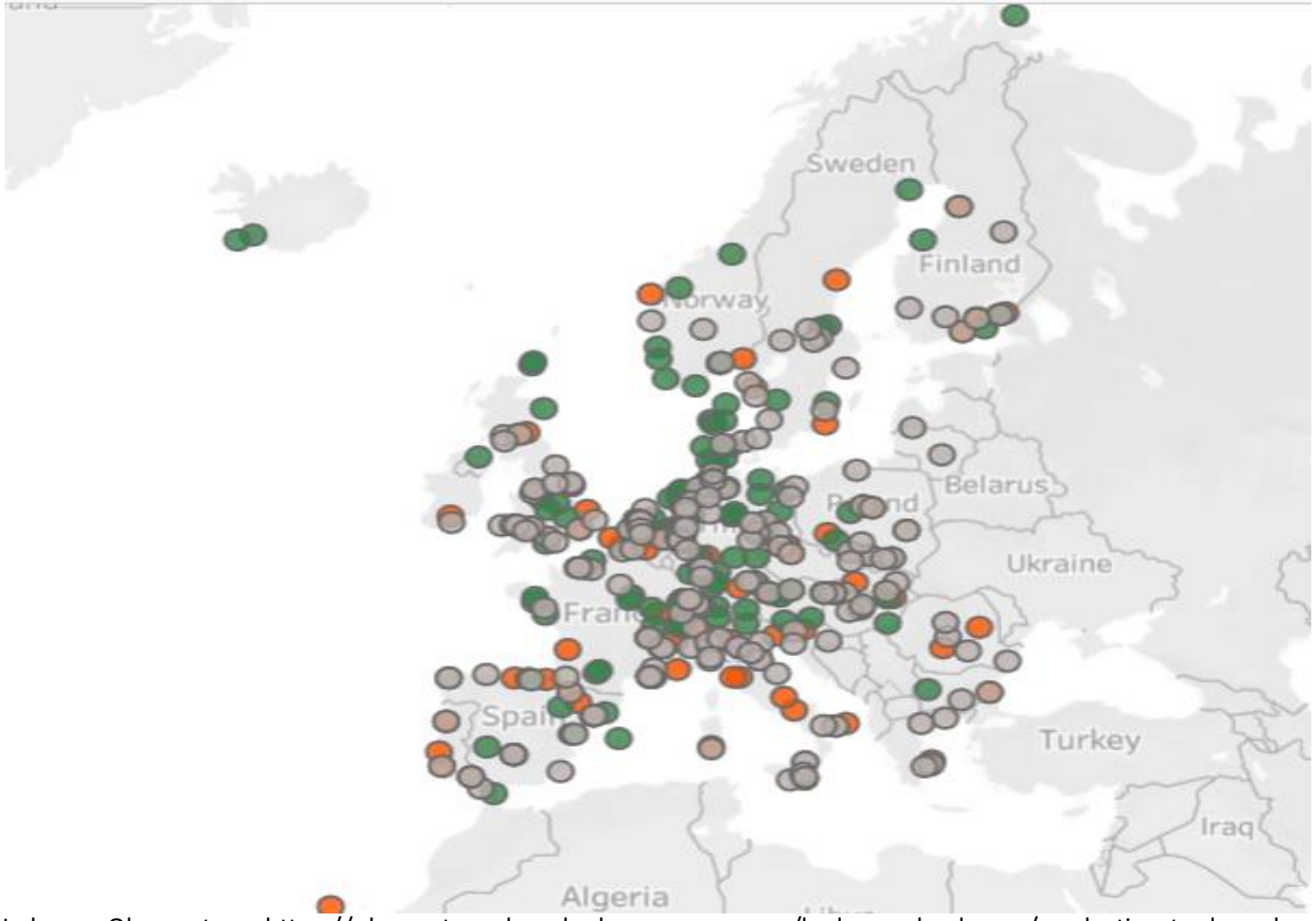


Source:European Hydrogen Observatory,, https://observatory.clean-hydrogen.europa.eu/hydrogen-landscape/production-trade-and-cost/hydrogen-production

5.EU Hydrogen Production

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EU Hydrogen Production in 2024



