SUBMISSION

EU Hydrogen Strategy

June 2020

The Global Carbon Capture and Storage Institute (the Institute) is an international think-tank whose mission is to accelerate the deployment of carbon capture and storage (CCS) as an imperative technology in tackling climate change. The Institute is headquartered in Melbourne, Australia, with offices in Washington DC, London, Brussels, Beijing and Tokyo.

The Institute is a specialist global organisation with deep expertise in all aspects of CCS including capture technology, geological storage, policy, law and regulation, economics, and public engagement.

Introduction

The Global CCS Institute welcomes the opportunity to comment on the European Union's consultation on its proposal on the development of a European hydrogen strategy.

Since the 2015 Paris Agreement refocused efforts on climate action, achieving a net-zero global economy has emerged as the pre-requisite for avoiding dangerous interference with the global climate system. The hard to abate sectors, for which solutions are more expensive or in some case, do not exist, can no longer be considered a problem for a later time. However, to achieve net zero by 2050 in Europe, solutions must be implemented, at scale, now. Clean hydrogen is one important part of the solution, having a role in decarbonizing stationary energy, transport, industrial and domestic heat, and other industrial processes in hard to abate sectors.

The two most significant challenges that must be overcome to produce and use sufficient hydrogen to make a meaningful contribution towards a climate neutral economy are scale and cost.

Currently 70 million tonnes per annum (mtpa) of hydrogen is produced globally; however, it estimated that between 425 and 650 mtpa of clean hydrogen will be needed by mid-century to reach net-zero emissions, indicating a significant scaling up challenge[1].

Cost is also a determining factor in the challenge of achieving appropriate scale rapidly. Budgets (both public and private) are finite and many deserving initiatives compete for scarce resources. Hydrogen Council estimates that producing clean hydrogen from natural gas with CCS at scale up to 2030 would cost approximately USD 6 billion, compared to unabated hydrogen production. In comparison, producing the same volumes of hydrogen with electrolysis would cost approximately USD 20 billion, based on the assumption of a 100% renewable electricity grid[2].

Today, the lowest cost option for producing clean hydrogen is from reforming of natural gas or gasification of coal (or petcoke and similar substances) with carbon capture and storage.

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1 Commonwealth of Australia 2018. "Hydrogen for Australia's future" and Energy Transitions Commission 2018. "Mission Possible: Reaching net zero carbon emissions from harder-to-abate sectors by mid-century"
2 Hydrogen Council 2020. "A path to hydrogen competitiveness. A cost perspective."

Hydrogen produced using coal or methane with CCS currently costs US$1.50-2.40 per kilogram compared to US$4.00- 7.45 for hydrogen produced using electrolysis[3].

The future cost of clean hydrogen will depend on prices of fossil fuels, electricity and CO2 costs, and therefore vary regionally. While the costs of hydrogen produced via electrolysis are forecast to fall, low-carbon hydrogen produced using CCS is expected to remain the most commercially viable option at least until 2030[4,5,6]. Even after 2030, fossil based clean hydrogen with CCS is likely to remain the lowest cost option for some time except perhaps in regions with outstanding renewable resources and low opportunity costs for not using that renewable electricity in the power grid, such as in Saudi Arabia. Renewable energy costs have reduced enormously over the past decade and will reduce further. However, CCS costs have also reduced over the past decade (e.g. 50% reduction for capture from coal power stations[7]) and will also continue to reduce, as more capacity is deployed.

Clean Hydrogen from Fossil Fuels with CCS

The production of commercial-scale quantities of hydrogen from fossil fuels is proven. Currently, around 70Mt of hydrogen is produced globally, 98% which is from the gasification of coal or the reformation of methane[8]. However, current global hydrogen production is emissions intense, emitting around 830Mtpa of CO2, more than twice the annual emissions of the UK in 2019.[9] To meet climate targets, current hydrogen production in Europe, almost all of which is from unabated fossil fuels, must be converted to clean hydrogen production through the application of CCS. Further, all additional hydrogen production required under any future European Hydrogen Strategy must be clean hydrogen.

Fortunately, the application of CCS to the production of hydrogen from coal or gas at commercial scale is proven. The first commercial facility (Enid Fertiliser) commenced operation in 1982. The Great Plains Synfuel plant has been producing 1,300 tonnes of hydrogen per day (mixed with CO in syngas) with CCS from brown coal gasification since 2000. Today, there are seven commercial scale hydrogen production facilities with CCS operating and one in construction with a total production capacity of approximately 1.5 million tonnes per annum of clean hydrogen.

