Global Hydrogen

Approaching sector tipping point – hydrogen FAQs

Equities & ESG
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- Sector OEMs poised for industrial scale-up and support from policy on the rise: hydrogen may at last be coming of age
- HSBC Hydrogen Week highlighted: 1) maturity of technology 2) green hydrogen prospects; and 3) business case for HGVs
- We address key investor questions on hydrogen

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Feedback from HSBC Hydrogen Week – strong growth momentum
Over the week of 29 June to 2 July we hosted expert speakers and leading sector OEMs in our inaugural virtual hydrogen investor event. Overall we see strong growth momentum for hydrogen technologies, which we believe will play an increasingly key role in global decarbonisation efforts.

Manufacturer scale-up, rising corporate activity and explicit policy support
Producers of electrolysers (which enable the generation of clean hydrogen) are scaling up rapidly to meet a multi-GW pipeline of announced projects that can drive down the costs of 'green' hydrogen to a level comparable with today's 'grey' hydrogen. Fuel cell technologies (which convert hydrogen into power) are also maturing and OEMs are scaling up capacity to pursue applications across transport (with much focus on trucks), power and industry. Industrial partnerships, JVs and rising M&A activity signal greater corporate strategic alignment with hydrogen and project announcements continue to increase in scale. This is underpinned by increasingly explicit policy support, most notably in the EU, which now targets 6GW of green hydrogen capacity by 2024 and 40GW by 2030.

Is it really different this time? Key investor questions
Building on deep dive Spotlight reports on we have published on green hydrogen and on decarbonising trucks, in this note we attempt to address key investor questions we have received:

1. *What is different this time? What are companies saying?*
2. *Green vs grey hydrogen: how do we close the cost gap?*
3. *Is offshore wind more attractive for hydrogen than other renewables?*
4. *Will hydrogen lose out to batteries in transport applications?*
5. *Does decarbonising HGVs with hydrogen make sense?*
6. *How is policy support for hydrogen developing?*

This is a redacted version of the report published on 10-Jul-20. Please contact your HSBC representative or email *AskResearch@hsbc.com* for information.

Hydrogen FAQs

- HSBC Hydrogen Week highlighted approaching tipping point
- OEMs ready for scale-up and policy support is on the rise
- We answer key investor questions on the hydrogen sector

HSBC Hydrogen Week feedback

Over the week of 29 June to 2 July we hosted expert speakers and leading sector OEMs in our inaugural virtual hydrogen investor event. We present our main conclusions below.

Technologies poised for scale-up
Overall we heard that both electrolyser and fuel cell technologies are poised for industrial scale-up thanks to strong demand growth both in upstream (hydrogen generation) and downstream (end market applications for hydrogen in transport, power and industry). OEMs believe that industrialisation can drive a 30-50% drop in equipment costs by 2025 and a 70+% fall by 2030 compared with current levels. This is key to green hydrogen reaching cost parity with grey hydrogen and ultimately enabling the decarbonisation of wide segments of the global economy such as transport, heavy industry and heat.

Focus on decarbonising HGVs
We noted an increasingly compelling role for hydrogen in the long-haul heavy goods vehicle (HGV) segment. This is owing to two key advantages over battery-powered electric trucks, namely: 1) lower weight leading to longer range; 2) rapid refuelling time. As long-haul road transport typically moves along main road arteries (c.5% of the road network), it requires far fewer refuelling stations compared to more localised transport. This is important as hydrogen refuelling technology is relatively immature and lacks standardisation.

Policy support on the increase
Crucially, policy momentum for hydrogen is on the increase, which is key given that only a handful of niche applications are business-case positive today (e.g. fork lift trucks). Japan, Korea and China already have substantial support mechanisms in place. In June 2020 California set firm targets in place for zero emission commercial transport. In June several countries such as Germany, Portugal and Netherlands set national hydrogen targets.

On 8 July the EU released its EU Hydrogen Strategy, potentially positioning Europe as the hydrogen leader. The scale of and budget for the hydrogen ecosystem and for renewable power were a surprise, beating the figures outlined in a leaked draft in June. By 2024 the EU envisages 6GW or 1m tonnes of renewable hydrogen production rising to 40GW (or 10m tonnes) by 2030. The total investments planned to 2030 are EUR24-42bn for electrolysers as well as EUR220-340bn to scale up and directly connect 80-120GW of renewable capacity in order to power the hydrogen production. Driven by this, we see accelerated hydrogen adoption across industries/geographies and thus greater confidence in improving hydrogen economics to 2030.

