frontier economics

Low carbon hydrogen: a low carbon solution in Europe?

A webinar for the USEA

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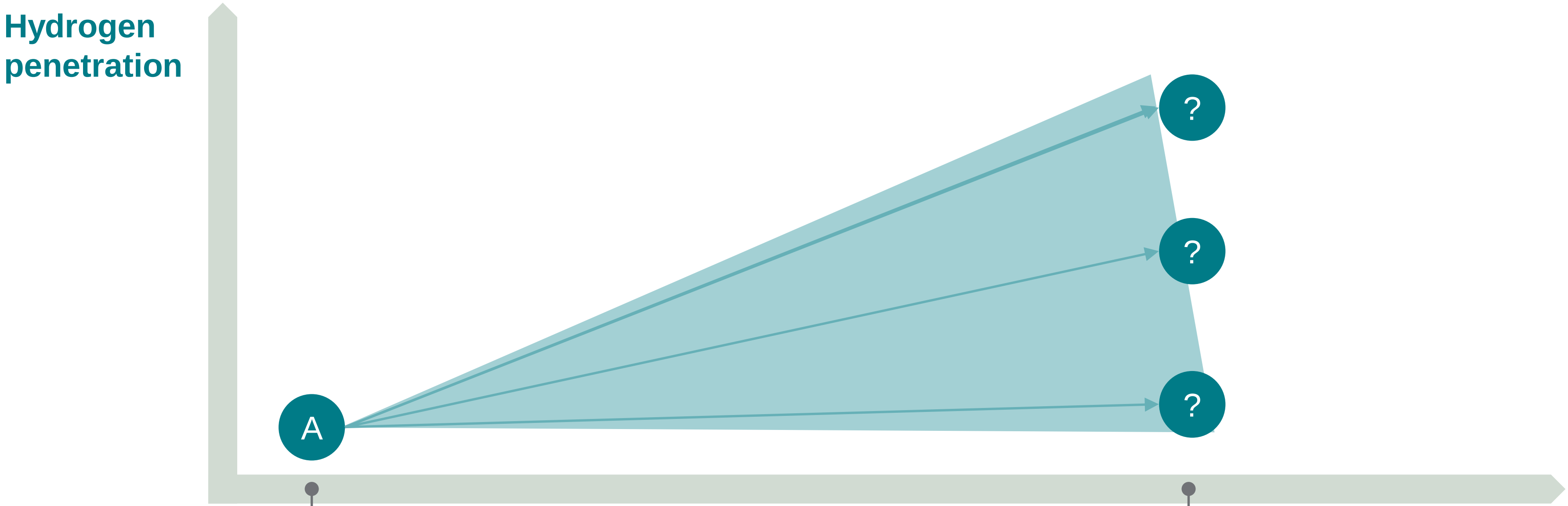
There is major uncertainty around how hydrogen will be used across Europe on a path to 2050



The short-term:

- Industrial clusters, with relatively limited dedicated network infrastructure
- Some transport
- Blending in some places

The medium-term:

The long-term:

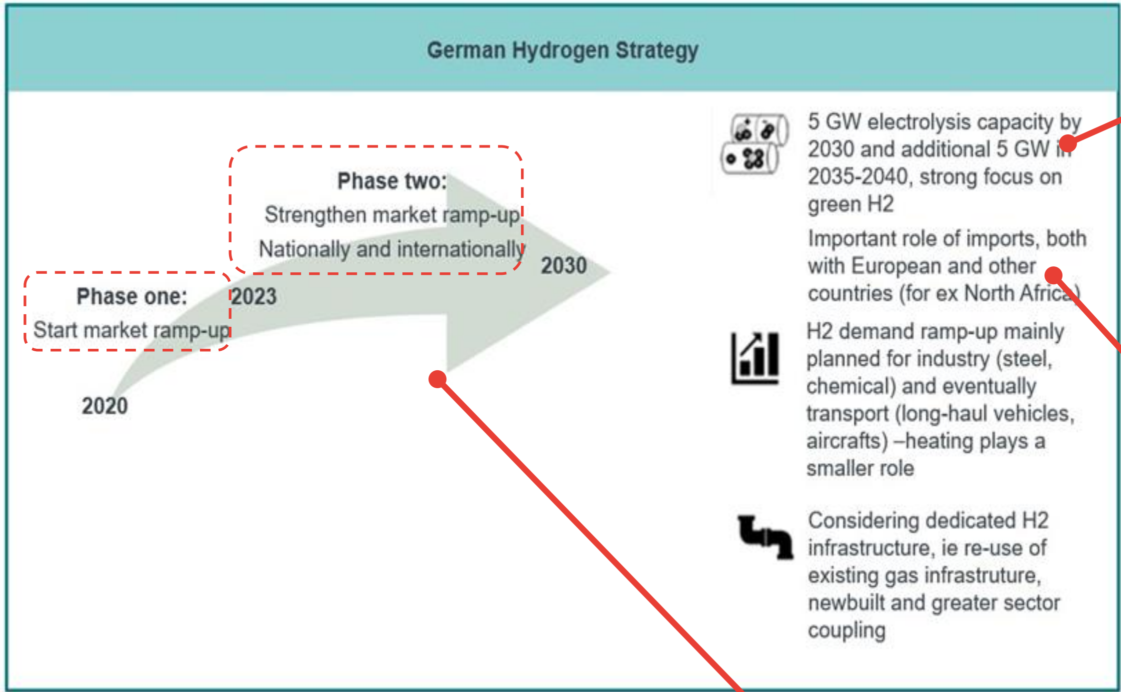
- Limited use in clusters
- Regional dedicated hydrogen grids
- Largescale conversion of several sectors