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3 IEA 2018. "World Energy Outlook 2018"
4 IEA 2019. The Future of Hydrogen, Seizing today's opportunities. International Energy Agency, Paris, available at < https://www.International Energy Agency.org/hydrogen2019/>.
5 CSIRO 2018. National Hydrogen Roadmap
6 Hydrogen Council 2020. Path to hydrogen competitiveness, A cost perspective
7 GCCSI 2019. Global Status of CCS
8 IEA (2019. The Future of Hydrogen, Seizing today's opportunities,
9 Global CCS Institute 2019), 'CO2RE Database, Climate Change Report', accessed from <https://CO2RE.co/ClimateChange>.

Facility	H2 Production Capacity	H2 Production Process	Operational Commencement
Enid Fertiliser	200 tonnes per day of H2 in syngas	Methane reformation	1982
Great Plains Synfuel	1,300 tonnes per day of H2 in syngas	Coal gasification	2000
Air Products	500 tonnes H2 per day	Methane reformation	2013
Coffeyville	200 tonnes H2 per day	Petroleum coke gasification	2013
Quest	900 tonnes H2 per day	Methane reformation	2015
Alberta Carbon Trunk Line - Sturgeon	240 tonnes H2 per day	Asphaltene residue gasification	2020
Alberta Carbon Trunk Line - Agrium	800 tonnes H2 per day	Methane reformation	2020
Sinopec Qilu	100 tonnes H2 per day (estimated)	Coal/Coke gasification	Expected 2021

Table 1. Hydrogen Production Facilities with CCS in Operation or Construction

Scaling up production of clean hydrogen from fossil fuels with CCS is relatively simple from a technology and resource perspective. Mature technology is available “off the shelf” at commercial scale now. Pore space for CO2 at the multiple giga tonne scale is available across Europe and particularly beneath the North Sea where geological storage of CO2 has been undertaken for almost 25 years (at Sleipner).

Having said that, incentivising sufficient private sector investment in new clean hydrogen production capacity is a significant challenge. The challenge of achieving meaningful scale is best illustrated through a simple quantitiative analysis. The stated objective is to achieve a climate neutral economy (net-zero emissons) in Europe by 2050. Achieving net-zero emissions by 2050 will require significant progress by 2030. Lets assume that just 10% of expected European fossil fuel energy demand in 2030 is instead met through clean hydrogen. European fossil fuel demand is expected to be 1197Mtoe (million tonnes of oil equivalent) in 2030.[10] Providing only 10% of that energy would require 38.3 Mt of hydrogen[11] or production capacity of 10,500 tonnes per day. This demand could be met by replicating the capacity of the Great Plains Synfuel plant, which has operated with CCS for 20 years, eight times over in Europe. Alternatively, this demand could be met by replicating the capacity of the Quest plant, which has operated with CCS for five years, 12 times over in Europe. Attracting the private capital necessary to build eight coal gasification plants or 12 steam methane reforming plants (or a combination of the two) in Europe with the necessary CO2 transport and storage infrastructure to produce clean hydrogen would be difficult from a commercial perspective. However there are

10 IEA 2019. World Energy Outlook. Stated Policies Scenario.
11 Using the average of the higher and lower heating values of H2, 131MJ/kg

many policy options available, that have proven successful in other jurisdictions, that could be included in the European Hydrogen Strategy to overcome those commercial barriers.[12] Importantly, there are no technology or primary resource constraints that would disqualify this level of ambition.

Building a clean hydrogen production industry in Europe from fossil fuels with CCS will provide the additional benefit of reducing the social and economic dislocation that communities that currently rely upon fossil fuel production for employment would otherwise suffer as a consequence of climate action. The utilisation of fossil resources without the CO2 emissions will support a just transition for those communities.

Clean Hydrogen from Renewable Powered Electrolysis

Scaling up production of meaningful quantities of clean hydrogen from renewable energy with electrolysers is extremely challenging.

Currently, only a fraction of one percent of global hydrogen production is from renewable powered electrolysis[13]. The largest renewable powered electrolysers currently produce less than 10 tonnes of hydrogen per day. They must scale up by a factor of 100 to be comparable to fossil based hydrogen production with CCS, and to be relevant for climate mitigation purposes. Renewable hydrogen costs are around three times higher than clean hydrogen from fossil fuel with CCS, making the commercial challenge much more difficult. Further, renewable hydrogen from electrolysers at a meaningful scale will require very large quantities of renewable electricity.

