Transcript

**Hydrogen CPD-Module 1-Background**

Slide 1:

Hello, my name is Katriona Edlmann. I am the Chancellor's Fellow in Energy at The University of Edinburgh, and I will be your guide to all thing’s hydrogen within this SCCS Hydrogen Course. ​This first session will provide an overview of why we need hydrogen, where it can be most usefully deployed to support Net Zero and what policies and funding are in place to support the Hydrogen economy in Scotland.​

Slide 2:

Hydrogen is essentially a chemical energy carrier, rather like natural gas. It has the highest energy - per mass - of any fuel and, when it “burns” in air, it releases that stored energy, producing only water with no harmful greenhouse gases. ​It can be produced sustainably from the electrolysis of water powered by renewable electricity and is a versatile energy carrier that can be compressed into a gas or liquid and transported and used in much the same way as natural gas is today.​

​Slide 3:

Hydrogen has spurred multiple waves of interest in the past without significant traction, often coinciding with global oil crises.

However, the target of Net Zero emissions by 2050 has meant that there is no hiding place for any emissions, and all sectors of the economy need to significantly cut their emissions​.

To see how we can most effectively reduce emissions with current and future Net Zero technologies, it is helpful to understand the sources of these emissions. ​As you can see in the figure on screen showing the total greenhouse gas emissions in the UK in 2020 by sector, over ¾ of these emissions are related to energy use from fossil fuels across transport, energy supply, industrial processing, commercial business use and residential heat and cooking.

And while some progress has been made in reducing emissions by switching from coal to gas power generation, increased variable renewable energy generation, increased energy efficiencies and the use of heat pumps, we still have a long way to go to reach our Net Zero targets, particularly in the harder to decarbonise sectors​.

It is worth highlighting that in 2023, over 80% of our total energy used still comes from burning fossil fuels. ​

​Slide 4:

The particular appeal of hydrogen is that it can do two things very well:​

It can support the expansion of our sustainable renewable energy system by providing large scale inter seasonal energy storage for renewable energy integration and distribution of energy across sectors, providing system resilience and energy security. ​

Hydrogen can also progress the decarbonisation of the hard-to-abate sectors, where full electrification options are not currently possible. This includes long-haul transport and energy intensive industries that use high temperatures in their processes. It can also provide decarbonised feedstock for industry through the production of synthetic fuels using captured carbon and it can help to decarbonise building heating. ​

So, you can see why the potential for hydrogen to support Net Zero has captured the attention of policymakers and industry players around the world.

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Within any discussion around decarbonising energy through the deployment of intermittent renewable energy, I always think it is important to do a reality check on the scale of the task ahead.

The figure on screen shows Great Britain's energy use in GWh per day, with the peach line representing the contribution of renewable electricity from wind, solar and hydro, the red line is our total electricity demand, the black line is the energy use for transport, and the blue line is the total gas demand – of which around 70% is for domestic heating.​

It goes without saying that to move towards net zero we need to reduce our overall demand through energy efficiencies, building insulation and changing our own habits – none of which are an easy ask. ​

But concentrating on the figure on screen I wish to highlight three key messages:

* The first is to highlight the huge fluctuation in energy demand from summer to winter, which can increase by 2000 GWh per day over a matter of weeks as the temperatures drop. This is primarily delivered by gas, as shown by the blue curve. As we move to an energy system based on variable renewable energy supported by well-insulated housing stock and heat pumps, we will still need to ensure the additional reliable delivery of 1000’s of GWh additional renewable electricity per day in the winter. As renewable energy is inherently variable, this will require TWhs of energy storage to ensure we can heat our homes throughout the winter, and at the moment, this scale of storage can only be delivered by hydrogen.
* Secondly, I want to highlight the current gap between total electricity demand in red and the delivery of renewable electricity in peach. Generally, the renewable energy peaks at around 400 GWh per day, but fluctuates enormously over very short time scales. The total electricity demand ranges between 800 and 1000 GWh per day, depending on the season. To deliver our existing electricity demand from renewable sources alone will require a doubling of the existing electricity supply from renewable energy with a guaranteed supply of uninterrupted controllable electricity, which again will require GW scales of hydrogen energy storage to ensure the lights stay on as we transition from gas to renewable electricity generation.
* The third message is a reminder of the very high energy demand from transport, shown as the black line, which is almost entirely delivered from fossil fuels. If there is a complete switch to electric vehicles, that is going to add an additional energy requirement of around 1500 GWh per day from variable renewable energy – again requiring GW’s of hydrogen energy storage to ensure a consistent uninterrupted electricity supply.