The European Commission's Strategy on Hydrogen from July 2020 reflects a high level vision

Phases	*Phase 1 (2020 – 2024)*	*Phase 2 (2025 – 2030)*	*Phase 3 (2030 onwards)*
Production	▪ **6 GW** of renewable hydrogen electrolysers installed ; ▪ Production of 1 million tons of renewable H2	▪ **40 GW** of renewable hydrogen electrolysers installed ; ▪ Production of 10 million tons of H2	▪ **Large scale deployment** of hydrogen to reach all hard-to-decarbonise sectors

Among member states, Germany is one of the frontrunners in relation to green hydrogen development

Germany is actively promoting hydrogen projects, with one large-scale electrolyser is in operation, another one under construction, and pilot projects with 600 MW capacity planned until 2025.



Source: Frontier Economics based on German Hydrogen Strategy, 2020

Germany is planning to **invest c.€9bn** in H2, with:

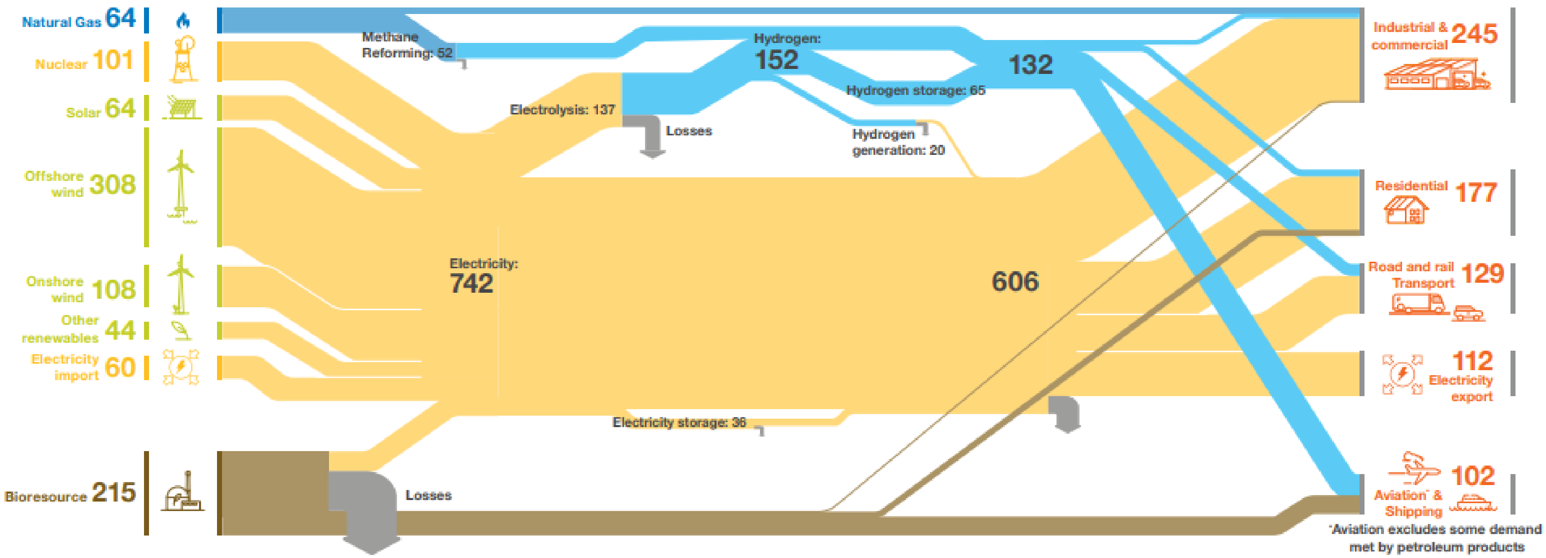
- €7bn aimed at supporting the development of 5GW of domestic electrolyser capacity by 2030; and
- €2bn for the development of production partnerships with other countries for H2 imports.

Imports will play an important role since it is unlikely that the large quantities of hydrogen that will be needed for the energy transition can be produced in Germany alone.

The Government Hydrogen Strategy mentions a **phase one** of market ramp-up between 2020 and 2023, and a **phase two** where the ramp-up should strengthen nationally and internationally up to 2030.