Producing 38.3Mt of clean hydrogen (i.e. 10% of expected fossil energy demand in Europe in 2030) using elctrolysers would require 2110TWh of renewable electricity.[14] That is approximately 50% more than the total renewable power generation from all renewable sources in Europe in 2018, and 90% of the total renewable power generation expected in 2030. Supplying sufficient additional renewable electricity to meet this requirement would require almost a doubling of the renewable energy expected to be generated in 2030.

12 GCCSI 2019. Policy Priorities for Incentivizing Investment in CCS
13 International Energy Agency (2019). The Future of Hydrogen, Seizing today's opportunities, International Energy Agency, Paris, available at < https://www.International Energy Agency.org/hydrogen2019/>.
14 Assuming 55kWh per kg of H2

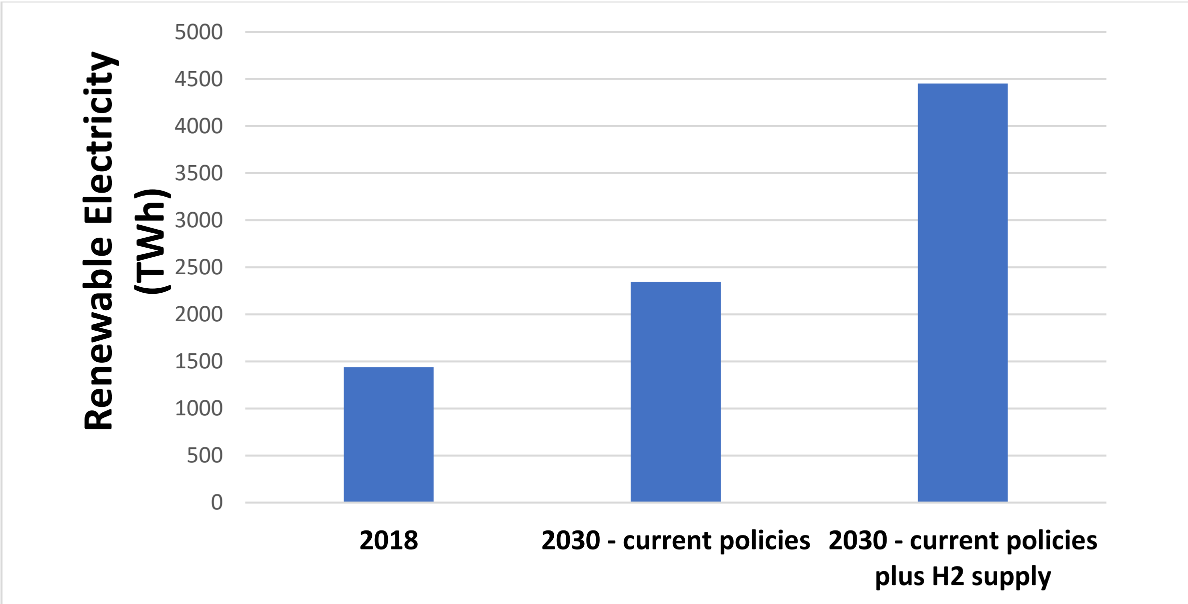

Figure 1. Additional Renewable Electricity Required to Displace 10% of European Fossil Fuel Energy demand in 2030 with Hydrogen Produced by Electrolysers

The alternative of diverting renewable electricity that is already produced, from direct use as electricity, to the production of hydrogen could even result in a net increase in CO2 emissions defeating the purpose of utilizing hydrogen. Electricity that would have otherwise been supplied by renewable sources would most likely be supplied from unabated coal or gas. Further, the production of hydrogen via electrolysis is inherently inefficient with around 30% of the energy lost in the conversion process. Wasting 30% of a scarce resource (renewable electricity) when there is an alternative production process is not rational. Better environmental and economic outcomes would likely result from the use of scarce renewable electricity to displace fossil based generation in the grid than to divert it to hydrogen production where almost one third of the electricity is lost.

The capacity of renewable generation required to be installed to produce sufficient electricity to produce meaningful quantities of clean hydrogen would be enormous. According to Wind Europe[15], the average capacity factors for onshore and offshore wind in Europe in 2019 were 24% and 38% respectively. To be conservative, let's assume that all additional renewable energy installations are offshore wind (as they have the highest capacity factor) and further, that the average capacity factor of new installed capacity increases to 45% from 2020 onwards. Using these hypothetical assumptions, 534GW of additional capacity would be required to be installed before 2030 to supply the renewable electricity necessary to produce sufficient hydrogen to displace 10% of Europe's expected fossil energy demand in 2030. Ramping up wind generation at that rate, as shown in figure 2. would likely be extremely challenging .