This provides a stark reminder that to electrify everything through variable renewable energy will require the delivery of 1000’s of GWh of additional renewable electricity and hydrogen energy storage to meet both daily and inter-seasonal decarbonised energy demands.​

​Slide 6:

The Scottish Government Climate Change Plan ​sets out to address these issues through changing behaviors to reduce emissions, particularly in transport; expanding our natural carbon sinks through forests and wetland restoration and the research and development of negative emission technologies, It will also invest in the decarbonization of heat, and the development of carbon capture and storage technologies along with hydrogen technologies. All of these will be set within the context of green job creation and economic growth.

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All future energy scenarios in the UK that reach net zero require a significant contribution from hydrogen.

Analysis by the Department for Energy Security and Net Zero and the National Grid future energy scenarios both anticipate that hydrogen will make up 20-30 % of the UK final energy mix, with the rest coming from renewable electricity.

Putting that into context, this future projection for hydrogen energy is the same as the current total energy provision from electricity​.

​Slide 8:

I just want to add in here a few important considerations that surround the role of hydrogen in supporting our Net Zero ambitions. ​

There is a significant push against hydrogen from some quarters as, from an engineering perspective, the efficiencies just don’t compare to renewable electricity and heat pumps, and this is true, but the world we live in is simply not as straightforward as that. Around 85% of the UK’s homes are currently heated by fossil fuels, and only 4% have an energy performance certificate rating that makes them suitable for heat pumps. Heat pumps will be perfect for new homes but are unlikely to be suitable for our ageing housing stock, even with retrofitted insulation. ​

There are also those who believe traditional batteries can solve all our energy storage needs, and they certainly have an important role, but not for large-scale inter-seasonal energy storage needs. But more than that, I want to highlight that batteries have an enormous demand for critical minerals, most of which come from regions with extremely questionable environmental, social and governance policies. Fuel cells have significant reduced critical mineral demands so would reduce this risk. ​

I also want to highlight that our electricity grid was not designed for a renewable energy system, and the grid reinforcements program is not keeping pace with the growth in renewable energy, which means vast quantities of renewable energy are being wasted through curtailment. So far, over 16.6 TWh of energy from renewables have been completely wasted costing billpayers 1.1 billion pounds, and this will grow exponentially with the increased employment of offshore windfarms without adequate grid reinforcements. ​

I would say that to reach Net Zero, we are going to have to be pragmatic. There will be times when the most powerfully efficient and cost-optimised green technology option simply does not work at that moment in that setting - and we will need all of the available decarbonisation technologies.  ​

​Slide 9:

There are a number of challenges we face with the nascent hydrogen economy including policy and regulatory uncertainty, investor confidence, coordination between supply and demand for market creation and growth, and the investment required to develop the hydrogen transport and storage infrastructure networks and their integration within the existing energy systems, the renewable energy system and the carbon capture and storage system.​

I would always emphasise what I see as the two most important challenges. Firstly, safety reassurances and public perception as we have to bring everyone on this journey to Net Zero so the benefits to society, the environment and the wider economy from the hydrogen economy are clear and all stakeholders are reassured about the safety of hydrogen. I have a saying that we need to make hydrogen every day, and even a little boring as people become more and more familiar with its use. Pilot projects such as the Aberdeen hydrogen buses are a perfect example of this. No one thinks twice about jumping on board the hydrogen buses, and I am sure anyone cycling behind the bus is delighted to avoid a lung full of diesel fumes.

The second key challenge is the issue of cost. For the moment, as we do not have significant natural hydrogen reserves to draw upon, hydrogen needs to be made and as such, production costs are higher than fossil fuels and renewable electricity.  ​

And while one kilogram of hydrogen contains a vast amount of energy, making it an efficient and lightweight energy carrier - because it is so light the amount of energy you get by volume is much lower than with other conventional fuels. To get that ideal, efficient kilogram of energy for transport, storage and use, hydrogen must be compressed, liquified or bonded into various hydrogen carriers, such as ammonia or methanol, to get that better energy density by volume. This, of course, has further implications for cost and complexity. ​But it is worth highlighting that as more green hydrogen production facilities are deployed globally, the costs will drop, with most estimates suggesting green hydrogen will be cost competitive with fossil fuels by 2030.

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The adoption of hydrogen as a new energy vector is a complex endeavour that requires government intervention.​

At its simplest, there are six key policy areas identified as necessary for hydrogen deployment.​

First up is to establish targets and long-term policy signals to create a vision for the role of hydrogen providing investors with certainty that there will be a future marketplace for hydrogen. ​

Then, we need policies to support the production and demand of low carbon hydrogen. Along with policies that mitigate investment risks for infrastructure projects.

