THE COMPETITION BETWEEN ELECTROLYSER TECHNOLOGY TYPES

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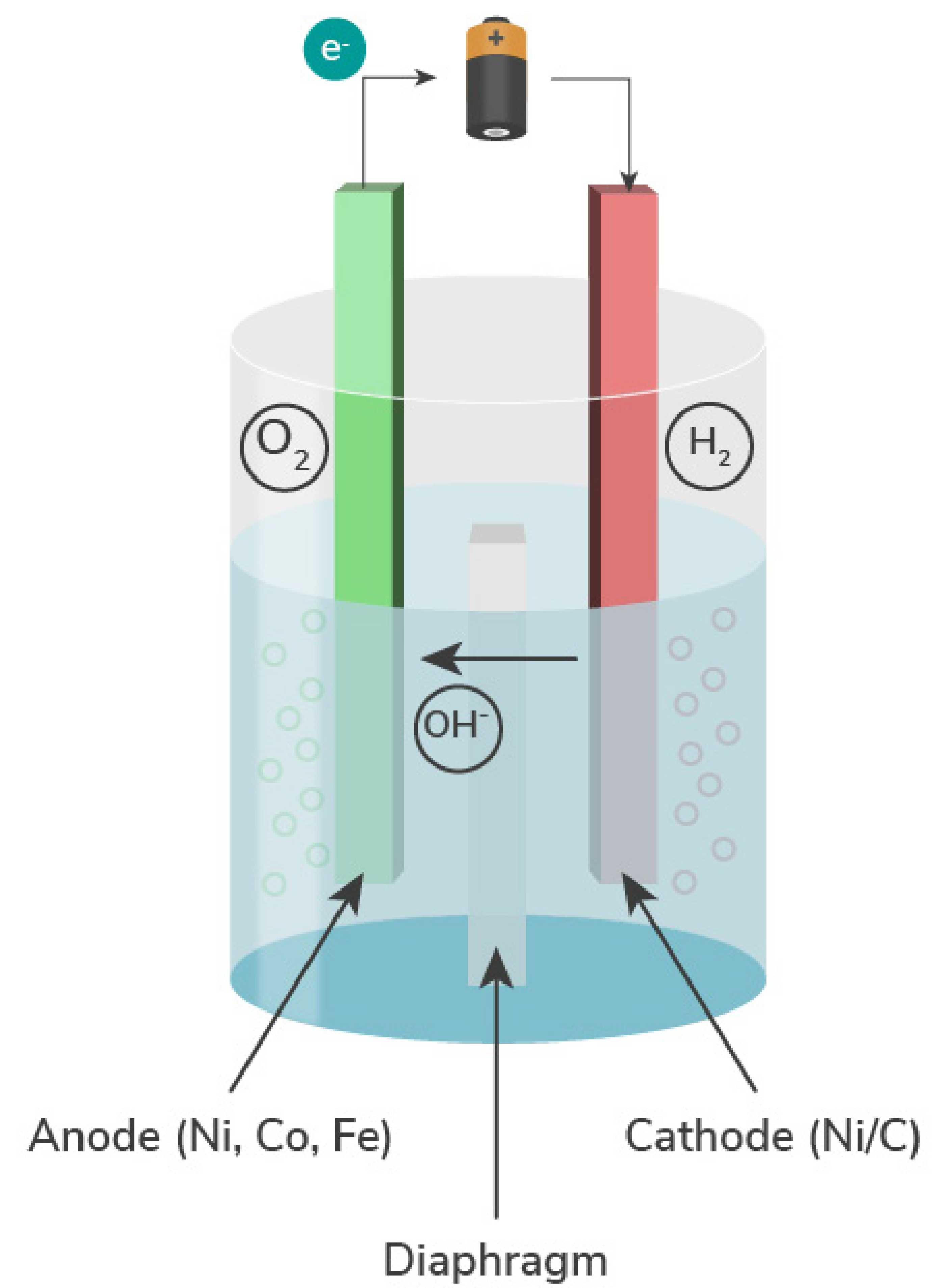
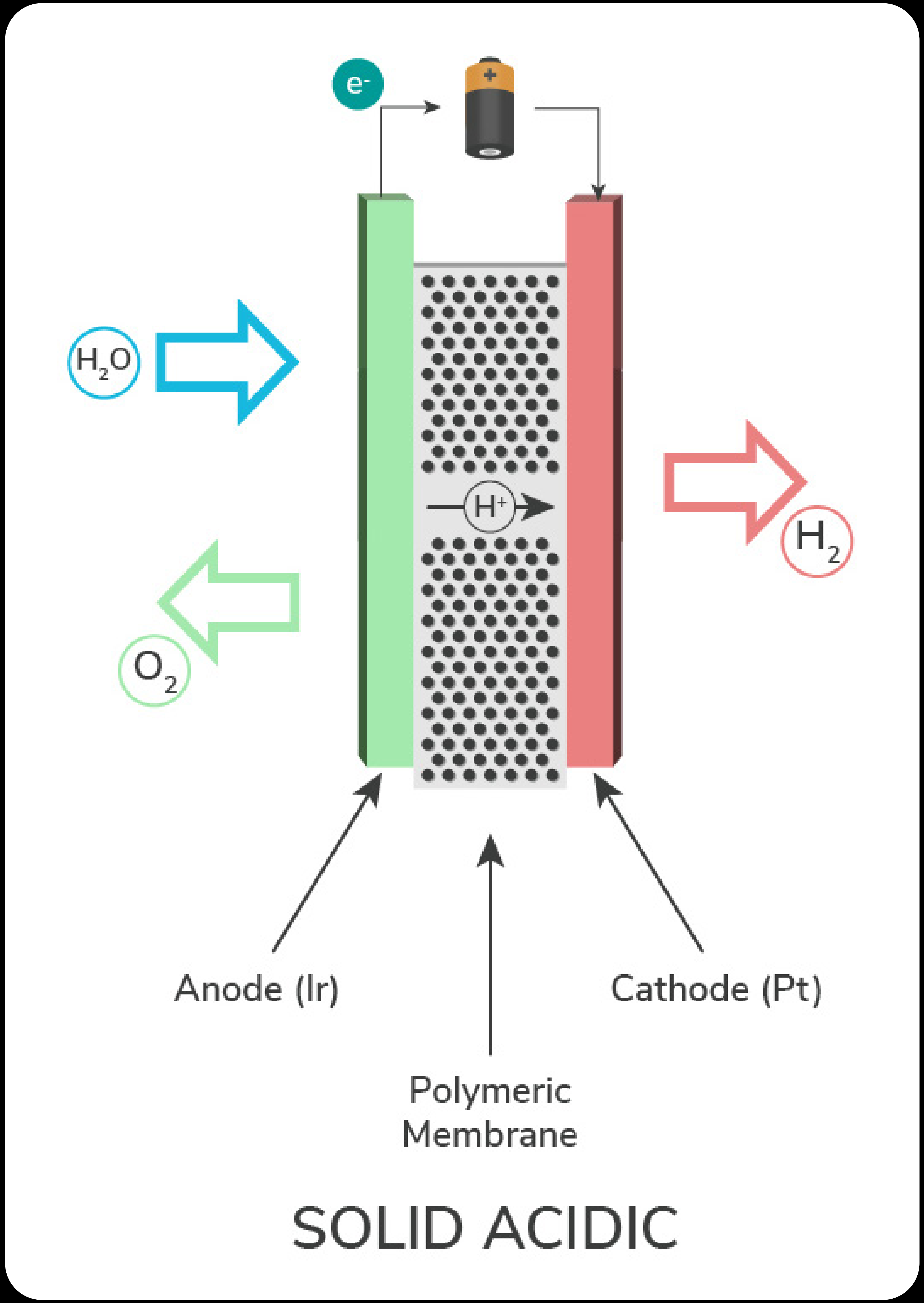
WHAT ARE THE MAIN TYPES OF ELECTROLYSER?