Global Hydrogen – key investor questions

Following thematic reports we have published on green hydrogen and on decarbonising trucks, we have met and discussed with many investors. In this note we provide feedback on key questions from investor meetings

1) Why is it different this time? What are companies saying?

Firstly, we note an acceleration of M&A activity as corporates position themselves more directly in hydrogen, either through stakes in technology OEMs or outright acquisitions. Secondly we see a number of new industrial partnerships aimed at accelerating the uptake of hydrogen technologies, particularly in transport. Pooling know-how and sharing R&D costs certainly makes sense for manufacturers, in our view.

Corporate actions in hydrogen technologies

Joint Venture/Acquisition	Description
Nikola / CNH Industrial / Bosch	USD250m of funding by CNH to accelerate Nikola's plans to develop fuel-cell technology in heavy-duty trucks. CNH will provide manufacturing know-how, purchasing power and plant engineering to Nikola's technology. The other key development partner Bosch will provide the fuel cell systems.
Michelin / Faurecia	Combined initial investment of EUR140m to accelerate development of next gen. fuel cells, launch mass production and expand in Europe, China and US. Faurecia will contribute with its technological hydrogen mobility expertise and Michelin with its hydrogen fuel cell kit manufacturing know-how
Weichai / Ballard	An equity investment of USD163m by Weichai in Ballard followed by the formation of a JV to support the FCEV market in China. The JV will assemble fuel cell parts supplied by Ballard. Assembled modules will be sold to Weichai to support its commitment to supply min 2000 FCEVs in China by 2021, using Ballard technology
Bosch / PowerCell	Agreement to jointly develop PowerCell's existing S3 fuel cell stack for the automotive industry. Bosch will produce and sell the jointly developed fuel cell and PowerCell will get royalty payments for each fuel cell sold
Cummins / Hydrogenics	Cummins acquired fuel cell and hydrogen production technology provider Hydrogenics. The acquisition is expected to strengthen Cummins' existing fuel cell expertise.
Daimler / Volvo	50/50 joint venture to develop and accelerate fuel cell technology. Volvo paid EUR600m and Daimler is transferring its entire fuel cell activities (developed for the passenger segment). The collaboration will reduce development costs
ITM Power / Linde	Linde acquired a 20% stake in ITM power. Linde will predominantly handle EPC of contracts and ITM will provide electrolyser systems.
Weichai / Ceres Power	Weichai took a 20% stake in Ceres to explore new fuel cell business models in the Chinese market
Toyota/ Beijing Automobile Group / China FAW corp. / Beijing SinoHytec / Dongfeng Motor Corp. / Guangzhou Automobile Group Co.	Toyota teamed up with five companies in China with the aim to develop fuel cells for commercial vehicles and increase its penetration in the China market. The new entity will have an initial capital of USD46m and Toyota will have 65% ownership in the new company.

Source: Company data

Thirdly we see a rising diversity of project announcements, often by large consortia and of increasing scale and ambition. Momentum towards industrialisation looks clear, in our view. We outline some recent key developments and announcements in the next table.

Project announcements of green/blue hydrogen

Company	Country	Description
Equinor	UK	1) Development of 600MW auto thermal reformer (ATR) with carbon capture to convert natural gas to hydrogen, located in Saltend Chemicals Park (SCP) industrial cluster in the UK. 2) Hydrogen generated from the plant will enable industrial customers in the park to switch over to hydrogen and the power plant in the park to move to a 30% hydrogen to natural gas blend 3) As a result, emissions from SCP will reduce by nearly 900k tonnes of CO2 per year
Keppel / Mitsubishi Heavy Industries	Singapore	1) MOU to explore hydrogen powered tri-generation plant concept for data centres 2) Hydrogen generated through steam methane reforming will be supplied to tri-generation plant which produces heat, power and cooling. Chilled water produced by the plant will be used to cool data centre's systems and facilities 3) Hydrogen manufacture unit will be fitted with carbon capture system to reduce emissions
McPhy / Atawey / TSM (MAT)	France	1) Consortium selected to supply 14 hydrogen stations which will be deployed in France 2) The project is expected to generate EUR11m in sales. McPhy will install 5 hydrogen stations out of the 14 stations
Ørsted	Denmark	1) Plans to install 5GW offshore wind hub connecting Denmark, Poland, Sweden and Germany which will support large scale production of green hydrogen 2) The hub situated in Baltic Sea will be called "the world's first energy island"
ACWA / Air products / NEOM	Saudi Arabia	1) A JV project to produce 650 tonnes of hydrogen/day and 1.2mn tonnes/year of green ammonia 2) Electrolyser plant will be integrated with 4GW of solar, wind and other renewable projects 3) A total investment of USD5bn will be done in the project

