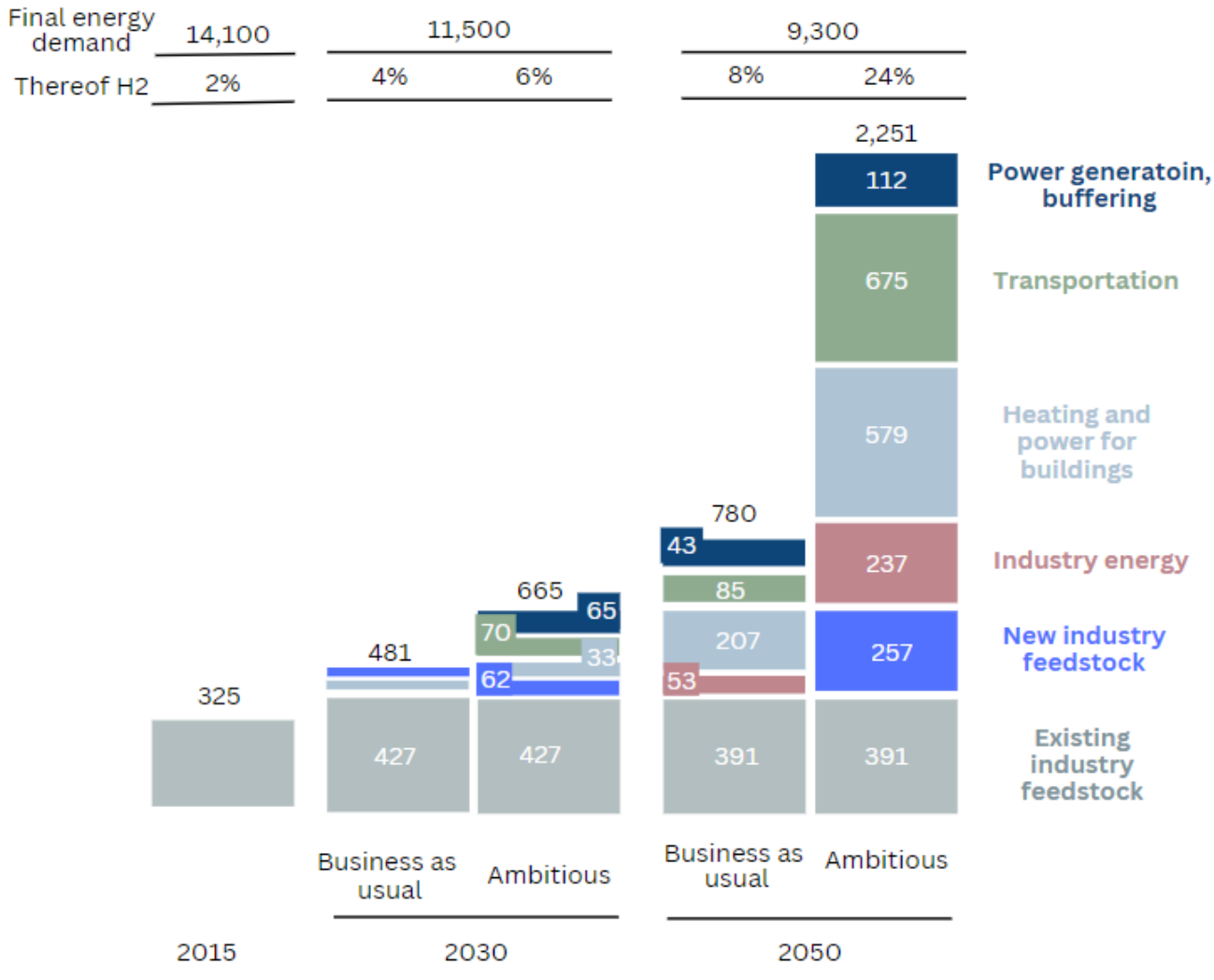
# Graphite in hydrogen production

The global energy crisis sparked by Russia's invasion of Ukraine has highlighted the urgent need to tackle the overlapping challenges of energy security, energy access, climate change and economic recovery. Clean energy technology, including hydrogen, is at the heart of all policy packages addressing these interrelated issues.