Green hydrogen, produced via water electrolysis, has the opportunity to provide a zero-carbon energy source and vector. Electrolysers split water into hydrogen (cathodic reaction) and oxygen (anodic reaction), with renewable energy passing an electric current through the system. The hydrogen produced can then be used directly as a fuel, an energy storage system for renewable energy, or within current hydrogen-based industries. It is expected that clean hydrogen production will be an important contributor towards the energy transition. Despite the great potential, we are yet to reach widespread commercialisation at utility scale. The main challenges are the high thermodynamic potential required to split the water, which leads to unfavourable kinetics and often expensive components.

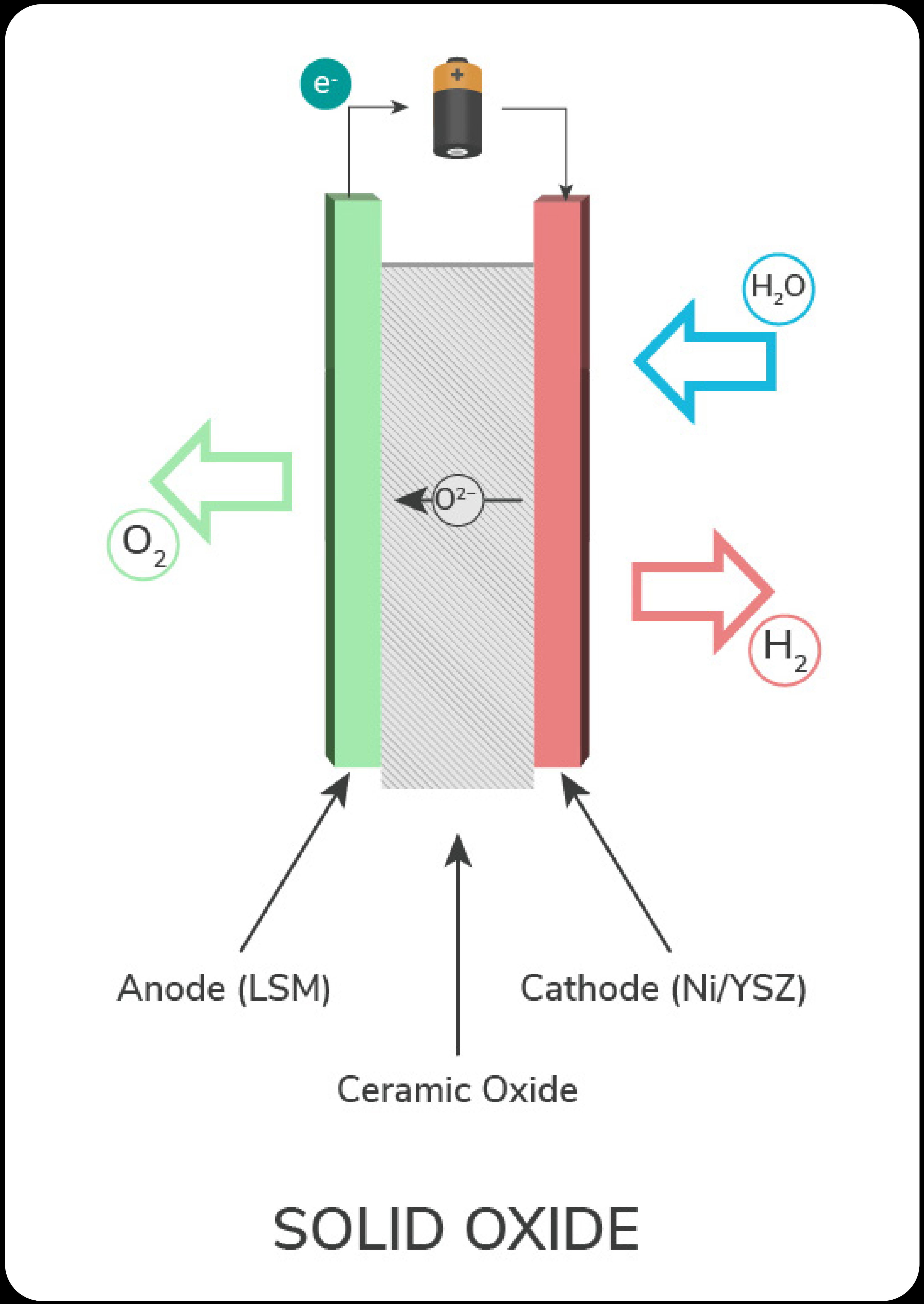


LIQUID ALKALINE

Several electrolyser designs are currently available, which vary in terms of the pH environment and gas crossover strategy, and developments are working towards lowering costs and improving effectiveness. Different systems offer varying characteristics, with a range of efficiencies, costs of production, stack sizes and hydrogen purities. Looking into the commercially available options, alkaline water electrolysers (AWEs), proton exchange membrane (PEM) electrolysers, and solid oxide electrolyser cells (SOECs) are gaining worldwide traction, with several manufacturers focusing on the development of these systems around the globe. They operate under different pH conditions and have different maturity levels, and all three electrolyser options mentioned have characterised benefits and limitations.



Alkaline electrolysers are the lowest cost and most mature technology due to the simplest methodology but provide the lowest efficiency and hydrogen purity due to thick membranes required in the system. In comparison, PEMs, which operate under higher pressure and harshly acidic and oxidising environments, require expensive electrocatalysts due to the extreme conditions and so experience relatively high costs, but benefit from a small stack design, high efficiencies and high hydrogen purities. PEMs also have a faster operational response time, which is useful when considering the intermittency of renewables. SOECs, the least mature option discussed, have advantages of offering the greatest efficiency while requiring low-cost materials but require elevated temperatures (up to 850°C) and are still in development stage, limiting current wide-spread viability.



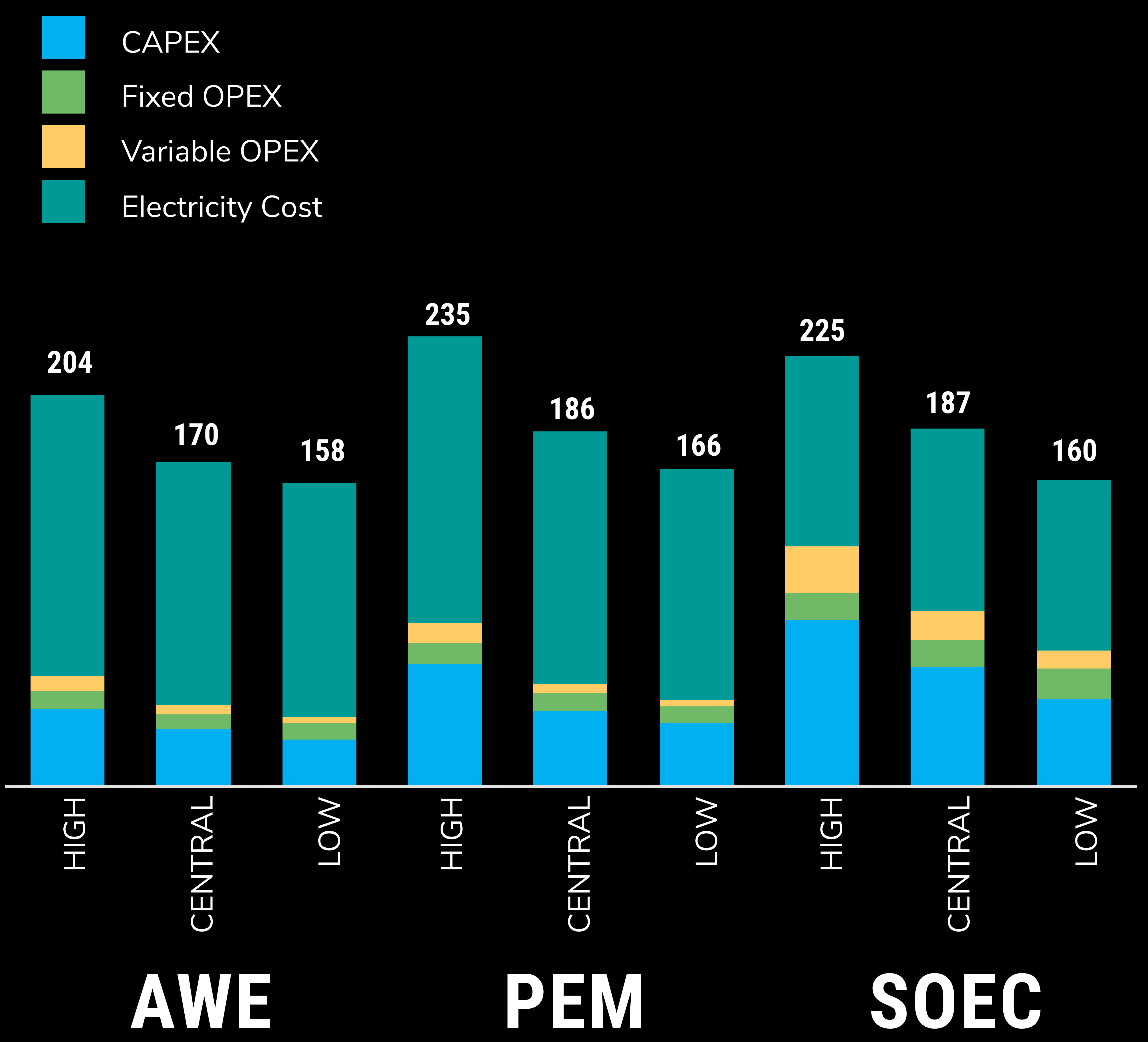
THE COSTS OF EACH ELECTROLYSER:

