Net Zero, Energy and Transport Committee Inquiry -
Scotland's electricity infrastructure: inhibitor or enabler of our energy ambitions?

Submission from PlusZero - April 2023

- PlusZero welcomes the Net Zero, Energy and Transport Committee inquiry into Scotland's electricity infrastructure and its relevance to Scotland's energy ambitions.

- PlusZero is a clean power start-up specialising in the production, distribution and operation of green hydrogen, made from renewable energy that has been produced on the Scottish Islands. PlusZero aims to be a major player in the clean energy sector, delivering market-disrupting solutions and making a significant contribution to the development of a thriving Scottish hydrogen technology sector.

- PlusZero currently produces green hydrogen in the Western Isles, which we believe is the most rapidly scalable green hydrogen production location in the UK, with the potential to reach GW scale by 2030 with the right investment and partnerships. Utilising a circular economy model, PlusZero's electrolyser, based in Stornoway, uses surplus electricity produced by onshore renewable power in the Western Isles to produce green hydrogen via the electrolysis process, which splits water into hydrogen and oxygen. We are now raising investment to allow us to rapidly scale our commercial green hydrogen production business, PlusZero Energy, with intentions to build the first 50MW of electrolyser capacity at our planned large scale green hydrogen production facility in the Western Isles.

- The green hydrogen that PlusZero produces on the Western Isles is used as a fuel for the clean portable power arm of our business, PlusZero Power. PlusZero Power's green hydrogen generators are a carbon and pollution-free alternative to diesel generators. During 2021, PlusZero established itself as one of the UK's leading full-service hydrogen innovators, delivering a series of pre-commercial high-profile trials of our carbon-zero green hydrogen based portable power solution at the Edinburgh International Festival and COP26 in Glasgow and Edinburgh Castle.

- As a company specialising in green hydrogen, this response addresses the targeted questions relevant to Scotland's hydrogen economy. PlusZero would be pleased to provide further detail and insight to the Committee as it continues its work on this topic.

Question 3. What role will dispatchable* (defined as energy generation that can be available on demand) electricity sources - pumped hydro, battery technologies, thermal generation (hydrogen power, gas with CCS) - play in

ensuring security of supply and system resilience? Should any other technology play a role in supporting Scotland's electricity system?

PlusZero's specialism is the production, distribution and operation of green hydrogen, so our response to this question focuses on the significant role which green hydrogen can play as a dispatchable source of power in supporting Scotland's energy system.

Scotland has vast onshore and offshore renewable energy generating potential from wind, but also significant wave and tidal potential when the technology is fully matured.

The challenge with an increasingly large-scale wind energy sector in Scotland is the potential mismatch between when the wind is blowing and when the demand for electricity is there. This creates periods where this renewable energy generating potential is curtailed due to insufficient demand and/or grid transmission issues. For a national energy system that is underpinned by large scale renewable energy production, such as in Scotland, an essential component of that system must be storage – whereby energy can be released via appropriate dispatchable electricity generating technologies when demand or economic value for energy is higher.

Green hydrogen production creates an opportunity to utilise this curtailed power to create a value-adding product, both from an economic and carbon reduction perspective. This creates revenue from electricity sales for renewable developers and improved investment returns that would otherwise have assumed a certain proportion of output curtailment.

Green hydrogen production therefore creates the opportunity to capture the energy generated from surplus wind energy that would otherwise be lost, and store it in the form of chemical energy in hydrogen (or derivatives such as green ammonia etc), which can then perform useful work in the form of fuel energy for transport, heating, power etc displacing fossil fuels such as diesel in the process, and contributing significantly to achieving Scotland and the UK's net zero targets.

Other appropriate dispatchable technologies can also play a role in renewable energy capture such as large-scale chemical batteries, or pumped hydro. PlusZero's view is that Scotland should look to adopt as much dispatchable electricity systems that seek to capture and store surplus renewable electricity as installed generation capacity increases, and become less reliant on fossil fuel based dispatchable systems such as natural gas plants.

We recognise however that each carbon-free dispatchable solution has its challenges. Based on current technologies, the use of green hydrogen as a fuel for electrical grid power generation (as an alternative to natural gas for instance) results in large energy conversion losses, meaning that much less energy will be returned to the grid than what might otherwise be stored in battery technology. However, the cost of current battery technology is such that it is much more expensive to store large amounts of energy in battery form, compared to producing and storing in hydrogen form. There are also significant concerns with some battery technology about the sustainability of the raw materials used and the recyclability of them at end of life. The upfront capital cost of constructing new pumped hydro schemes is substantial and can face challenges from the perspective of impact on existing landscapes.

PlusZero anticipates that the performance and nature of hydrogen and battery technologies will evolve over time to address these issues, meaning that their suitability as dispatchable electricity systems will improve in the medium to long term as Scotland's renewable energy production sector expands.