**Hydrogen could provide up to 24% of total energy demand, or up to 2,250 TWH of energy in the EU by 2050.**

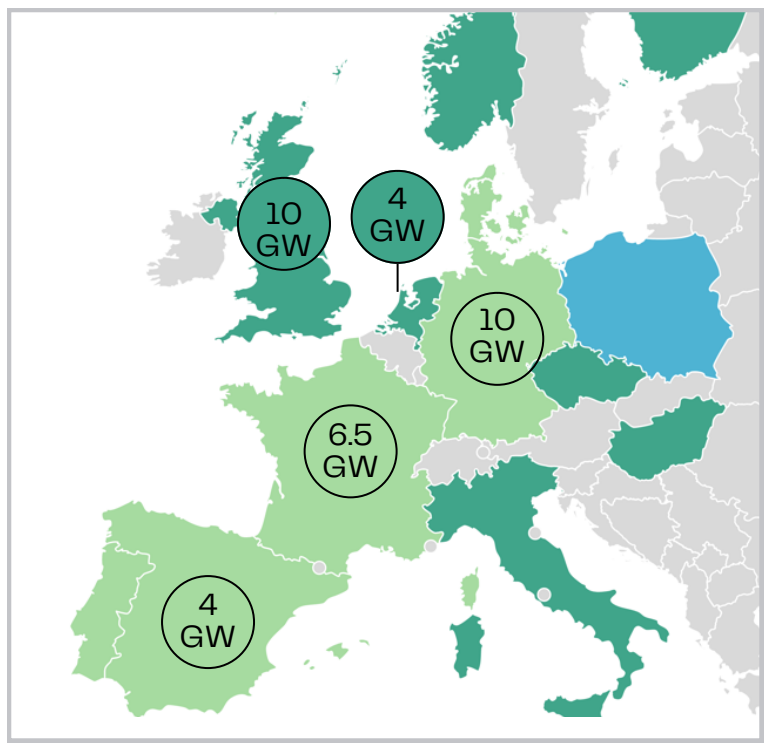



Source: Hydrogen Roadmap Europe; Fuel Cells and Hydrogen Joint Undertaking, 2019

**Overview of announced national strategies for hydrogen and targeted supply capacities for 2030**

**Technology choice:**

- **Electrolysis-based hydrogen**
- **Low-carbon hydrogen based on reformers with CCS**
- **A mix of both low-carbon and renewable hydrogen**




Source: Hydrogen4EU

**Graphite's unique properties** of both a metal and a non-metal, such as **flexibility**, **high thermal and electrical conductivity and is highly refractory and chemically inertia** make it an **essential raw material in the hydrogen production** (electrolysis) and energy storage.

## Fuel cells

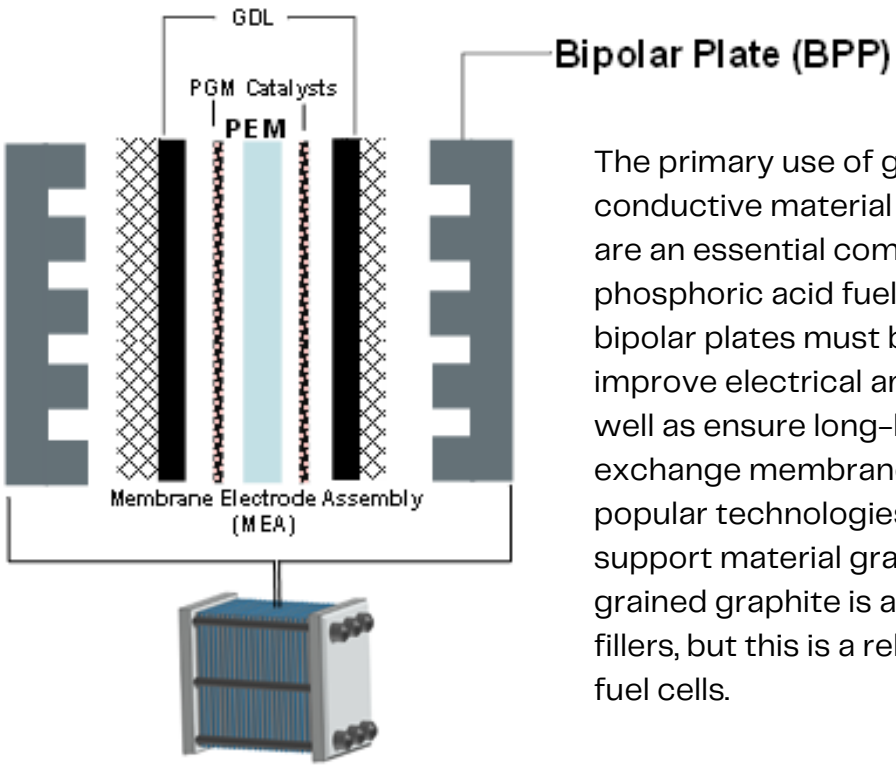
A fuel cell is an electrochemical device that converts the chemical energy from combustible fuels (hydrogen, ammonia, lower alcohols) into electricity through an electrochemical reaction of the fuel with the air (oxygen) or another oxidising agent.