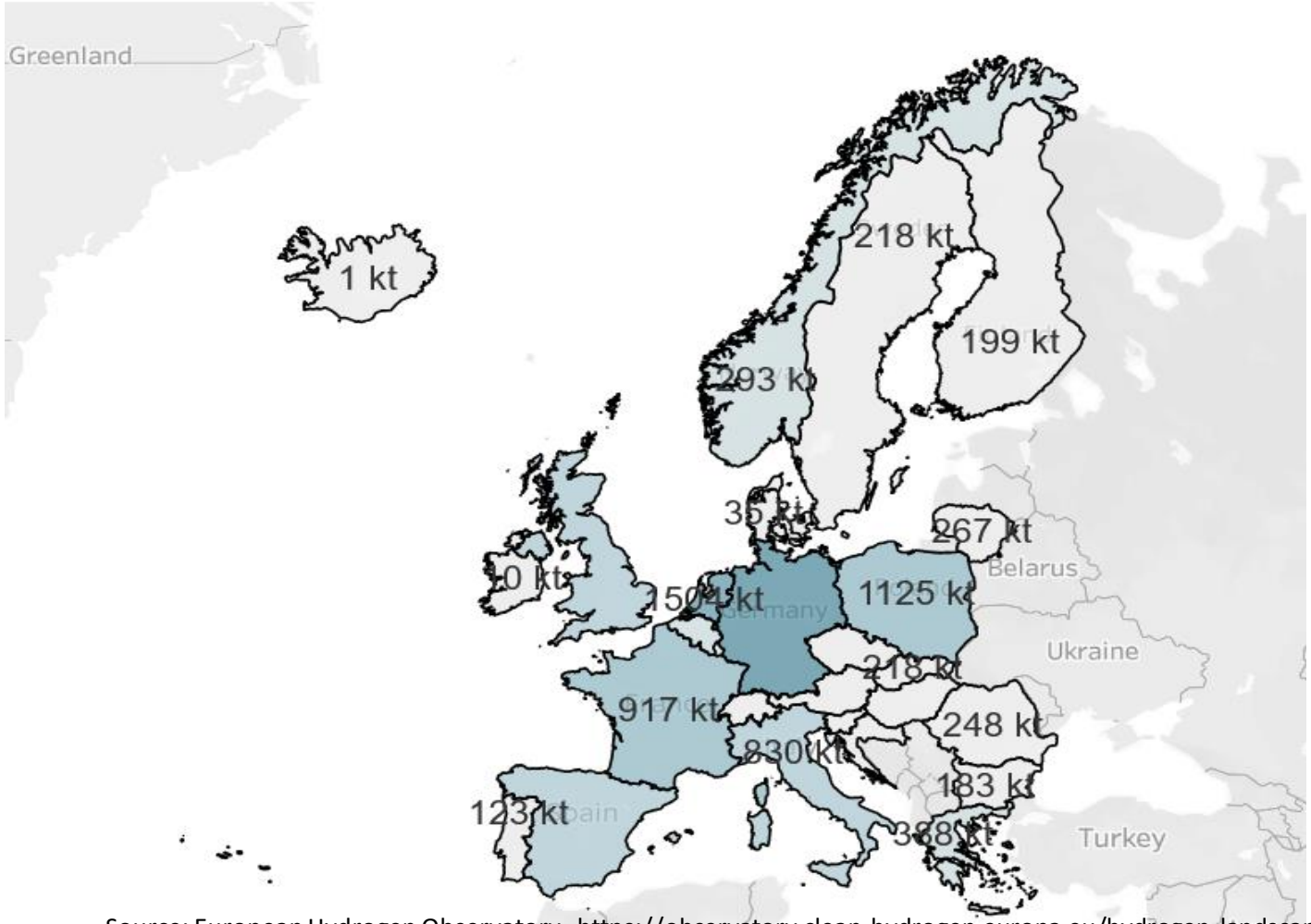
Currently, hydrogen is still largely produced from fossil fuels, especially natural gas. However, the EU is making significant efforts to shift towards more sustainable production methods, primarily through water electrolysis powered by renewable energy sources.