To develop the market for hydrogen, we need policies that will mitigate investment risks and facilitate access to finance.​

To drive down costs, we need policies that promote research and development along with strategic demonstration projects.​

And finally, is the need to establish appropriate regulatory frameworks and low-carbon hydrogen standards that are globally compatible, to facilitate trade and boost investor and consumer confidence in the hydrogen market.​

 ​Slide 11:

First up are long-term policy signals that provide stakeholders with certainty that there will be a future marketplace for hydrogen. The images on screen show just some of the key hydrogen related policies released in the last few years, and it is a pretty crowded timeline, so much so that it is almost impossible to keep up with all of the hydrogen related policies, consultations and white papers.

Hydrogen’s journey began with the Committee for Climate Change report on hydrogen in a low carbon economy in 2018, which began to explore the role hydrogen could play in supporting our Net Zero target. This was followed by the UK Government's ten-point plan for a Green Industrial Revolution, published in November 2020, which was the beginning of the formal adoption of hydrogen as a key contributor to achieving Net Zero in the UK, specifically through Point 2: Driving the Growth of Low Carbon Hydrogen. However, hydrogen is instrumental in Point 4: Accelerating the Shift to Zero-Emission Vehicles, Point 6: Jet Zero and Green Ships, Point 7: Greener Buildings and Point 8: Investing in Carbon Capture, Usage and Storage.​

From then, a whole host of policy documents, consultations and strategies have been published, all related to developing a hydrogen economy, with a focus on industrial decarbonisation, transport, heat and a just transition of the North Sea oil and gas industries as fossil fuels are phased out. This was coalesced into the UK Hydrogen Strategy published in August 2021.

The Russian invasion of Ukraine brought energy security front and centre, resulting in the British Energy Security Strategy, which addresses our underlying vulnerability to international oil and gas prices by reducing our dependence on imported oil and gas and rolling out even more renewables and hydrogen. This resulted in a doubling of our low carbon hydrogen production capacity target to 10GW by 2030, beginning to be realized through the first hydrogen allocation round with 11 successful projects, totalling 125MW hydrogen production capacity. The hydrogen storage and transport business models minded to positions were published in August 2023, with the market engagement starting in Dec 2024, with the aim of beginning contract negotiations in early 2025 for 2 hydrogen storage projects and their related infrastructure.

There is no doubt that the UK and devolved governments are fully committed to the decarbonisation opportunity presented by hydrogen.​

Slide 12:

So, business models are huge enablers of the hydrogen economy.

The UK Hydrogen Strategy and following British Energy Security Strategy committed to design new business models for hydrogen production, transport and storage infrastructure by 2025. The Low Carbon Hydrogen Production Business Model was first published in December 2022 which was followed by the Hydrogen Transport Business Model and the hydrogen Storage Business Model minded two positions published in October 2023. This was followed by market engagement on these first allocation rounds, which closed in February 2024.

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Let’s first consider the investment packages to stimulate hydrogen production through the low-carbon hydrogen production business model. ​

The low-carbon hydrogen production business model will provide revenue support to hydrogen producers to overcome the cost gap between low-carbon hydrogen and high-carbon fuels. This recognises that the price at which hydrogen can be sold will not cover the costs of production plus a reasonable return to investors. It delivers “top-up” payments to account for this difference and provides investors with a measure of revenue certainty. ​

The plan mechanism is similar to the contracts for difference model successfully used to decrease the cost of renewable electricity, but also includes a reward mechanism that incentivises producers to achieve higher sales prices, which will then reduce the size of the support payments.​

The hydrogen production business model will be delivered through the Low Carbon Hydrogen Agreement between a government-appointed counterparty and the hydrogen producer.​

And it is important to reiterate that hydrogen will only be considered low-carbon if it meets the UK Low Carbon Hydrogen Standard of 20 grams of CO2 per MJ of produced hydrogen or less at point of production.​

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Getting the produced hydrogen to the customer is a critical piece of the UK’s burgeoning hydrogen economy. ​In August 2023, the UK government indicated its “minded to” position for the Hydrogen Transport Business Model (HTBM) to operate on a Regulated Asset Base (RAB) model, supplemented by an External Subsidy Mechanism to work in conjunction with the RAB.

Under the Regulated Asset Base model, storage providers/owners and operators of hydrogen pipelines would agree an “allowed revenue” conditional on operational performance targets being met. Revenues would be subsidised by an external funding mechanism while the hydrogen economy is in its infancy, transferring the risk to the external subsidy funder, and resulting in a guaranteed regulated return which will provide investors with certainty. ​

DESNZ proposes implementing a RAB for hydrogen pipelines through the gas transporter licences granted under the existing framework of the Gas Act in 1986, however it has not made any decisions on the configuration of roles and responsibilities between Ofgem and Government.​

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For the Hydrogen Storage Business Model (HSBM), the approach will involve private law contracts to create the business model, which will offer a "revenue floor" to ensure baseline profitability and mitigate demand risk while providing a sales incentive on storage services. The government also considers taking equity stakes in facilities.