Fuel cells are used to power buses, boats, trucks, trains, planes, scooters, forklifts, even bicycles. There are fuel cell-powered vending machines, vacuum cleaners, and highway road signs. Miniature fuel cells for cellular phones, laptop computers and portable electronics are on their way to market. Another highly relevant application is CHP systems. Hospitals, credit card centres, police stations, and banks are all using fuel cells to provide emergency power to their facilities. Wastewater treatment plants and landfills are using fuel cells to convert the methane gas they produce into electricity. Telecommunications companies are installing fuel cells at cell phone, radio and 911 towers.

**Fuel Cell applications**

## Fuel cell composition

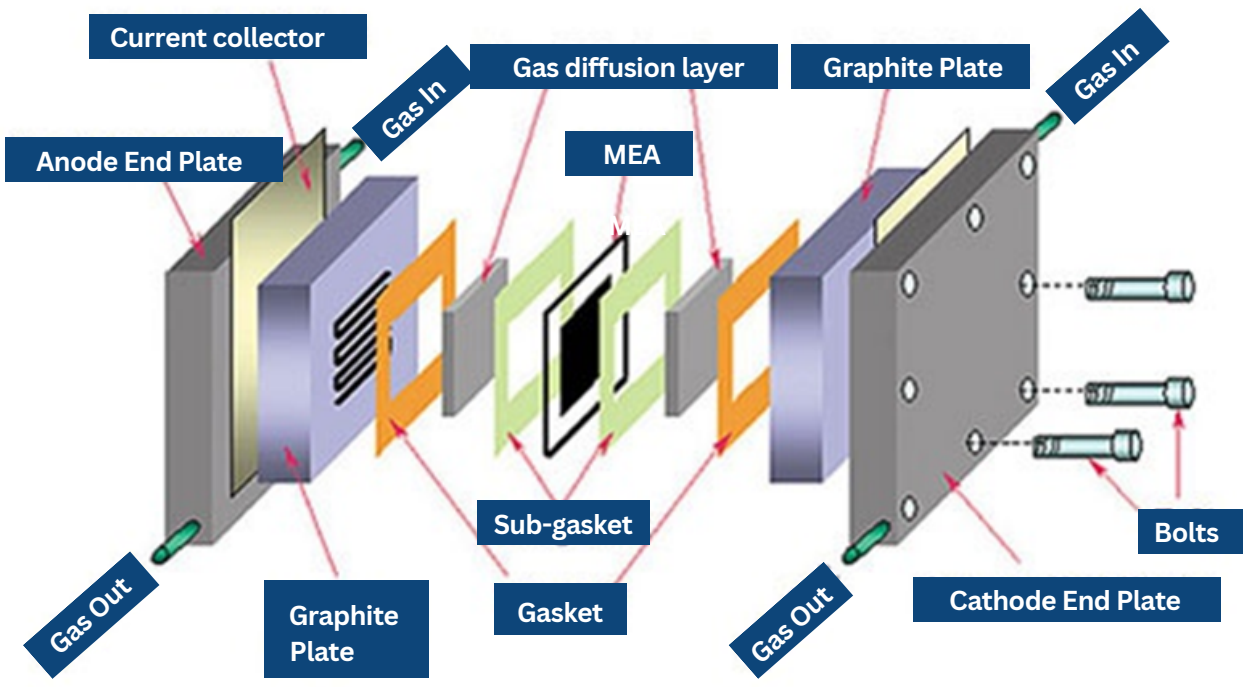
### Current technology




The primary use of graphite in fuel cells is as a conductive material for the bipolar plates, which are an essential component of PEM and phosphoric acid fuel cells (PAFCs). Thin graphitic bipolar plates must be pure and of high quality to improve electrical and thermal conductivity, as well as ensure long-life operation. The proton-exchange membrane fuel cells, one of the most popular technologies, require for the catalyst as support material graphitic carbon blacks. Fine grained graphite is also used as additives and fillers, but this is a relatively small component of fuel cells.