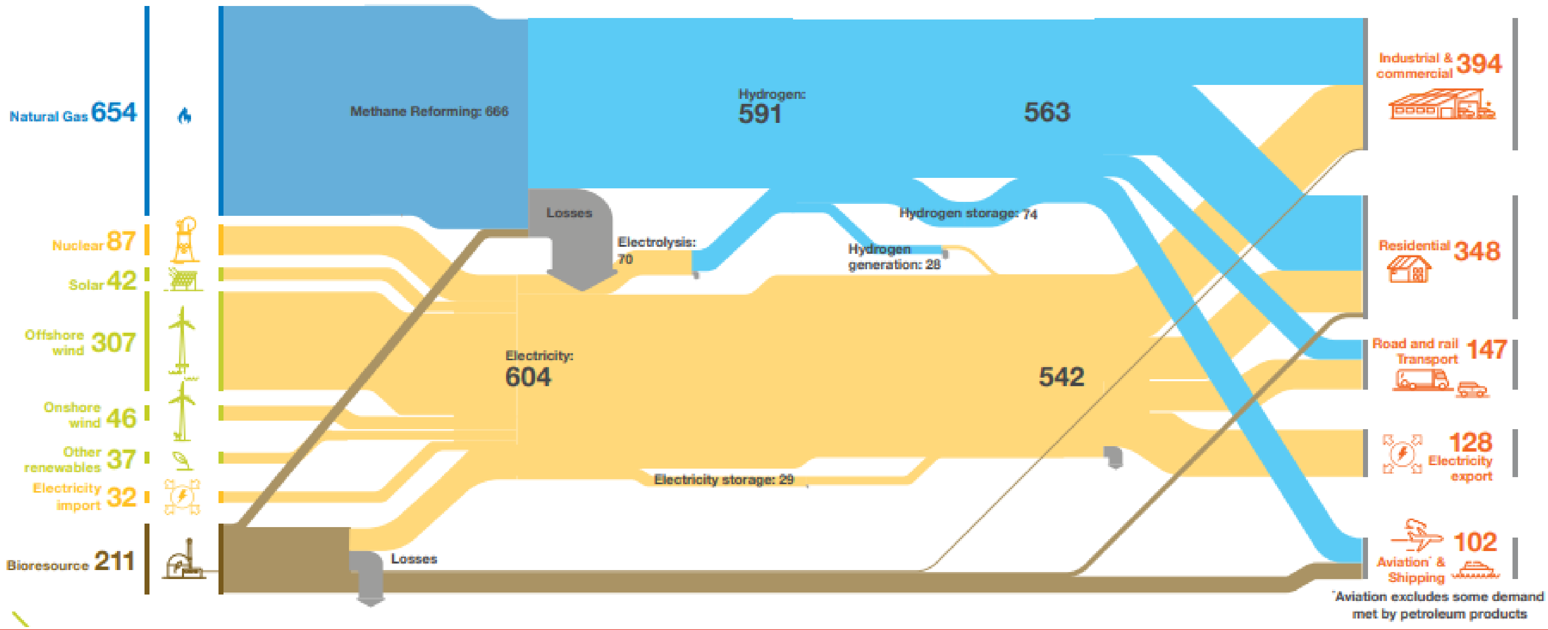
The UK is also envisaging widespread use at the 2050 horizon

Consumer transformation (2050)



- Home heating, transport and industry largely electrified
- Hydrogen produced in the UK primarily through electrolysis

System transformation (2050)



- Widespread use of hydrogen for home heating, industry and HGV fuel
- Hydrogen produced mainly through methane reforming with large requirement for natural gas with CCUS

Source: [National Grid, Future Energy Scenarios.]

Decarbonisation via hydrogen is an option across a large range of sectors

- Decarbonisation options for high-heat processes are limited and low carbon hydrogen can replace grey hydrogen as feedstock.
- Strong potential for hydrogen to play a role but will likely need to display track record of reliability
- Development will also depend on feasibility of post-combustion carbon capture as an alternative

- Decarbonisation options for heavy transport limited – strong potential for hydrogen to play a role
- Fuel Cell Electric Vehicles (FCEVs) expensive & require extensive refuelling infrastructure – public transport more likely to be first mover, in between urban depots alongside some trucks on defined journeys in between refuelling stations possibly supplied via tube tanker or trailers

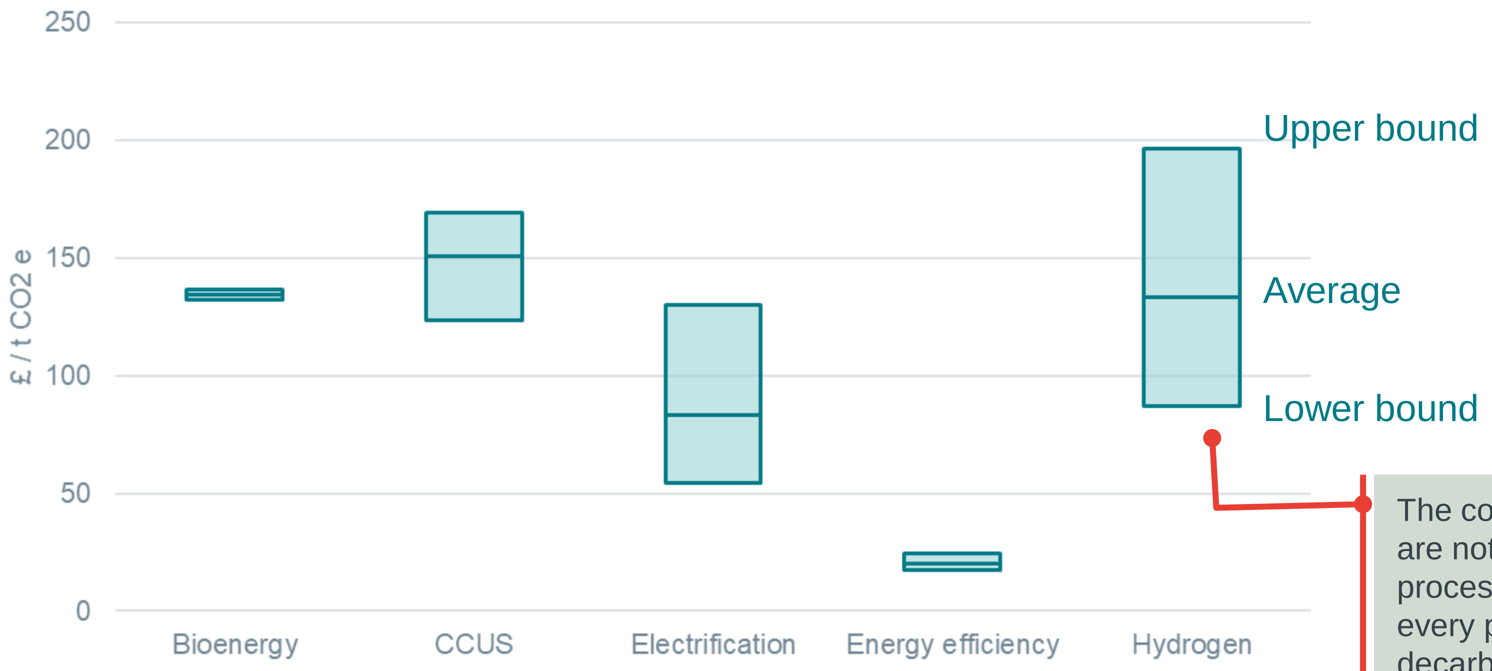
- Electrification (and district heat) compete for building heat
- Relative to electricity, significant complexity around use of hydrogen for heat (network & in house conversion)
- But for some buildings, electrification not feasible, and may need something to address peaks of electricity demand (e.g. hybrid heat pumps)