Source: European Hydrogen Observatory,, https://observatory.clean-hydrogen.europa.eu/hydrogen-landscape/production-trade-and-cost/hydrogen-production

6. EU Hydrogen Production

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EU Hydrogen Production in 2024



- In this context, technologies such **as PEM electrolysers** play a crucial role, as they enable efficient and flexible hydrogen production, particularly in combination with renewable energy.
- At the same time, scaling up hydrogen production requires substantial investments, technological innovation, and, importantly, secure access to critical raw materials.
- Therefore, hydrogen production is not only a technological challenge, but also a strategic issue closely linked to energy security, industrial policy, and the availability of key resources.

Source: European Hydrogen Observatory,, https://observatory.clean-hydrogen.europa.eu/hydrogen-landscape/production-trade-and-cost/hydrogen-production

6.Challenges related to critical raw materials in the context of the development of the European Union's hydrogen economy.

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➢ Supply chains and risks

•**Dependence on imports from China:** e.g. 70% of global rare earth metal processing, 60% of nickel.

•**Geopolitical risks:** supply monopolies, embargoes, climate regulations.

•**Price volatility:** e.g. the sharp increase in lithium prices between 2020 and 2023.

•**Need for diversification:** development of domestic extraction (e.g. deposits of critical raw

The EU imports most of its critical raw materials from external sources, which exposes it to supply disruptions. For example, around 60–70% of **platinum and rare earth metals come from China**. In addition, raw material prices are highly volatile (similar to oil markets). Therefore, the EU is focusing on shortening supply chains and building strategic reserves (e.g. critical raw materials stockpiling).

6.Challenges related to critical raw materials in the context development of the European Union's hydrogen economy

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➢ Recycling and circularity

•Recycling mechanisms for key metals: platinum from catalysts, lithium and cobalt from batteries,

•The EU promotes a circular economy (the CRMA requires companies to develop recycling plans) and provides funding for the development of recycling technologies.

•**Barriers:** high recovery costs, fragmented waste streams, lack of infrastructure.

•**Example:** the Horizon programme funds projects for recovering Pt/Ir from fuel cells.

According to the EU raw materials strategy, recycling is becoming crucial. For example, the practical recovery of platinum from fuel cells or lithium from batteries is still on a limited scale, but there is growing pressure to expand these processes. The EU is introducing recycling obligations (CRMA) and investing in innovation (Horizon, IPCEI). A fully circular system reduces dependence on imports and helps protect the environment.

6.Challenges related to critical raw materials in the context of development of the European Union's hydrogen economy.

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Examples of projects

•**European Lithium and Magnesium Alliance:** development of European lithium mines (Spain, Germany) with EU support (IPCEI).

•**BLOOM project (hydrogen in Poland):** KGHM Polska Miedź invests in fuel cells and nickel recycling, with a local partner supported by EU grants.

•**"Power-to-X" project** (e.g. HyGreen, Netherlands): hydrogen electrolysis powered by PV and hydrogen storage.

Many projects demonstrate integrated value chains. For example, the lithium alliance connects European mines with battery manufacturing. Innovations such as Hy2Tech link PV with local hydrogen production (reducing import dependence). These value chains typically require secure supplies of **cobalt and nickel.**

Conclusions

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Critical raw materials are essential for a **secure and sustainable hydrogen economy** in the European Union.

•The EU must actively secure access through **diversification and investments in recycling**.

•Strong policy initiatives (such as the Critical Raw Materials Act and Important Projects of Common European Interest) represent a step in the right direction, but **consistent implementation is required**.

•**EU–industry cooperation** is crucial: joint demonstration projects and educational programs (to build social acceptance for extraction activities).

We should **accelerate investments in critical raw material value chains for hydrogen** and to **urgently implement standards for sustainable extraction**.

In conclusion, the development of hydrogen in Europe depends on access to appropriate raw materials. EU countries and companies must act jointly to avoid bottlenecks. The potential is enormous—if we focus on innovation and strategic partnerships, the European Union can become a **global leader in the hydrogen economy.**

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Sources:

- European Commission – *Critical Raw Materials Act* (2023).
- European Commission – REPowerEU Startegy (2022).
- European Commission – IPCEI Hydrogen.
- IEA – *Global Hydrogen Review* (2023).
- IRENA – *Geopolitics of the Energy Transformation* (2022).

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Thank you for your attention