PEM Fuel Cell Stacks and single cell structure (courtesy: SGL Carbon)

### Future technology

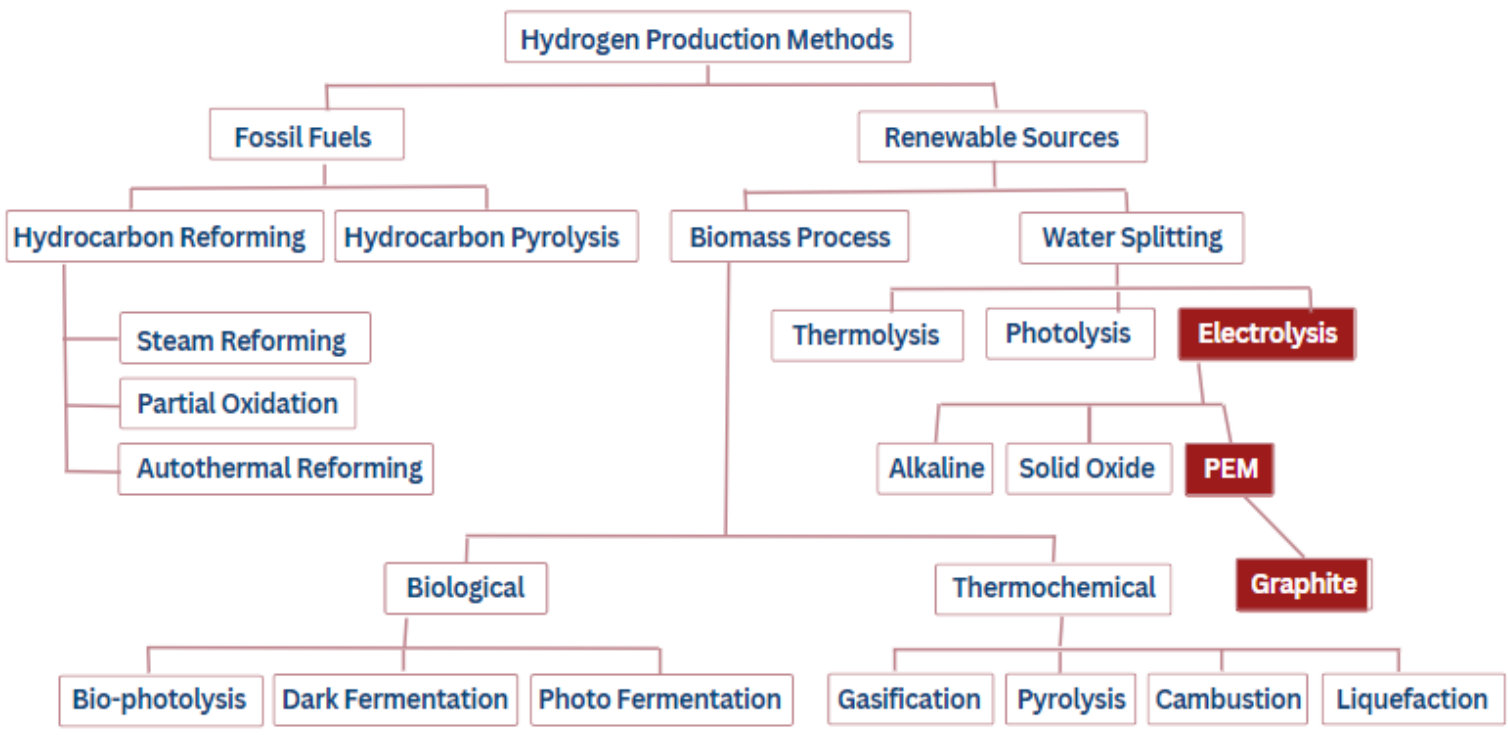



Source: https://www.nextsourcematerials.com/graphite/about-graphite/

According to the United States Geological Survey, fuel cells have the potential to consume as much graphite as all other uses combined if PEMFC propulsion systems would be introduced widely. Currently passenger cars use bipolar plates based on coated steel and there is around **80 kg of graphite in each fuel cell vehicle**.