Each different electrolyser type offers varying costs per kilogram of hydrogen produced, impacted by the capital costs, operating costs and efficiencies of the system leading to variations in electricity requirements. To investigate this further, we have modelled the current 2024 costs of each technology within the UK, using high, central and low technology cost estimations provided by BEIS, and current costs of UK offshore wind.

This data is separated into CAPEX, fixed OPEX, variable OPEX and electricity cost, and highlights the variety in investment and operating costs experienced by the different types. The wide variation in electricity cost of alkaline systems compared to SOECs emphasises the difference in efficiencies.

COST (£/MWH H2)

High, central & low tech cost estimations
Offshore wind electricity source



Source: Gemserv Analysis, BEIS

However, when compared to current grey hydrogen prices (~£1-2/kg H2), green hydrogen production routes are still much costlier than the conventional, carbon-based route. Expensive electrolyser set-ups, the high costs of electricity and a lack of renewable sources are the main culprits. It is expected that over time electrolytic production costs will fall, and to levels comparable with carbon-based routes in the longer term. This will be driven by high growth in the green hydrogen market (expected CAGR of 55%) pushing technological development and the advancement of renewable electricity sources.

CURRENT AND EXPECTED GLOBAL PRODUCTION CAPACITIES:

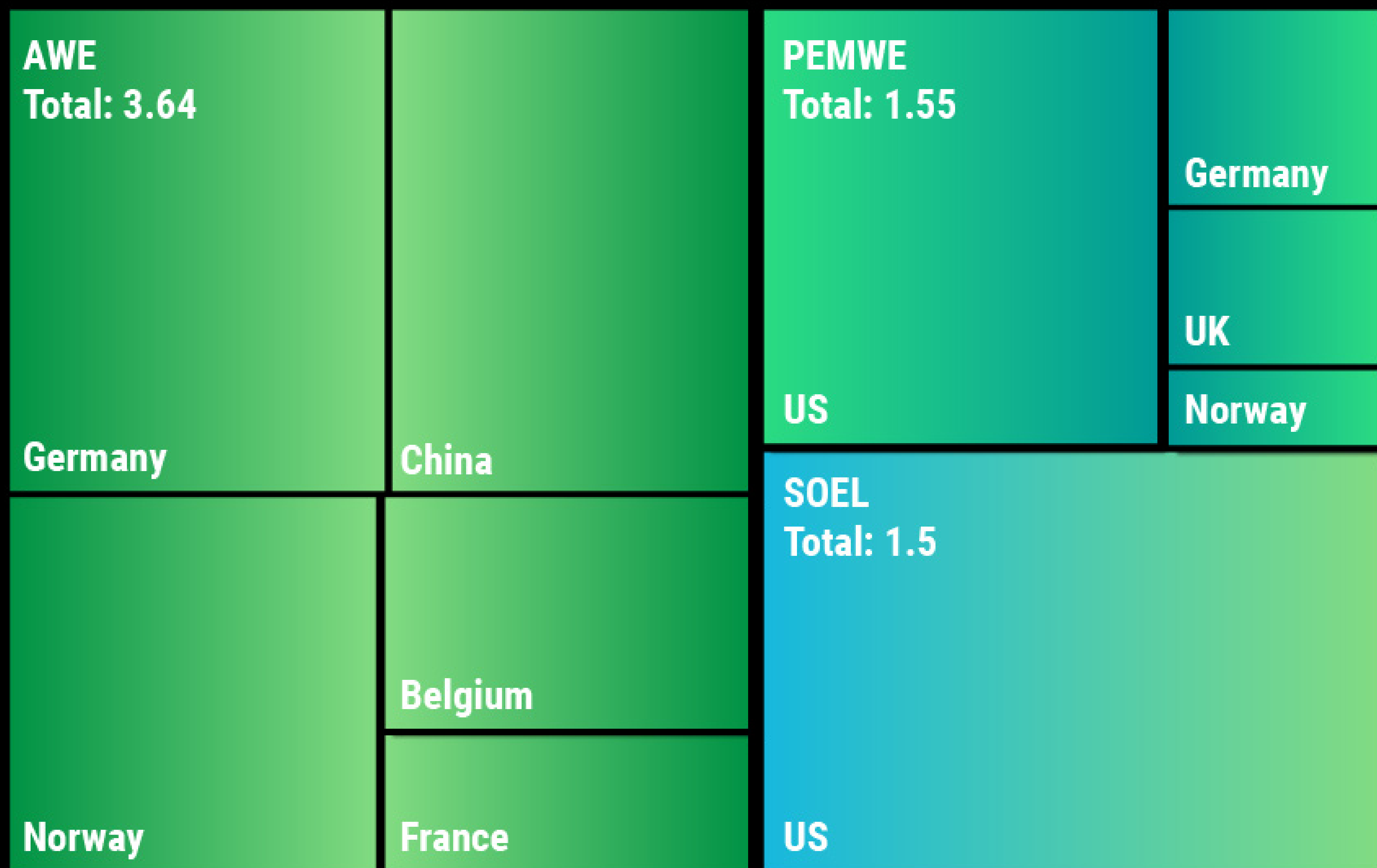
Looking at the current regional dispersion of the different technology types, there is a clear preference for the most commercialised option, AWEs. Looking at all technologies as a whole, from 2024 to 2030 the total global capacity is estimated to increase over 800%, with UK capacity growing 25x within the PEM industry. This reflects the opportunities and high prospects of the sector, and promotes the development of a strong hydrogen industry which will allow the benefits of the technology to be optimised.

Development within the area is happening at a rapid pace: in the UK alone 11 new production projects were backed by the UK government in 2023, and both patents and research papers focused on green hydrogen have grown steadily since 2014.