- Renewables is first focus for electricity decarbonisation – but will need a technology for longer term energy storage for power
- This could be hydrogen – could repurpose some of existing gas storage facilities – but significant conversion losses
- Hydrogen may also directly substitute natural gas for dispatchable generation (competing with other gases / CCS)

- In the short term, blending in methane pipes may also be a source of demand.

Taking the example of industry…. hydrogen is often an expensive abatement option…

Industrial abatement in a sample region of the UK: Carbon abatement cost of different technologies in 2050

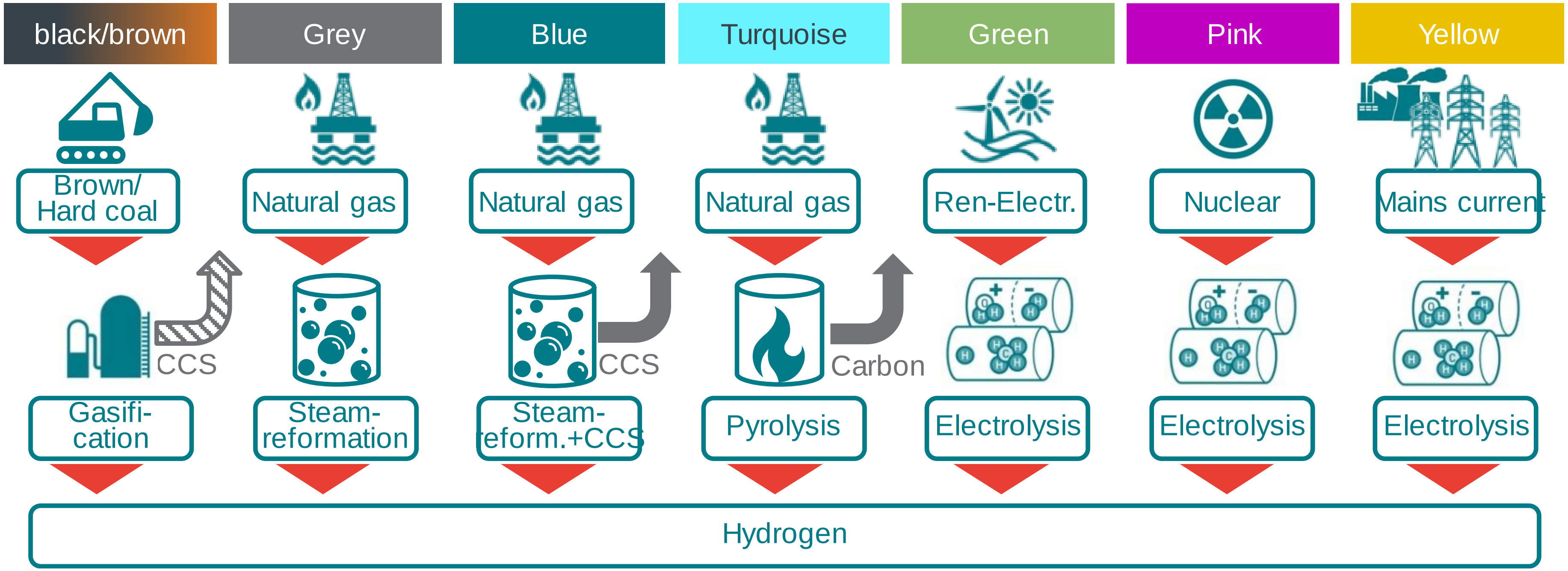


The costs shown here are not for substitute processes because not every process can be decarbonised by all fuels

… but it can tackle hard-to-decarbonise use cases

Source: [CCC Sixth Carbon Budget]

The uncertainty on the future size of the market also reflects differing views on the acceptable « colours » of hydrogen