In summary, while renewables-produced hydrogen is generally desirable, its role in the future energy mix has to be based on a realistic assessment and understanding of its scaling

[15] Wind Europe 2020, Wind energy in Europe 2019, Trends and Statistics

implications as well as, ultimately, a competitive cost structure. Addressing these needs to then achieve the necessary scale and unit cost reductions could take a considerable length of time, which is a material challenge when urgency of action is a key issue.

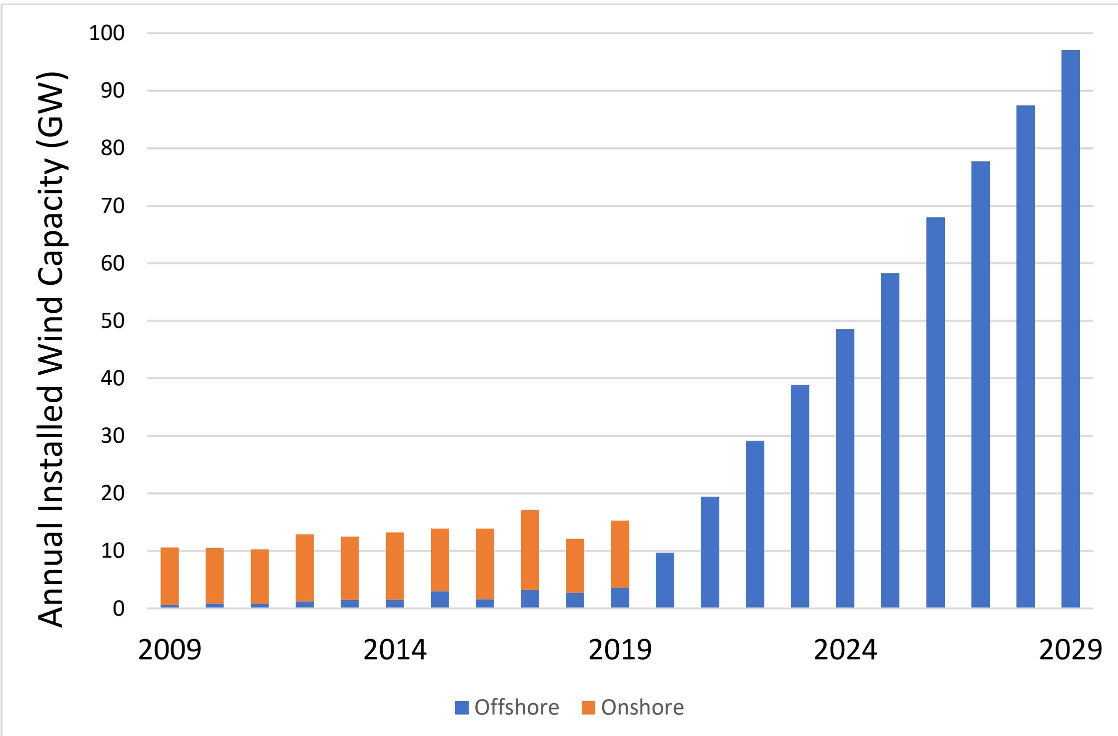

Figure 2. Additional Annual European Wind Power Capacity Required to Supply Sufficient Renewable Electricity to Produce Sufficient Clean Hydrogen to Displace 10% of Europe's Expected Fossil Energy Demand in 2030[16]

Conclusion

Clean hydrogen can make a significant contribution to achieving a climate neutral economy in Europe. It has significant application in stationary energy, transport, domestic and industrial heat, and industrial processes. The rapid ramp up of large scale clean hydrogen production is required to support ambitious climate targets.

Deploying mature technologies, proven at commercial scale for decades that are available now will facilitate a growing market for clean hydrogen in Europe by underpinning demand and enabling early investments in infrastructure and supply chains. CCS can enable early, clean hydrogen at scale, which can kick-start a European clean hydrogen economy.

[16] Historical annual capacity is from Wind Europe 2020, Wind energy in Europe 2019, Trends and Statistics, and includes the EU 28 plus Bosnia & Herzegovina, Kosovo, Montenegro, North Macedonia, Norway, Russia, Serbia, Switzerland, Turkey, and Ukraine.