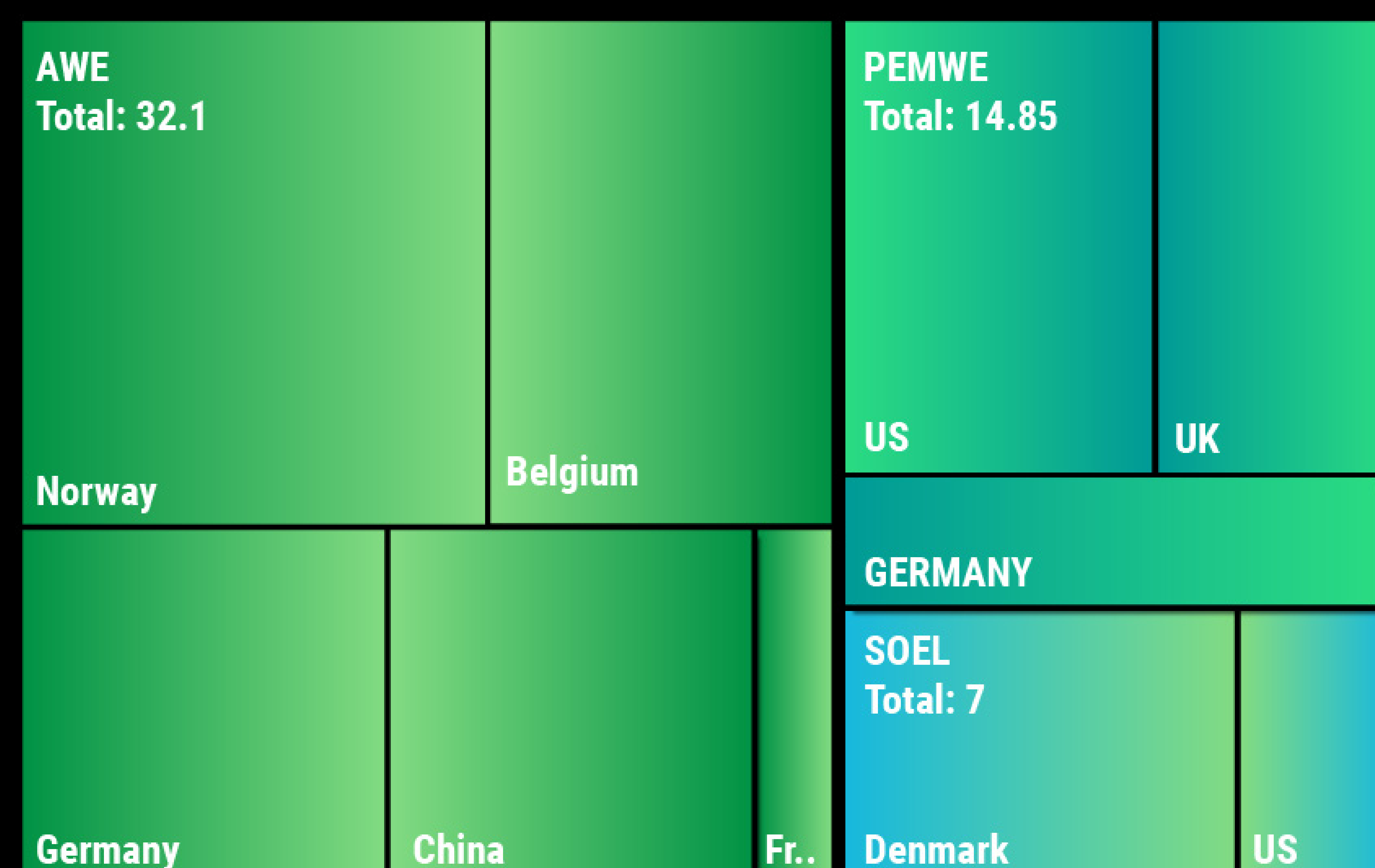
Globally, innovation development and investment within green hydrogen production are being promoted, with a variety of different funding mechanisms available worldwide.

For example, the US Department of Energy has pledged $7bn of funding towards a hydrogen economy, and the Japanese Government has committed to investing $107bn within the next 15 years to supply the country with hydrogen. It is highly likely that further technological developments lower costs and make green hydrogen production even more appealing, offering a decarbonised solution to help push forward the energy transition.

CAPACITY 2024 (GW)



CAPACITY 2030 (GW)



*IEA data, based on company HQs

As we have seen, currently AWE systems dominate the electrolyser market, due to their high commercial viability and lower cost association. In the short-term, it is likely that this trend will continue, as shown within the 2030 estimated capacity of 32.1GW. As time passes and the technology advances, leading to reduced investment and operational costs, we expect the higher efficiency options of PEMs and SOECs to take a greater share of the market, along with novel, alternative electrolyser designs.

The market share of each option will depend upon the speed and progress of the technological advancements needed to drive costs down. The varying production requirements and outputs experienced by different electrolysers will likely mean that the suitability of each will depend on the situation – for example, SOECs are best suited where there is a ready heat source available (e.g. near industrial facilities), while the operational response benefits of PEMs mean that these electrolysers are well-suited for renewable intermittent electricity sources. Overall, there will be a place for all discussed electrolyser types in the market, along with novel electrolyser technologies in development, with different designs working together to provide the required green hydrogen demand, and the next ten years will see great progress in electrolyser adoption and capabilities.

If you have any questions about this article or are curious to find out more about the competition between the electrolyser types, please contact the author of this piece rachael.quintin-baxendale@gemserv.com.

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Rachael Quintin-Baxendale,
Graduate Hydrogen Consultant

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