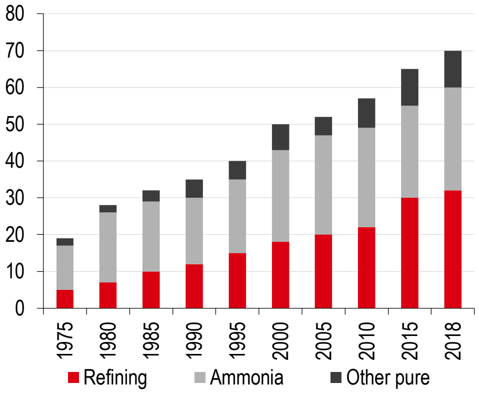
Source: Company data

2) How do we close the gap between grey and green hydrogen?

Essentially, we do this by massively scaling up green hydrogen, so that equipment costs plummet, and by using cheaper renewable electricity. Here it's worth a quick recap. Over 90% of pure hydrogen produced globally is used in the oil refining and chemicals sectors. According to IEA, global demand of pure hydrogen was 70-74m tonnes in 2018, 52% of which was used in diesel refining, 42% in ammonia production and only 6% in other (mostly chemical) industries.

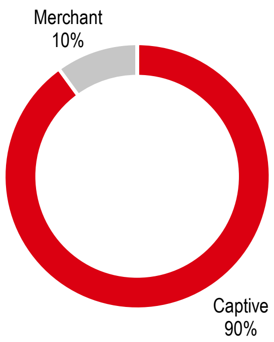
On the supply side, 90% of hydrogen is produced for in-house use, as is the case for refineries. Merchant sales account for c.10% of the pure hydrogen market with the three biggest gas companies, Linde, Air Liquide and Air products we estimate accounting for over 75% of the total merchant market.

Global annual hydrogen demand in pure form by application (in million tonnes)



Source:IEA, 2018 data

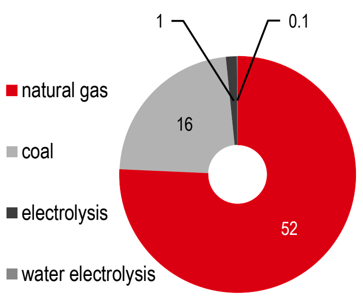
Pure hydrogen production by type



Source: Company reports, HSBC estimates

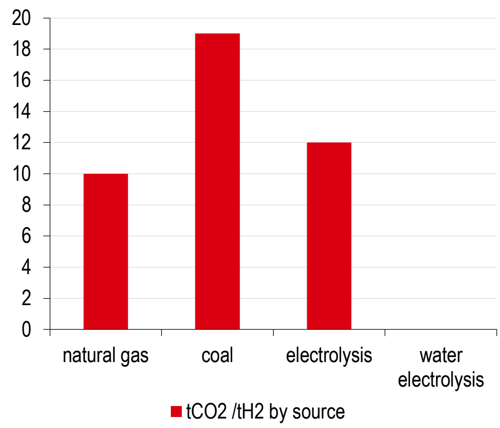
Over 99% of pure hydrogen is generated via carbon emitting technologies, of which steam methane reforming (SMR) of natural gas is the most widely used ('grey' hydrogen – 75% of the total market). Even electrolysis, when using a fossil-fuel power source, is highly carbon intensive. Only water electrolysis powered by renewables is zero emission – 'green' hydrogen.

Dedicated hydrogen production by source (mt)



Note: 2018 data. Source: IEA

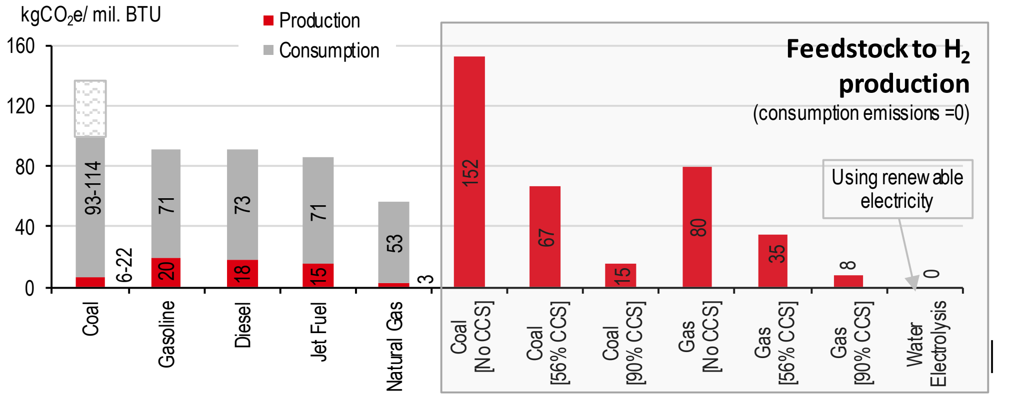
CO_2 emissions per source



Note: 2018 data. Source: IEA

Emissions from producing grey hydrogen from natural gas or coal are actually greater than the equivalent emissions from directly consuming these fossil fuels (this is because the production process itself is energy intensive).