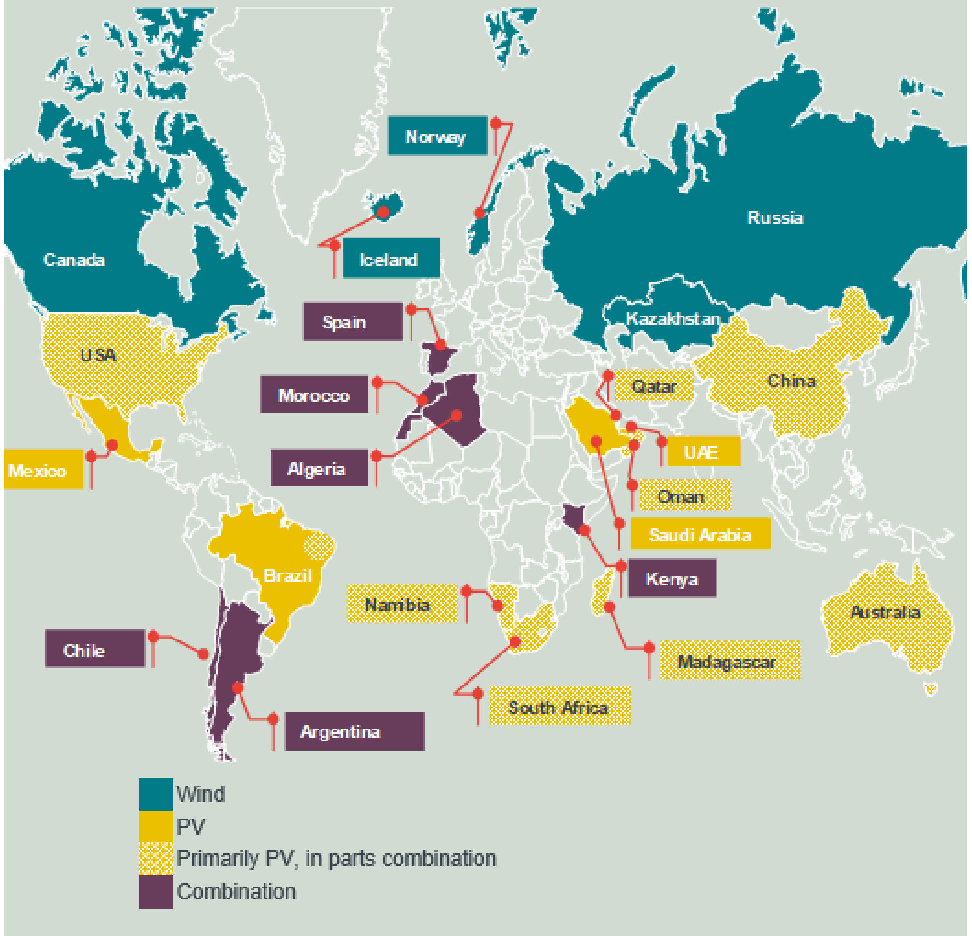


- This technologies differ in their level of competitiveness…
  - Eg in the UK, green hydrogen is expected to cost c. £80/MWh in 2050 vs c. £40/MWh for blue hydrogen + carbon capture and storage
- but costs are very uncertain, and the debate is also largely political

Imports are also expected to be an important supply option

The Hydrogen Council estimate that imports of green hydrogen (in various forms) to Europe in 2030 could be €70-150/MWh

Screening of potential producer countries
(cost/potential/political stability)



Ammonia

- Hydrogen is converted to ammonia, shipped, and reconverted to hydrogen via 'cracking'
- Ammonia shipping is already well-established technically

Syn-methane

- Hydrogen is methanated (via adding CO_2) to produce synthetic methane, which is then shipped at -163C and regasified at a methane reformation plant
- Natural gas transportation is well established

Liquid hydrogen

- Hydrogen is liquified at -253C, transported by ship, and regasified at the import terminal
- Process is very inefficient and expensive due to cooling equipment required. Liquid H_2 ships do not exist commercially today

Liquid Organic Hydrogen Carriers

- Hydrogen is attached to a carrier via hydrogenation, shipped at 20C, and reconverted via dehydrogenation and compression
- Efficiency is low (overall 20-30%), however LOHC are relatively easy to transport with existing infrastructure

The focus in European policy is on the near term challenges associated with getting hydrogen markets up and running

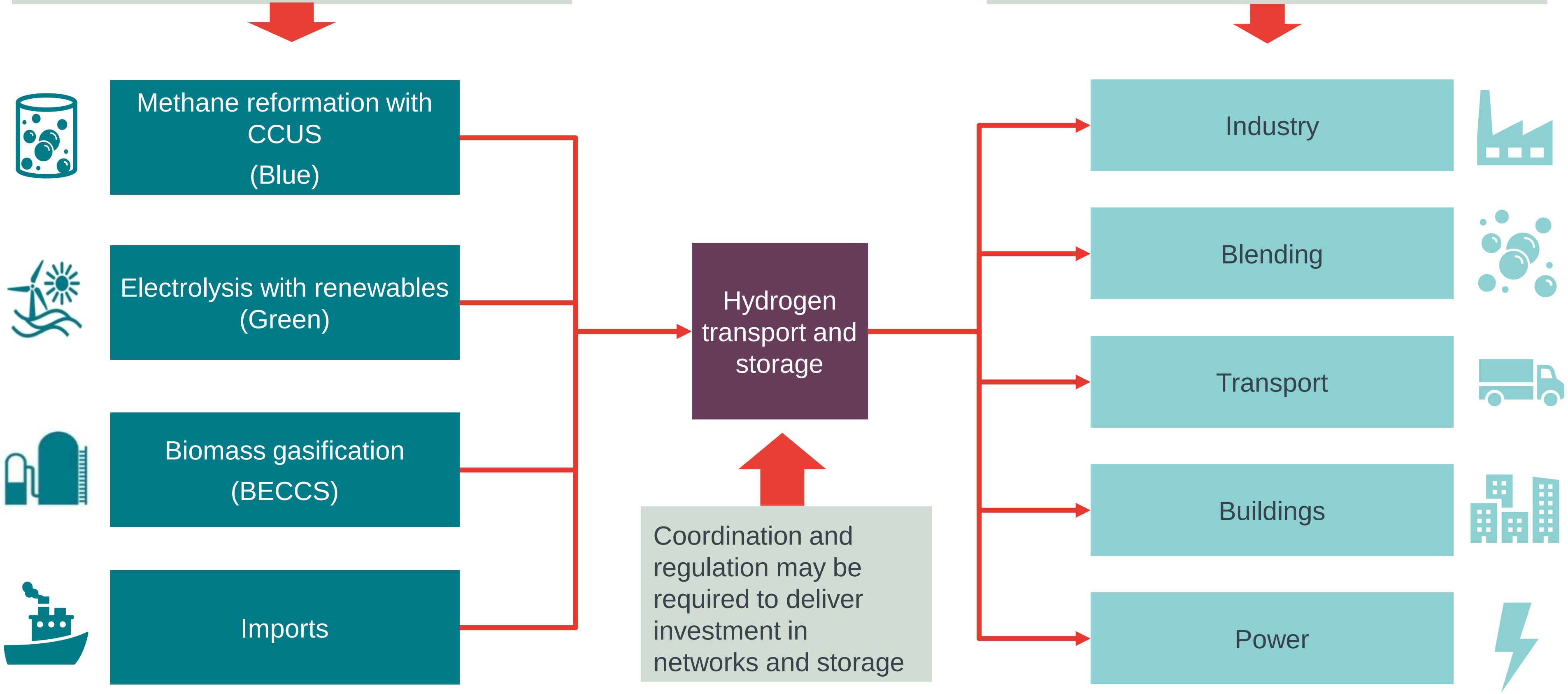
	Near term	Medium term	Net zero economy
Conditions	• Immature technologies • Niche markets • Policy risks across the value chain	• More mature technologies • Liquid markets for new vectors • Greater policy stability across the value chain	• Subsidy free • Stable policy
Priorities	• Delivering initial investments • Getting infrastructure in place to enable market • Delivering learning	• Getting markets to work efficiently • Avoiding cross sectoral distortions	• Internalising carbon externality