The government also considers taking equity stakes in facilities. The HSBM will initially focus on supporting geological storage but will keep the option open to support above-ground storage in certain circumstances.

There is a requirement for collaboration between applicants for the HSBM and the HTBM as part of a transport and storage cohort assessment process to ensure transport and storage projects align, which I think is really important to join those dots.

The current proposed timeline of the HTBM and HSBM is that the application window will open Q3 of 2024, with successful projects announced in Q4 2025.

The eligibility criteria for the hydrogen storage business model requires a new build or converted multiple geological gas storage facility; deploy a geological storage technology with a TRL of 7 and above to ensure projects are commercially deployable, so this excludes everything but salt caverns and a minimum energy value of 50 GWh (higher heating value) of stored working gas.

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These business models are backed by two key funding support mechanisms:​

The £240 million Net Zero Hydrogen Fund (NZHF), which runs from 2022 to 2025 to fund project development and capital expenditure, and the Hydrogen Business Model (HBM) which provides ongoing revenue support mechanism implemented via Low Carbon Hydrogen Agreements ​

In all instances, there is strong recognition by industry that the decision making, negotiations around the contracts for differences and the timeline of implementation need to be significantly speeded up to enable project developers to move forward at pace and unlock early private sector investment – this a key recommendation from the UK Hydrogen champion, Jane Toogood.​

Slide 17:

So having looked at the role hydrogen play in our low carbon energy future and the policy and funding enablers for the hydrogen economy it is important to consider the final piece of the puzzle, that of bringing society with us on this journey.

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The debates, discussions and dialogues about how we shift to a different type of future, or a different social-technical system, have both historical and contemporary roots. In the 1980s there were large scale social movements against the wind down of coal mining.

In modern society, Net Zero presents a different challenge, where there is a need to shift broader economic production and society at large towards decarbonisation and sustainability. Net Zero is fundamentally a human challenge, and both a societal and technological challenge. People matter – through behaviours, choices, resistance and support. A just transition is fundamentally about ensuring these voices count, and that the burdens and opportunities in Net Zero are fairly distributed and that the process is open and inclusive.

In the context of Hydrogen, we’ve already seen examples where public sentiment can derail hydrogen heating trials if the consultation process is not fully thought through or given enough time to engage and build trust with communities.

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We are all familiar with the idea of transition – the movement from one system state - in this case a carbon intensive, fossil fuel-based energy system - to a system that is more diverse, decarbonised, decentralised and (hopefully) democratic. While there is a loose consensus on the end point of reaching Net Zero by 2050, there is a LOT of debate around the process of change, how fast we should go and how this should be managed.

There are many competing definitions, visions and principles of what a Just Transition means. While it is academically interesting to explore these, it helps us to boil this down to a few key interpretations and approaches. On the right on the screen in blue is the Scottish Government Just Transition Commission’s interpretation of the Just Transition – pursuing a planned transition, equipping skills, empowering communities and local economies, and there is fairness in the burdens and benefits.

In some of the other definitions of a just transition these themes are repeated with the same principles embedded in any just transition – people count, it should be fair recognising social justice and be an inclusive process.

The "Just" refers to justice and draws upon both climate justice, energy justice and social justice. The common theme between these is that we should ensure that the *benefits* of transition are fairly distributed across society -not just to those who have the money and power- and the impacts must not fall upon those with the least ability to pay or adapt.

In short, how we transition is important, with fairness, equity, inclusivity and transparency at its heart.

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The just transition agenda tends to be dominated by a focus on jobs –

While important, this is not nearly enough and will not develop the broad social base of support - and behaviours - required to achieve Net Zero.

One of the takeaways for this quick dip into the just transition is to understand that we consider a Just Transition to have three operational elements – jobs and skills; community revitalisation & wealth; and participation and empowerment.

These elements cross over and intersect – just transition fails if we cherry pick or just focus on one element.

So when considering building and training the workforce of the future, in relation to hydrogen, a transition will focus on diversification of green jobs, the business case and planning; the investment in skills in the H economy and improving accessibility and diversity of the workforce.

Community revitalisation means investment and building local community wealth. Hydrogen could bring in opportunities for local supply chains and infrastructure but also opens the potential for community ownership of infrastructure. Addressing social concerns like endemic fuel poverty and housing are key elements of local transitions.

Who is at the table is also important to consider. Just like in the recent examples of the hydrogen trials in Redcar England, getting participation and inclusion right is essential for success and gaining social licence to operate. This aspect of a just transition also ensures multiple voices are included in consultation and communities are empowered to engage and steer developments – both in local governance and involvement in development.

Slide 21:

So, this concludes the first module of the hydrogen course.

The next module, Module 2, covers hydrogen production and demand.

Thank you for attention. Please bring your questions and comments or discussion points to the webinar that accompanies this course.

And I will look forward to seeing you then. Thank you.