Greenhouse gas emissions from fossil fuels and hydrogen



Notes: BTU = British thermal unit. 1 mil. BTU = 0.025 tons of oil eq. (toe) = 1,055 mega joules (MJ). Capture rate of 56% for natural gas with CCS (carbon, capture and storage) refers to capturing only the feedstock-related CO2 whereas a capture rate of 90% for CCS is also applied to the fuel-related CO2 emissions; consumption emissions from endues conversion into energy (burning/other process); production emissions from production, processing (incl. refining), transmission, storage and distribution. Includes fugitive methane emissions as well; emissions for H2 do not cover transmission and distribution related emissions. Source: HSBC, IEA, US EIA, GEA, UNFCCC

Another avenue for lowering hydrogen production emissions is adding carbon capture and storage (CCS) to grey hydrogen – this is 'blue' hydrogen and can be carbon neutral if all carbon is captured.

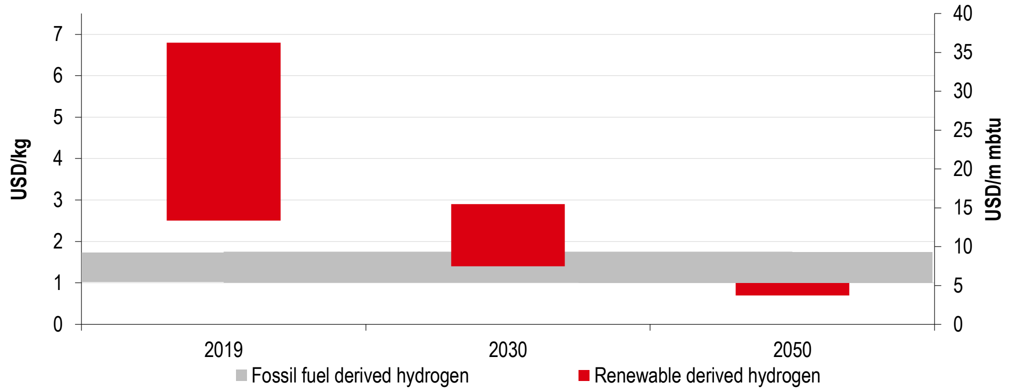
An overview of hydrogen production routes

Type of hydrogen	Grey	Blue	Green
Production route	Natural gas reforming / coal gasification	Natural gas reforming / coal gasification + carbon capture	Electrolysis of hydrogen compounds
Cost (USD/kg)	1.0-1.5	1.5-2.5	4.0-6.0
Pro	Relatively cheap, commercially widespread	Carbon neutral	Zero carbon (where power source is renewable)
Con	High carbon emissions	High CCS investment costs	High capex and water intensive

Source: HSBC

The issue with green hydrogen has always centred on unfavourable economics. In 2019, unit production cost of green hydrogen was USD2.5-7/kg vs USD1-2/kg for grey hydrogen. BNEF forecasts green hydrogen prices can fall to USD1.5-3/kg by 2030 and <USD1/kg by 2050.

Renewable hydrogen costs are expected to fall by 2050



Source: BNEF

A major driver for the cost decline of green hydrogen is the sharp fall in electrolyser equipment costs. Companies are ramping up to meet a rapidly growing multi-GW pipeline of electrolyser projects. We expect capex to fall from USD1000/kW in 2019 to USD400/kW in 2040 driven by economies of scale.

In January 2020 we had identified a 3.2GW electrolyser project pipeline with visibility to 2025. By June that pipeline has doubled and now stands at 6.2GW, driven by recently announced large size orders of 750-1000MW providing visibility to 2030. According to a June 2020 Wood Mackenzie report, the project pipeline stands at 8.2GW with 2GW of unspecified orders.