- Increasing focus on exposing investors to market signals

Getting supply and demand up and running at the same time, with new technologies across the value chain is challenging

- **Production technologies are at different levels of maturity and have very different costs.**
- Externalities are not fully covered.
- International standards and import/export infrastructure are required for imports

- **Hydrogen is not a direct substitute for the incumbent fuels.**
- **Demand for it is uncertain and largely policy-driven**
- Existing policies vary across sectors



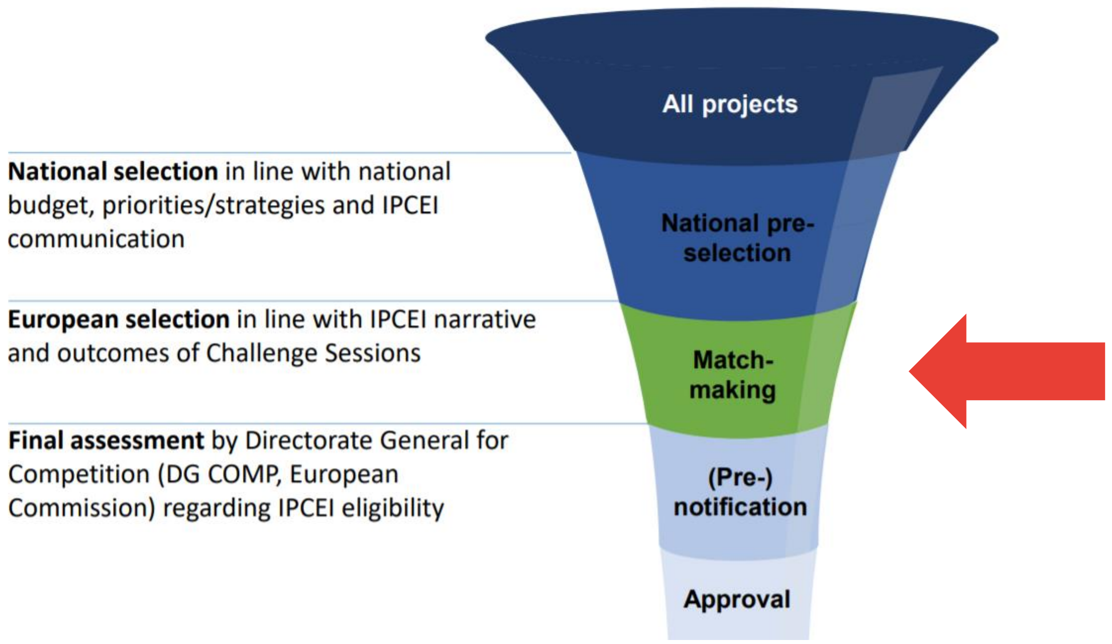
There is no consensus yet in Europe on the best instruments to incentivise low carbon hydrogen – beyond R&D funding

European countries have converged on production subsidies (alongside a carbon price) for renewable electricity… but for low carbon hydrogen, a consensus has not emerged. Even within countries, a range of tools are on the table