## Water Electrolysis

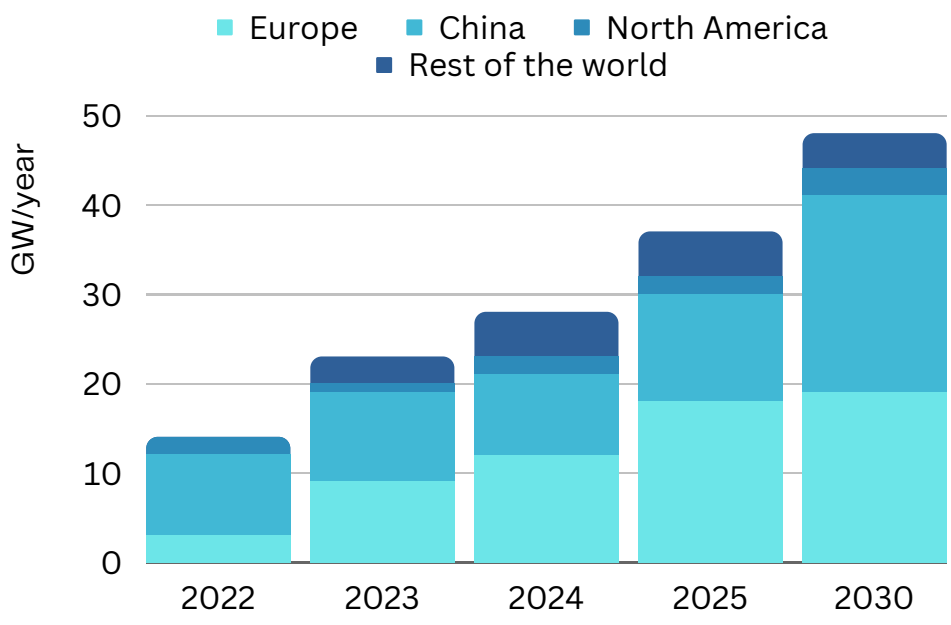
Renewable hydrogen can be obtained via water electrolysis using renewable electricity to split water into hydrogen and oxygen. It will play a key role in decarbonising sectors where other alternatives might be unfeasible or more expensive. It can be used to replace fossil-based hydrogen for transport and industrial processes, and to start new industrial processes, such as steel.




Source: Material Science for Energy Technologies

Renewable hydrogen is mainly produced via water electrolysis. The installed capacity of electrolyser factories has rapidly increased, reaching 8 GW in 2022. Based on company announcements, global manufacturing capacities could reach 60 GW per year by 2030 and include gigawatt production lines for three of the four competing electrolyser types: alkaline, polymer electrolyte membrane, and solid oxide electrolyser cell.

**Electrolyser manufacturing capacity by region 2022-2030**




The electrolyser is an electrochemical reactor which splits water into hydrogen and oxygen by means of electricity. Hydrogen produced in this sustainable way, (without emitting carbon dioxide into the atmosphere) can be the basis for a decarbonised economy.

## Hydrogen production facts & figures: what others say:

**Hydrogen Europe:**
**In 2022**, demand for hydrogen is estimated at between **8.4 and 8.7mt.**

**International Energy Agency**
Demand for **hydrogen** has grown **more than threefold** since **1975.**

**NASA**
NASA fuels its **spaceships with hydrogen** and **the resulting water is so pure** that the astronauts drink it.

**Fuel Cells and Hydrogen Observatory**
**More than half** of the total EU, EFTA, and UK hydrogen consumption takes place in just four countries: **Germany, the Netherlands, Poland, and Spain.**

**European Commission**
To meet **REPowerEU goals**, investments **between €86-126 billion** will be needed.

**The Energy Transitions Commission**
Decarbonisation with hydrogen will require **$15 trillion** between **2022** and **2050.**

**Hydrogen Europe**
**Portugal** produces **the most affordable renewable hydrogen** in the EU at €3.50/kg.

**Clean Hydrogen Monitor**
Despite increasing capacity for clean hydrogen in Europe, **99.3% of hydrogen** was produced **by conventional, polluting methods.**

**Gas for Climate**
The **European Hydrogen Backbone** proposes **39,700 km of hydrogen pipelines** by 2040.

**International Energy Agency**
Global **hydrogen demand** is forecast to **more than double** by 2030.

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