Announced project pipeline- PEM electrolyser

Location	Capacity (MW)	Developer	Start	End use
Germany	10	Shell	2020	Oil refining
Canada	20	Air Liquide	2020	Industry, mobility
Germany	140	Linde, Siemens, VNG	2024	Industry, chemicals, oil refining, power storage
Australia	300	Siemens, Hydrogen renewables Australia	-	Mobility, Gas grid injection
UK	100	ITM Power, Ørsted	-	Power to gas, transport
Germany	50	Vattenfall, ARGE Netz, MAN Energy	-	Power, industry, synthetic gas for transport
Australia	1000	Macquire	2027	Industrial uses
Netherlands	750	Shell, Gasunie	2027	Industrial uses
France	760	ENGIE, Air Liquide	2027	Industry, mobility, energy
Germany	100	BP, Evonik, Nowega, OGE & RWE	2022	Industrial use, refinery and chemicals
Portugal	100	-	-	Industrial uses
UK	250	ENGIE, ODE	2032	Power to gas
	3580			

Source: BNEF, Wood Mackenzie, HSBC

Announced project pipeline- Alkaline electrolyser

Location	Capacity (MW)	Developer	Start	End use
US	1000	Nikola Motor company	2020	Transport
France	500	H2V industry	2021	Gas grid injection, industry, transport
Paraguay	310	ECB group, Paraguay government	2022	Renewable diesels, synthetic fuels
Netherlands	250	BP, the Port of Rotterdam Authority	2022	Oil refining
Netherlands	100	Tata steel, Nouryon	2023	Chemicals, transport
Netherlands	100	Engie, Gasunie	2022	Gas grid injection, industry
Australia	50	Crystal Brook landowners, Neoen	-	Gas grid injection, industry, transport
Denmark	20	Shell	2020	Oil refining, power & energy storage & transport
Netherlands	20	SkyNRG, Nouryon and Gasunie	2022	Aviation fuel
Australia	15	Hydrogen Utility	2021	Power to grid, storage, ammonia, chemicals
Japan	10	Toshiba Energy sys., Tohoku Elec. power	2020	Transport, power industry
	2375			

Source: BNEF, Wood Mackenzie, HSBC

Announced project pipeline- other technology

Location	Capacity (MW)	Developer	Start	End use
Germany	100	TenneT, Gasunie, Thyssengas	2022	Gas grid injection, industry, transport
Germany	100	Amprion, OGE	2023	Power to gas, transport, heating, storage
Australia	50	Crystal Brook landowners, Neoen	-	Gas grid injection, power, transport, ammonia
Norway	20	Nordic Blue Crude AS, Sunfire, EDL	2023	Synthetic crude oil
Germany	15	BP, Uniper Fraunhofer Institute	-	Synthetic fuels, power to gas, oil refinery
	285			

Source: BNEF, Wood Mackenzie, HSBC

3) Is offshore wind better suited for green hydrogen than other renewables?

Other key considerations in closing the cost gap between grey and green are: 1) electricity cost and 2) electrolyser utilisation rate.

The unit cost of offshore wind electricity (or levelised cost of electricity – LCOE) is higher than both solar and onshore wind today, but we expect that gap to close rapidly as larger turbines drive better economics. At this point offshore wind will offer a better value proposition for green hydrogen production compared to onshore and solar power thanks to its higher load factor.

The levelised cost of green hydrogen production by 2030, assuming a unit electricity cost of USD50/MWh for offshore wind, electrolyser capex of USD500/kW and a load factor of 50%, falls to USD3.2/kg and would fall nearer USD2/kg if the electricity cost can reach USD30-40/MWh, not inconceivable given 14MW turbines in the market and existing subsidy free offshore bids.

Hydrogen can complement offshore wind by enabling storage of renewable power during non-peak hours. We see multiple projects underway to analyse this opportunity, given it would be win-win for both offshore developer and hydrogen consumers. For instance, electrolyser OEM ITM power is developing the GIGA STACK project in conjunction with Ørsted and Phillips 66. ITM power will install 100MW of electrolyser to be fed by Ørsted's Hornsea-1 offshore wind farm and the Phillips 66 refinery located adjacent to the hydrogen plant will use the hydrogen manufactured.

The Netherlands under its national hydrogen strategy plans up to 2GW of offshore wind farms to provide power to hydrogen electrolysers.

Very low electricity cost may help solar and onshore wind

On the other hand, solar auction bids have come in well below USD20/MWh and onshore wind PPAs in windy areas such as Texas are below USD25/MWh. This provides an attractive combination for green hydrogen even if load factors will be lower (20-35%). We expect to see a mix of renewable technologies used for powering green hydrogen which are likely in EMEA for example to depend on regional resource availability (offshore wind in northern Europe, solar in southern Europe, Middle East and north Africa).