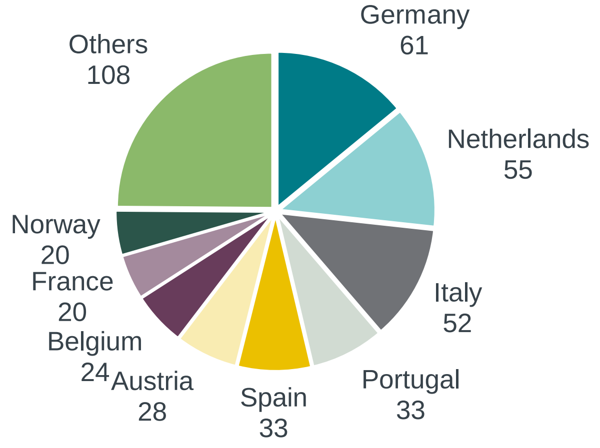
Type of support mechanism	High level description	Examples from Europe
Carbon price	▪ Tax ▪ Emissions trading scheme	▪ Mainly seen as a complement to more targeted measures in the near term, due to the potential distributional issues, as well as the difficult in managing policy risk.
Production subsidy	▪ Capital grants ▪ Premium payment ▪ Revenue stabilisation payments ▪ Payments to cover availability ▪ Carbon CfD for producers	▪ UK expected to announce a producer subsidy imminently – focussing on largescale production for industry ▪ The Netherlands has introduced a carbon CfD scheme (SDE ++) which can cover the costs of CCS for blue hydrogen.
End user subsidy	▪ Premium over carbon price ▪ Carbon CfD ▪ Subsidy per unit consumed	▪ Germany is introducing a pilot carbon CfD aimed at the steel and chemical industries
Obligation	▪ Tradeable obligation ▪ Quotas	▪ UK has just announced changes to its Renewable Fuels Transport Obligation to help fund green hydrogen projects ▪ Germany is introducing a quota for – e-fuels in aviation fuel.

IPCEI funding is also likely to be important across the board to fund early development of new projects

- Important Projects of Common European Interest (IPCEI) framework is an EU State Aid framework that allows Member States to finance investment in areas which contribute to EU objectives (such as the energy transition).
- IPCEI project must:
  - significantly contribute to strategic EU objectives
  - involve several EU countries
  - involve private financing by the beneficiaries
  - generate positive spillover effects across the EU

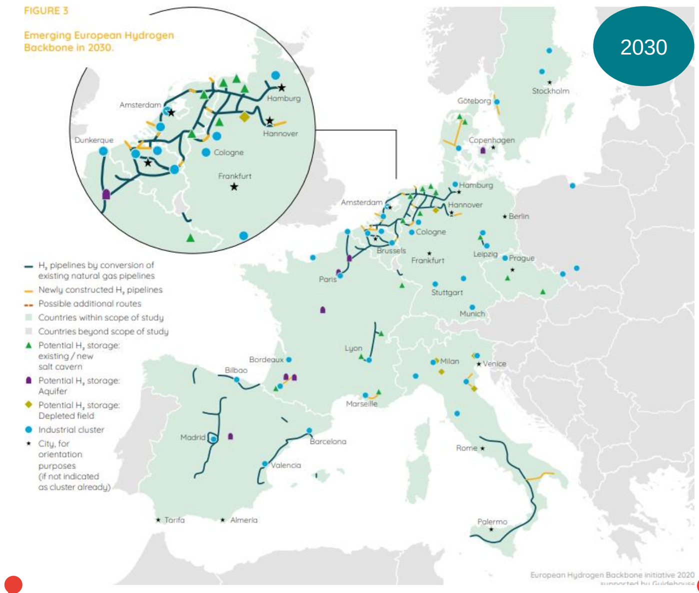


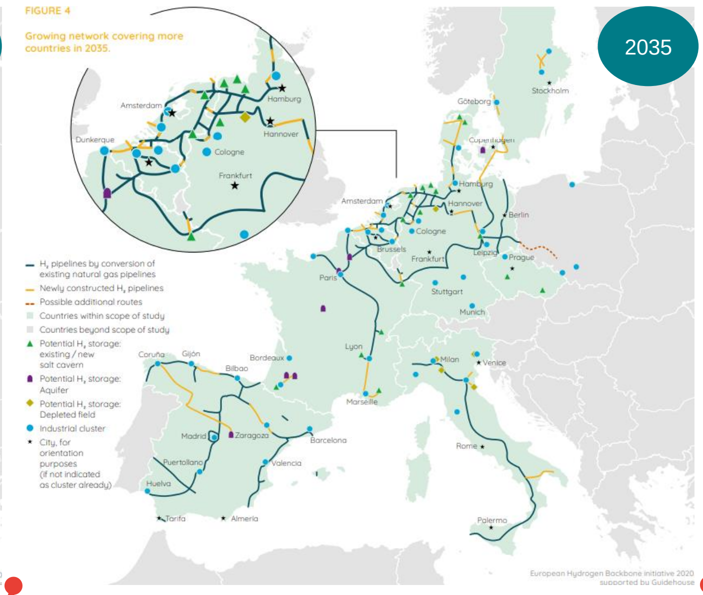
As of June 2021, **434** projects have passed national selection and are in the matchmaking phase

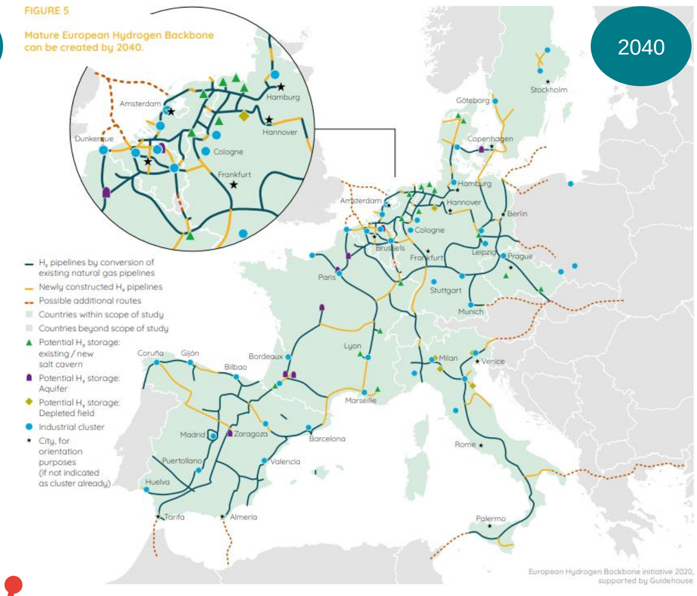


Source: IPCEI Matchmaking Procedure

Gas infrastructure operators at the European level have published a vision for the development of a European Hydrogen Backbone







