PÖYRY

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Utilising the versatility of hydrogen to fully decarbonise Europe

Utilising the flexibility of a hydrogen economy in a fully decarbonised European energy system

Focussing on reducing the costs of producing hydrogen could ease the transition towards a zero carbon future – in gas heating, heavy transport, industrial heat, feedstocks, and power generation.

Transport

Electrification of cars and vans dominates the transport transformation, but heavy, long-haul applications are more suited to hydrogen.

Heating

Residential and commercial heating connected to gas converts to utilising hydrogen with elsewhere seeing a significant expansion of electrification.

Power generation

Wind and solar PV are the cheapest forms of power generation. Hydrogen CCGT power plants are used to bridge seasonal gaps.

Smart networks

Gas distribution networks undergo conversion to transporting hydrogen, while more gradual and selective electrification means electricity grids only need to expand by half the level previously required in the more aggressive 'All-Electric' pathway.

'HYDROGEN ECONOMY' PATHWAY SUMMARY

Since Pöyry published its first two pathways looking at how to fully decarbonise Europe's energy system by 2050 we have undertaken various further pathway analysis. One such pathway – for which we received input from a global gas and oil company – considers the benefits of higher hydrogen use, on the basis of the same macro-economic assumptions as previously referenced but reflecting the potential for hydrogen production technology costs to be lower than previously assumed[1].

Results from this 'Hydrogen Economy' pathway (see Figure 1) show that hydrogen can contribute significantly to:

- **heavy goods transportation** where battery vehicles are less practical;
- **heat in industry and buildings**, avoiding the need for disruptive conversion of existing buildings to accommodate heat pumps and improving the likelihood of consumers accepting the changes required; and
- **power generation**, contributing to bridging seasonal gaps and allowing zero carbon balancing plant.

The potential for additional hydrogen as a feedstock in industry has not been analysed in this study. This therefore represents additional upside for hydrogen demand in the pathway.

MINIMISING DISRUPTION IN PEOPLE'S HOMES AND BUSINESSES

Hybrid heat pumps were a main feature in the 'Zero Carbon Gas' pathway, as an option of managing the decreasing viability of stand-alone heat pumps in cold temperatures.

If additional focus is given to cost reduction in hydrogen supply and reflecting the redundancies inherent in a hybrid heat pump-boiler solution, stand-alone hydrogen boilers will be the most economical technology option. Hydrogen boilers would compete with heat pumps to replace gas boilers to become the main sources for heat in residential and commercial sectors in colder countries, as shown in Figure 2. This choice will also be informed by consumer preference and acceptance of disruption and safety considerations.

In industry, hydrogen could be used both to raise steam, and also as a feedstock for processes. In some cases, companies will be able to choose between decarbonising gas after combustion (i.e. carbon capture and storage, CCS), or utilising hydrogen boilers. Which of these will be chosen will depend on a variety of factors (including proximity to other processes that could use CCS, proximity to CCS network). In some regions, CO_2 transportation or sequestration will be impractical, so hydrogen will have to play a large role there. More generally, post-combustion CCS may be more suited to large-scale emission sources, whereas hydrogen could be preferable in distributed applications.

FIGURE 1 – HYDROGEN DEMAND IN THE ENERGY SECTOR ACROSS EUROPE

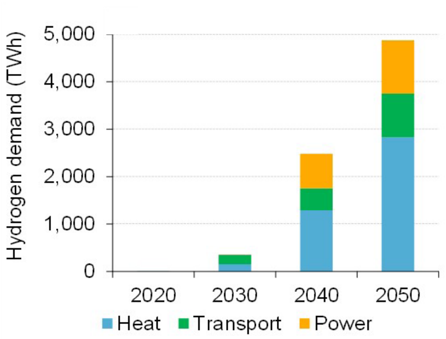
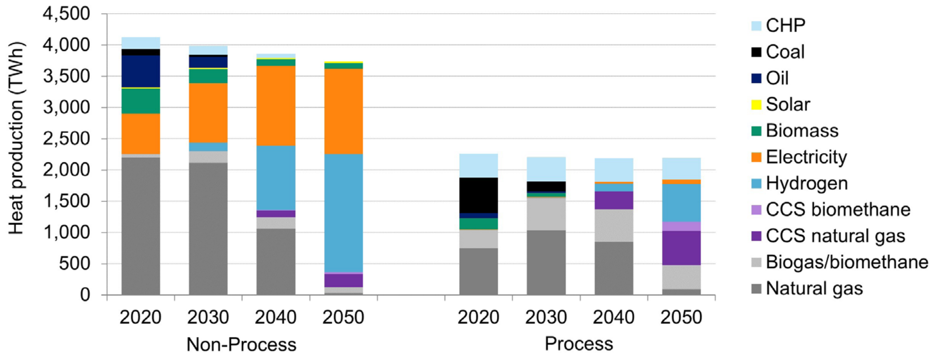