Cost of renewable hydrogen with varying LCOE and load factors (USD/kg H2)

LCOE	Capex electrolyser														
	USD750/kW					USD500/kW					USD250/kW				
USD0/MWh	5.7	2.8	1.9	1.4	1.1	4.2	2.1	1.4	1.1	0.9	2.8	1.4	0.9	0.7	0.6
USD10/MWh	6.1	3.3	2.4	1.9	1.6	4.7	2.6	1.9	1.5	1.3	3.2	1.9	1.4	1.2	1.0
USD20/MWh	6.6	3.8	2.8	2.4	2.1	5.2	3.0	2.3	2.0	1.8	3.7	2.3	1.9	1.6	1.5
USD30/MWh	7.1	4.2	3.3	2.8	2.5	5.6	3.5	2.8	2.5	2.2	4.2	2.8	2.3	2.1	2.0
USD40/MWh	7.5	4.7	3.8	3.3	3.0	6.1	4.0	3.3	2.9	2.7	4.6	3.2	2.8	2.6	2.4
USD50/MWh	8.0	5.2	4.2	3.7	3.5	6.5	4.4	3.7	3.4	3.2	5.1	3.7	3.2	3.0	2.9
USD100/MWh	10.3	7.5	6.5	6.1	5.8	8.9	6.7	6.0	5.7	5.5	7.4	6.0	5.6	5.3	5.2
Load factor	*10%*	*20%*	*30%*	*40%*	*50%*	*10%*	*20%*	*30%*	*40%*	*50%*	*10%*	*20%*	*30%*	*40%*	*50%*

Source: ITM Power

4) Will hydrogen lose out to batteries in transport?

Yes and no, we think. The table below shows the huge head start that battery electric vehicles (BEVs) have over fuel cell electric vehicles (FCEVs) in the passenger vehicle market. Car charging infrastructure is being rolled out and most car manufacturers have launched, or will be launching, a BEV. The world already uses electric power for 250,000 light-duty vehicles on top of a global passenger EV fleet of 5m+. Only Toyota and Hyundai are actively pursuing this FCEV market.

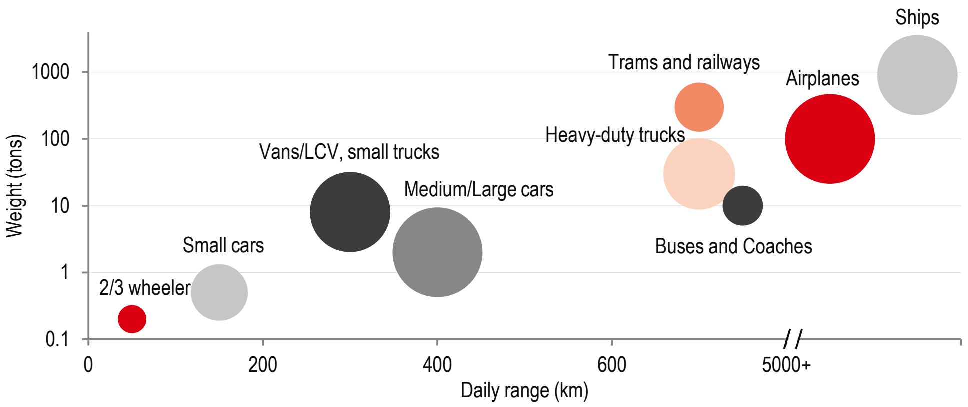
A comparison of BEV and FCEV parameters

EV type	Drivetrain	Charging / refuelling	Time to refill	Range	Refuelling infrastructure	Fleet in operation*
BEV	electric motor	home and public sockets	3-4 minutes	300km	>500k publicly accessible charging points	5,100,000
FCEV	fuel cells and electric motor	hydrogen refuelling pump	1-8 hours	400km	380 refuelling stations	12,950

*YE 2018 figure. Source: IEA, E4Tech

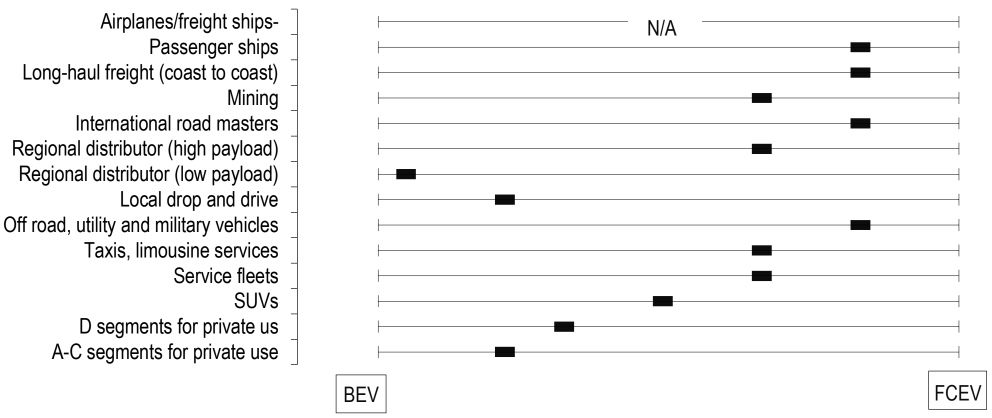
However, the heavier the vehicle and the longer distance it drives, the more the economics tip in favour of hydrogen over batteries. The high energy density of hydrogen makes this technology more attractive compared to batteries for long distance transport.

