Transcript

**Hydrogen CPD-Module 2-Production & Demand**

Slide 1:

Hello, my name is Ali. I am Chancellor's Fellow at The University of Edinburg, and I will take you through Module 2. This session will provide an overview of hydrogen production and demand.

Slide 2:

Globally, the shift towards hydrogen energy is gaining momentum. It's increasingly recognized not just as a fuel but as an energy carrier with the potential to decarbonize various sectors, including transportation, power generation, and industries like steel manufacturing.

In terms of production, hydrogen is versatile. It can be generated from a variety of resources, which we have summarised in this figure. Traditional methods primarily use natural gas or other fossil fuels. Around 96% of hydrogen is produced this way today, but the future lies in tapping into cleaner sources. This includes nuclear power, biomass, and particularly renewable sources like solar and wind energy, which Scotland is rich in. There is also naturally occurring hydrogen, which is hydrogen gas found naturally on Earth. For more details, please refer to our recent article at the bottom of this page.

Understanding the standards and regulations governing hydrogen production is crucial. The International Organization for Standardization (ISO) provides guidelines under ISO/TC 197 for hydrogen technologies, covering aspects like safety, purity, and production methods. The European Union also has directives and benchmarks focusing on sustainable and low-carbon hydrogen production. UK Government has set standards to ensure that the final Greenhouse Gas (GHG) Emission Intensity for our Hydrogen Product does not exceed 20 grams of CO₂ equivalent per megajoule, based on Lower Heating Values (LHV).

In Scotland, harnessing our robust renewable energy resources for hydrogen production is not just an environmental imperative but an economic opportunity. It aligns with Scotland’s goals for carbon neutrality and economic diversification, placing us at the forefront of the green energy revolution.

However, transitioning to a hydrogen-based energy system requires strategic planning. This includes investing in infrastructure, ensuring regulatory frameworks are in place, and fostering public-private partnerships. By doing so, we can facilitate a smooth transition that benefits both our environment and our economy.

Slide 3:

Now that we have covered why we need hydrogen and where it can be most usefully deployed to support Net Zero, let's move on to the production of hydrogen. There is a lot of jargon surrounding hydrogen production and a whole rainbow of colours to describe the different options, as we showed in the previous slide, but in practise there are three major types of hydrogen today.

First up is grey hydrogen, which accounts for over 96% of the current hydrogen production market, with 94 million tonnes of hydrogen produced globally in 2022. Grey hydrogen is produced by heating methane gas with high-temperature steam in a process called Steam Methane Reforming (“SMR”) or through steam-powered gasification of coal. This process is efficient, resulting in a cost of under 2 dollars per kg. However, it can release between 10 and 20 kg of CO2 for every kg of hydrogen produced and was responsible for ~900 million tonnes of CO2 emissions in 2022. As context this is more than double the entire emissions from the UK in that same year.

Decarbonising grey hydrogen production is a key driver of new low-hydrogen production technologies.

The UK produces nearly two thousand metric tonnes of grey hydrogen per day, which is the equivalent of 23 TWh per year. 99.8% is produced as grey hydrogen with unabated emissions from 31 sites, mostly produced on site for consumption within the same facility, there is very little available for open sale.

Slide 4:

Blue hydrogen is essentially grey hydrogen, with the CO2 emissions captured and stored securely in deep geological formations. Globally, around 1% of hydrogen produced is blue hydrogen.

Blue hydrogen costs are between 1.5 and 4 dollars per kilogram of hydrogen, which is around 1-2 dollars per kg more than grey hydrogen, reflecting the cost of the carbon capture and storage.

It is worth mentioning here the need for standards associated with what counts as low carbon hydrogen, as this is certainly a murky area - is say the use of CO2 captured during hydrogen production for enhanced oil recovery truly low carbon hydrogen?

There is now a global effort to define what constitutes ‘low carbon hydrogen’ at the point of production based on the lifecycle emissions across the entire production chain. The UK published their low carbon hydrogen standard last year, and to be considered low carbon, as we mentioned in the first slide, hydrogen must have a GHG emissions intensity of 20 grams of CO2 per MJ of produced hydrogen or less. This is in line with European and other standards ensuring an open export route.

In the UK, there are no current blue hydrogen production sites, but there are a number of blue hydrogen projects the pipeline totalling 14.3GW production capacity through the Acorn project in Scotland and the HyNet project around Liverpool and the Teeside East Coast Cluster.

Slide 5:

Green hydrogen uses renewable electricity to run electrolysers, which split water into hydrogen and oxygen and has negligible CO2 emissions.

It is a proven technology that needs to be scaled up to reduce costs, as currently, green hydrogen stands at 2-3 times the cost of grey and blue hydrogen. The global green hydrogen market size was valued at USD 3.2 billion in 2021 and is expected to expand at a compound annual growth rate of 39.5% from 2022 to 2030.

There are three different types of electrolysers, the most widely deployed with 62% of the market share are alkaline electrolysers followed by polymer electrolyte membrane or PEM electrolysers with 24% of the market share with Solid Oxide Electrolysers having a 14% market share. It is anticipated that alkaline electrolysers will remain the largest market.

There are significant innovations underway to improve the efficiency of electrolysers and reduce the cost of the produced hydrogen. This includes the ability for electrolysers to run on seawater, as is being piloted in the UK Dolphyn project.