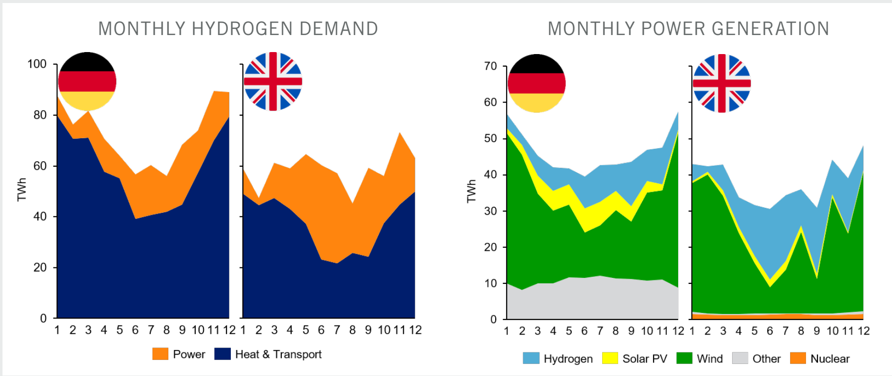
FIGURE 2 – HEAT PRODUCTION ACROSS EUROPE PER TECHNOLOGY



[1] 2050 capex assumption for SMR/ATR with CCS, and electrolysis reduced by 48% and 55%, respectively, compared to 2020 estimates.

INSIGHT – SEASONALITY IS MANAGED BY THE COUPLING OF HYDROGEN WITH ELECTRICITY

Making hydrogen cheaper has the benefit of it contributing to provision of seasonality. As illustrated for Germany and the UK, the charts on the left show how hydrogen demand from the seasonality of heat is now supported by usage in power generation. This is also reflected on the charts on the right, where the hydrogen used in the summer helps manage the lower wind generation in that season.

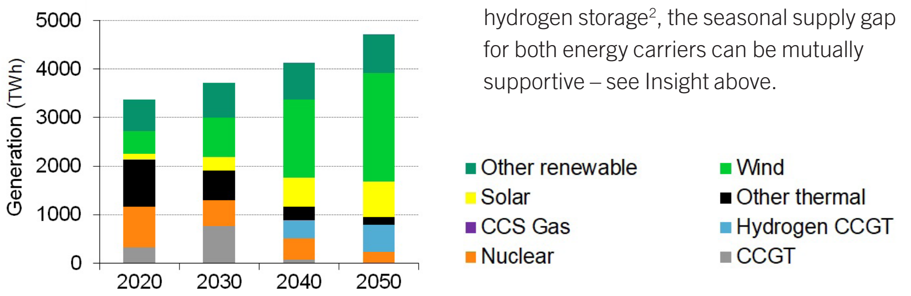


SEASONALITY IN A RENEWABLES-DOMINATED ENERGY SYSTEM

In most of Northern Europe, energy demand peaks in the winter – due to higher heat loads. Power generation, which, in a largely renewable system, is mostly based on wind, is also highest in that season.

However, power generation will be much more variable and there will be periods during which a lack of intermittent generation could put stress on the power system. Flexible demand and batteries will be used to manage surpluses and shortfalls on a short-term basis (hourly and across a week), but they will not be sufficient or efficient to cover differences between seasons.

FIGURE 3 – EUROPE'S POWER GENERATION TRANSFORMATION



USING HYDROGEN TO BALANCE SEASONAL DEMAND AND SUPPLY SWINGS

In a Hydrogen Economy pathway, the seasonality of both demand and supply of electricity can be used to an advantage across the energy sectors.

Like future electricity demand, hydrogen demand will be highly seasonal, due to heating loads. However, due to high capital costs of hydrogen production, it will be most economic to run these plants in a steady-state mode.

Here is where a coupling of hydrogen and electricity will be advantageous. Wind generation in the summer is lower than in the winter, but this is also when the analysis shows there will be an excess of hydrogen supply. By combining the shortfall of electricity with the excess of hydrogen, and supported by hydrogen storage[2], the seasonal supply gap for both energy carriers can be mutually supportive – see Insight above.

ENABLING THE HYDROGEN ECONOMY

Our analysis of a 'Hydrogen Economy' pathway shows hydrogen offering significant benefits to transforming Europe's energy system by 2050. By converting existing gas networks a hydrogen economy can be developed at scale to replace gas boilers and be used in industrial heat and processes and heavy goods vehicles. A hydrogen economy can support the continued mass deployment of renewable energy systems whist also solving the problem of managing seasonality.

To facilitate such an outcome studies and pilots in the area of both reducing hydrogen production costs and network conversion need to happen now in order for hydrogen to be at the centre of the energy transition. There may also be a need for support mechanisms to enable the switch to hydrogen. Accordingly, policy makers must make sure there are no artificial barriers to prevent the gas industry from developing the regulations and safety cases to allow a hydrogen economy to develop alongside electrification. It has the potential to deliver the net zero decarbonisation challenge by 2050 with less risk and at lower costs.

[2] The estimated available storage volume of salt caverns and depleted fields/aquifers that can be converted to use hydrogen is c.440TWh in 2050 across Europe.

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Pöyry decarbonisation services

Staying on top of your game means keeping up with the latest thinking, trends and developments. We know that this can sometimes be tough as the pace of change continues...

The original Fully Decarbonising Europe's Energy System by 2050 report is available to purchase. It has already been purchased by companies based in Norway, Ireland, UK, France, Netherlands, Germany, Austria, Czech Republic, Spain and Portugal with organisations ranging from producers, utilities, infrastructure owners, industry associations and government ministries. To find out more, or if you wish to discuss with Pöyry how we can support you in undertaking your own decarbonisation pathway analysis, please contact Richard Sarsfield-Hall, Benedikt Unger or your usual Pöyry contact.

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