2030: Interconnected regional cluster in the North based on ongoing and planned projects

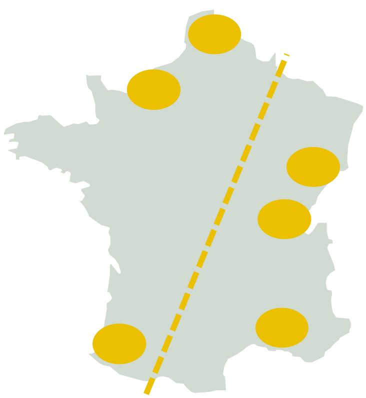
2035: More production in the south making use of solar resources and in the north making use of wind resources

2040: Pan EU infrastructure with large corridors connecting the majority of West-European countries

At this stage, a vision for H2 pipelines, not a project!

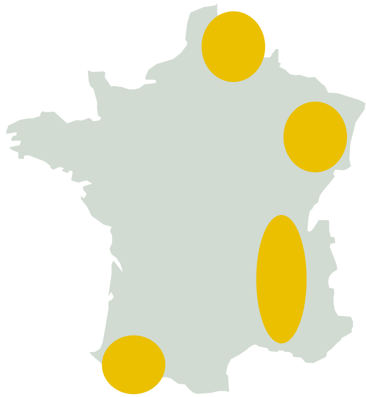
- Key question as to whether the backbone would “organically follow” the roll-out of supply and demand clusters to interconnect them and contribute to a deeper, more reliable market…
- …or whether cross-border supply and demand patterns could drive the case for a “transit” backbone more independently of developments (e.g. production in Spain / demand in Germany)

In reality, the implications for infrastructure (network and storage) are likely to depend on sources and sinks… for example, in France…



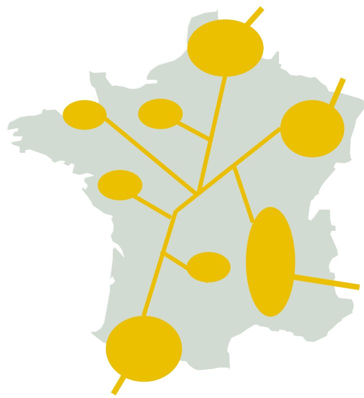
Small local clusters (+ possibly international transit)

- Very limited supply and demand for H2 within FR, but strong production and demand in other countries (e.g. ES and DE)
- Local clusters (likely point-to-point only) within France
- Possibility for a large transit pipeline – not interconnected with French clusters



Regional networks, not interconnected nationally

- Regional demand and supply centres with fairly diverse usages (industrial, transport, occasionally heating)
- Meshed regional networks, some of which could be cross-border, but not interconnected between each other



European hydrogen market place

- Diverse and strong supply and demand for H2 within FR and EU
- Dense / meshed national network (similar to CH4 today) with various international interconnections

Ambition of European Commission to **achieve this within next 10-15 years**

And the need for infrastructure will also vary through time

	Short term investment needs	Longer term investment needs
Small clusters scenario	Little or no investment – production sites closely linked with consumption	Little further investment – resilience and/or connecting loads around clusters
Regional grids scenario		Medium – regional distribution networks supplying local area
Hydrogen scenario		High – network required is close to existing T&D network
Transit backbone		High – long distance transit pipelines across international boundaries

The priorities of regulation of hydrogen networks are also likely to evolve over time

	Near term		Medium term	Long term
Hydrogen production business models	▪ Ensure third party access provisions are included in Government business models ▪ Ensure subsidies take account of potential revenue from third party access			
Coordination across the whole system	▪ Begin coordinating across the system	▪ Implement processes for whole systems coordination		
Network and storage regulation	▪ Minimal	▪ Establish regulatory system for shared infrastructure (unless in small clusters scenario)	▪ Apply regulatory system for shared infrastructure	

- Facilitate both conversions and new build
- Potentially different across network and storage
- Tendering or new natural monopoly operators?
- Need to decide who should pay – hydrogen users, all gas users, taxpayers, …

Takeaways from Europe

There is huge interest from policy makers, utilities and investors

The EU's ambition, and a centralised pot of funding, has been successful in catalysing huge interest in the sector

The focus of public authorities has meant that people are thinking about the implications of green H2 for both power and gas sectors (though the transport sector is less well integrated into the debates)

There isn't yet a consensus on all of the required policy instruments

Enabling low carbon hydrogen is more complicated than renewable electricity. Given the importance of policy risk across the value chain, support for both producers and customers may be needed, with a holistic, system-wide approach from government (though blending can help in the near term)

R&D and scale demonstrators could yield big cost reductions and it is clear that these cost reductions are needed for green hydrogen

While what you do with the network is important, we need to see where the market goes first. Eventually, regulation like that in gas might be relevant, and would provide confidence to investors.

It is clear that hydrogen can help meet climate targets… and it makes sense to focus now on least regrets options

There are some sectors where hydrogen is likely to be the only net zero consistent option…. and lots of sectors where there are a number of potentially viable options. Instead of arguing over the future, early policy should focus on least regret sectors and getting learnings from first of a kind projects.