The UK currently produces 2.21 metric tonnes (26 GWh) green hydrogen from 14 sites. However, the UK’s green-hydrogen pipeline comprises around 120 production projects that range in size from 2MW-5MW to more than 100MW, many of which are linked to large, offshore wind projects.

While the UK is taking a twin-track approach to low-carbon hydrogen production with blue and green, it is anticipated that by 2050, blue hydrogen will be phased out, and green hydrogen production will dominate.

Slide 6:

In summary, this slide simplifies the pros and cons of the primary methods of hydrogen production.

Grey hydrogen stands out for its cost-effectiveness and established technology but carries the burden of high carbon emissions.

Blue hydrogen, while leveraging existing infrastructure and capturing a majority of CO2 emissions, confronts us with the challenges of CO2 storage and associated capital expenditures.

Looking ahead, green hydrogen offers a zero-emission option using renewable sources. Though it comes with increased production costs and relies on the still-developing availability of renewables.

This spectrum of hydrogen production reflects our current options, balancing between established methods and the emerging solutions, crucial for achieving our carbon neutrality goals.

Slide 7:

Low-carbon hydrogen is anticipated to make up 20-35% of UK final energy consumption by 2050, but what does that actually look like in terms of amount of hydrogen required?

There are plethora of hydrogen demand scenarios available that range from the sublime to the ridiculous – the image on screen provides some indication of how the UK government anticipates how the use of hydrogen in the UK is likely to develop in the near- to medium-term. The analysis suggests potential hydrogen demand of up to 37 TWh by 2030 split across industry, power and transport, not including use of hydrogen for blending into the gas grid.

This could rise to 55-165 TWh by 2035 if we are to meet our sixth carbon budget, which is a legally binding target that places a restriction on the total amount of greenhouse gases the UK can emit over a 5-year period and is tied to our path to Net Zero by 2050.

We immediately encounter a discrepancy between the 37 TWh hydrogen demand needed by 2030 and what will be delivered in practice, as the UK Government’s low-carbon hydrogen generation target is 10 GW by 2030.

Slide 8:

As context it is sensible to look at how much hydrogen we may need within our future Net zero energy system.

Projecting forward to 2050 using the UK Net Zero strategy modelling and the National Grid future energy scenarios that achieve Net Zero, which is shown on screen - in both high electrification scenarios, there will be the requirement for between 130 and 240 TWh per year hydrogen required for industrial, commercial, transport and power generation.

If we look at the scenarios that include some allowance for hydrogen for heat, then the hydrogen required increases to between 435 and 500 TWh per year.

These are significant numbers of hydrogen generation, but it is worth bearing in mind that we currently produce 23 TWh per year of grey hydrogen.

Slide 9:

Having covered hydrogen production and network implementation, I will now highlight some of the ongoing hydrogen use projects, starting with transport.

I really like hydrogen transport projects as they also develop grass roots acceptability of hydrogen, making it every day and somewhat boring, which is exactly what we want.

There are a number of hydrogen-powered vehicle demonstration projects ongoing across the UK.

Aberdeen has been successfully operating a fleet of 57 hydrogen fuel cell vehicles and included the installation of 2 new hydrogen fuelling stations, which will enable them to grow their hydrogen powered fleet even further. If more councils follow suit and install hydrogen fuelling stations, this could enable the wider uptake of hydrogen vehicles due to increased access to fuelling stations across the country.

There are two projects underway to convert existing trains to a hydrogen fuel cell electric power train. This is important as only around 40% of the UK’s rail tracks are currently electrified so alternatives to diesel are necessary.

Other projects of note are the HyFlyer project which is replacing the conventional powertrain in an aircraft with electric motors, hydrogen fuel cells and gas storage, and it achieved its first successful flight in September 2020.

And the HySeas project, which is aiming to demonstrate that fuel cells may be successfully integrated with a proven marine hybrid electric drive system.

Slide 10:

Today, about 10 million tons of hydrogen is already used in the EU industry, mainly as feedstock for the production of ammonia and in the refining industry.

In the chemical industry, hydrogen is mostly used as feedstock to produce ammonia. Ammonia is mainly used as a fertiliser, but it is also a key component of various household cleaning products in the form of ammonium hydroxide. In industrial processes, ammonia serves as a refrigerator, purificator and chemical stabiliser.

In addition to ammonia, hydrogen is involved in the production of methanol, which is mainly used as a chemical building block to produce other chemical compounds, fuels and additives. In the refining industry, hydrogen is used in the conversion of crude oil for:

• Breaking large molecules into smaller molecules with higher added value (Hydrocracking)

• Removing contaminants such as sulfur, nitrogen and metals from crude oil fractions (Hydrotreating)

• Stabilizing some chemical products (Hydrogenation).

Slide 11:

Hydrogen plays a negligible role in the power sector today: it accounts for less than 0.2% of electricity generation.

This is linked mostly to the use of gases from the steel industry, petrochemical plants and refineries. But there is potential for this to change in the future.

Cofiring of ammonia could reduce the carbon intensity of existing conventional coal power plants, and hydrogen-fired gas turbines and combined-cycle gas turbines could be a source of flexibility in electricity systems with increasing shares of variable renewables.

In the form of compressed gas, ammonia or synthetic methane, hydrogen could also become a long-term storage option to balance seasonal variations in electricity demand or generation from Renewables.

Slide 12:

This concludes the second module of the hydrogen course. The next module, Module 3, covers hydrogen transport and storage. Thank you for your attention. Please note down any questions or comments and bring them to the webinar that completes this course.