A comparison of range and payload for different vehicle segments…



Source: FCH hydrogen roadmap Europe

…helps determine which electric propulsion technology (BEV or FCEV) is preferable



Source: FCH hydrogen roadmap Europe

5) Does decarbonising HGVs with hydrogen make sense?

Within the heavy goods vehicle (HGV) segment we see an emerging consensus that batteries make sense for short- to medium-haul commercial transport but hydrogen is better suited for long-haul.

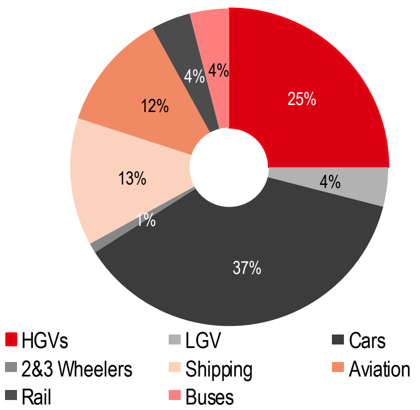
As mentioned, the high energy density of hydrogen makes this technology more attractive compared to batteries for long distance transport; the weight difference between a battery electric class 8 truck and its fuel cell equivalent can be as high as 1.5 tonnes, a significant parasitic load that would limit comparable range for the largest long-haul battery vehicles.

In addition, rapid refuelling time makes a difference for long-haul journeys, as multi-hour battery charging breaks would increase overall transport time. Existing charging stations used for passenger EVs may also not be sufficient to power the heavier and more energy demanding heavy battery electric trucks.

A key issue holding back hydrogen has been the lack of refuelling infrastructure. We see commercial and policy momentum to encourage and develop cheaper green hydrogen and to build related infrastructure for HGVs is slowly increasing. Furthermore, as long-haul road transport typically moves along main road arteries (c.5% of the road network), it requires far fewer refuelling stations compared to more localised transport. This is important as hydrogen refuelling technology is relatively immature and lacks standardisation.

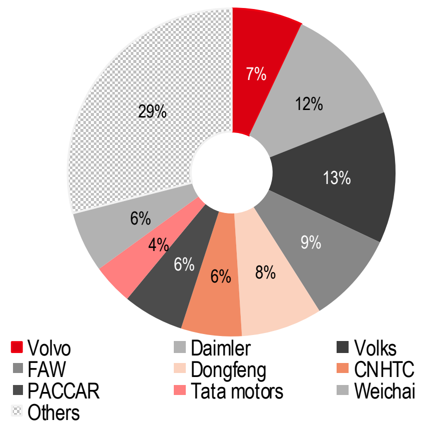
Europe is targeting 45,000 fuel cell electric HGVs by 2030 and 450,000 by 2040. Nikola envisages a global fleet of 200,000 fuel cell HGVs already by 2030. A number of companies are working on hydrogen HGVs, systems and related hydrogen refuelling stations, including Hyundai, Weichai, Toyota, Nikola and the Daimler Volvo JV.

HGVs create a quarter of all transportation CO2 emissions



Source: UCL, HSBC estimates, 2015 data

OEM dynamics: 2019 market share for >6 tonnes trucks (including all fuel types)



Source: IHS, HSBC estimates

6) How is policy support improving for hydrogen?

Policy momentum for green hydrogen is strong, particularly in the European Union. The EU eyes hydrogen as a key driver for the post COVID-19 recovery and adopted its EU hydrogen strategy on 8 July, which includes firm targets for 2024 and 2030. Additionally, member countries Germany, Portugal and the Netherlands have also adopted national hydrogen strategies to promote and develop hydrogen in their respective economies. In addition we note policy efforts in California towards zero-emission transport which are beneficial for hydrogen technologies. We believe policy support is essential to driving investments in the sector.

Policy support to green hydrogen industry

Region	Target	Investment support	Policy Description
European Union	6GW/40GW of electrolyser capacity by 2024/2030 producing 1mn/10mn tonnes of renewable hydrogen respectively	1) EUR24-42bn in electrolysers and EUR65bn in hydrogen transport, distribution, storage and refuelling stations by 2030 2) EUR220-340bn will be invested to scale up and directly connect 80-120GW of solar and wind plants to the electrolysers 3) EUR11bn will be invested in retrofitting half of the existing plants with CCS 4) EUR180-470bn of total investments in production capacities expected by 2050 5) Investments in end-use sectors to facilitate hydrogen consumption will also be made. For instance- a fossil based steel plant requires EUR160-200mn to be converted into a hydrogen based plant and EUR850-1000mn for rolling out 400 small scale refuelling stations	1) The policy aims at increasing share of hydrogen in energy mix from current 2% to 13-14% by 2050, addressing areas of the EU economy which cannot be decarbonised using renewable electricity like steel/chemical processes and transport 2) EU will form a Clean Hydrogen Alliance which will set an investment agenda and develop a pipeline of concrete projects 3) **Phase 1 2020-24:** existing fossil based hydrogen producing plants will be retrofitted with CCS or electrolysers in large refineries/chemical plants. 4) Limited transport infrastructure needs in phase-1 as production of hydrogen will be near to the end-use site but planning for transport backbone will begin 5) Policy support will be in form of liquid and well-functioning hydrogen market and incentivising both supply and demand side uses in order to bridge the gap between green and grey hydrogen 6) **Phase-2 2025-2030**: hydrogen will become an intrinsic part of the EU energy system and generate 173TWh of green hydrogen. 7) In 2030 hydrogen will be used further in steel industries, shipping and for rebalancing of electricity by storing renewable power into hydrogen 8) Policy support in phase-2 will be centred on building transport infrastructure and refurbishing the existing gas network to be used for hydrogen transport
Germany	5GW/10GW of electrolyser capacity by 2030/2040	1) EUR7bn for hydrogen projects in German 2) EUR2bn for foreign investments mainly Africa to promote German technologies and satisfy import needs in future	1) Through its National Hydrogen strategy, Germany aims to create favourable conditions for private sector investment in the production, transport and use of emission-free hydrogen 2) Electrolyser operators will be exempted from the renewable energy surcharge (RES fee), which constitutes 20% of electricity prices in Germany 3) To support hydrogen, use in industries, especially steel and chemicals, the government intends to financially support investments in electrolysers and compensate for losses resulting from using hydrogen instead of fossil fuels such as coal 4) With regards to the transport sector, the government plans to subsidise buying hydrogen vehicles and will provide financial support for hydrogen refuelling stations 5) Germany expects only 13-16% of its hydrogen demand to be met by local production, hence the government plans to provide financial and technological support to African countries in order to import green hydrogen
Portugal	Integration of hydrogen in Portugal's energy mix	EUR7bn for green hydrogen projects by 2030	1) Portugal's EN-H2 strategy aims to decarbonise transport and industry including cement, metallurgy, chemicals, mining, glass and ceramics 2) The first 1GW hydrogen project - Sines green hydrogen plant – planned by 2030. The plant will mainly rely on solar power 3) By gradually introducing hydrogen into country's energy mix, Portugal intends to save EUR300-600m in natural gas imports by 2030
Netherlands	Electrolyser capacity of 500MW/3-4GW by 2025/2030	EUR35m annually in green hydrogen	1) Netherland's hydrogen strategy aims to develop a green energy system centred on green hydrogen. An estimated 270k tonnes of hydrogen will be produced by 2030. 2) A total of 500MW of electrolyser capacity to be commissioned by 2025, powered by 2GW of offshore wind power 3) The green hydrogen generated will be used as feedstock for chemical and petrochemical industries in Rotterdam, Antwerp, Geleen, Terneuzen 4) For the transport sector, the plan includes setting up distribution centres from where hydrogen will be shipped across the country to refuelling stations at bus and train depots
US	100% zero emission bus fleets by 2040		1) As part of Innovative Clean Transit regulation (ICT), the California Air Resources board (CARB) has set a target for public transit agencies to gradually shift to 100% zero emission bus fleets by 2040 2) The incentive program offers rebates to California consumers ranging from USD4500-7000 on fuel cell vehicles and USD2000-4500 on battery electric vehicles
US	Every new truck sale in California to be zero emission by 2045		1) Advanced clean truck regulation aims to accelerate large scale transition of zero emission medium and heavy duty trucks under class 2b-8. 2) By 2035, zero emission truck sales should be 55% of class2b-3 truck sales, 75% of class 4-8 straight truck sales, and 40% of truck tractor sales

Source: National hydrogen strategy-Germany/Netherlands/Portugal, European Union hydrogen strategy, CARB

Disclosure appendix

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