It should also be noted that green hydrogen production itself can benefit from access to dispatchable electricity sources. As the industry scales and electrolyser capacity increases in line with renewable generating potential, the ability to draw power from the grid to maintain production at optimum levels when the wind is not blowing could become important for the economic operation of these plants.

PlusZero believes that there is a strong argument for government to play a role in supporting the type of strategic, whole system-based cost benefit, economic analysis and strategic optimisation that will be required to ensure Scotland's energy system develops in a way that will accelerate the decarbonisation of our energy system as quickly and cost effectively as possible. Dispatchable storage systems will play a key role in achieving such an outcome.

Question 4. What are the key barriers to deploying these technologies and how should they be addressed?

PlusZero believes that the critical bottleneck that will slow down the development of a vibrant hydrogen sector in Scotland and the UK is lack of green hydrogen production capacity.

PlusZero already has significantly more demand for our own green hydrogen fuelled clean portable power solution than we can support from current production capacity. This demand is across a wide range of industries such as construction, outdoor events and film and TV production.

PlusZero believes very strongly that demand will follow supply, which is why PlusZero is in the process of raising £100m to build the first 50MW of electrolyser capacity at our planned Western Isles-based green hydrogen production facility.

Government-led mechanisms can encourage business investment in green hydrogen production capacity and would help to accelerate the whole hydrogen technology supply chain.

PlusZero considers that there are several areas where UK and Scottish Government investment, paired with academic research, could support Scotland's journey to green hydrogen leadership.

- **Key component design, manufacture and assembly**

Scotland has skilled hydrogen engineering companies such as Logan Energy[1] that can design and integrate electrolyser stacks from Original Equipment Manufacturers into complete electrolyser units. However, there is currently no capacity within Scotland to produce the core electrolyser stack components needed to produce green hydrogen. Similarly, there are no Scotland-based companies that produce the

[1] https://www.loganenergy.com/

high-pressure composite storage vessels that are currently essential to store and transport compressed green hydrogen gas from production site to end user (whether by road, train or ship).

Given the billions of investment that will be made in the coming decades to realise Scotland's green hydrogen production potential, PlusZero suggests that it makes strategic economic sense for government, research and enterprise agencies to:

- Incentivise existing non-Scottish electrolyser and pressure vessel manufacturers to establish Scotland-based manufacturing sites that could meet the Scottish demand;
- Support the development and expansion of existing Scottish hydrogen engineering and systems integration companies so they can capture as much of the supply chain activity related to the development of a large scale Scottish green hydrogen production sector; and
- Support the development of Scottish companies that can design and manufacture core electrolyser stack technology and other essential components such as composite pressure vessels, allowing as much as possible of the supply chain value add to be captured.

- **R&D to improve electrolyser design and efficiency**

Current electrolyser technology is inefficient, losing around 50% of the total electrical energy input as heat. While co-locating electrolysers next to demand sources for heat can improve this efficiency by using electrolyser heat to displace the use of fossil fuels for heating and or industrial processes, this will not be practical for many green hydrogen production sites.

The cost of electricity is a critical determining factor in the commercial viability of green hydrogen production. Therefore, improving electrolyser efficiency and hydrogen output per MW of electricity will significantly improve commercial viability, encouraging more investment in production capacity, and bringing down the cost of green hydrogen for users – in turn, stimulating further demand.

Governments should support academia and research institutes to work closely with the hydrogen industry to both improve the design of existing electrolyser technology and to bring forward new, more efficient technology (such as solid oxide electrolysers) that improve design and efficiency.

- **R&D to reduce hydrogen gas transport costs and identify alternative approaches for transporting hydrogen**

While hydrogen gas contains more energy by weight than the fossil fuels we currently rely on, it is also the lightest element in the periodic table and requires to be compressed to very high pressures (200 to 900bar) to achieve an energy density suitable for storage and transport as a fuel. This takes significant energy for compression (or liquification) which further reduces the overall efficiency of any hydrogen-based system. The high-pressure storage vessels are also expensive to manufacture and very heavy, which in turn increase the cost and energy required to transport hydrogen to customers.

PlusZero considers that further R&D is required to identify improvements in the efficiency and costs associated with hydrogen compression. More sophisticated

solutions to compressed/liquified storage/transport systems would be of significant benefit to the sector.

There are also other mechanisms for storing hydrogen in a non-gaseous form, such as absorption within metal hydrides or liquid carriers, or chemical conversion into other, more easily transportable, substances such as ammonia. These and other approaches offer the potential for more efficient, energy dense and cost-effective transport of hydrogen compared to compressed or liquid hydrogen, but need R&D to become commercially viable at scale.

- **Investment support mechanisms**

PlusZero would also encourage the Scottish and UK governments to activate further market mechanisms to incentivise investment in green hydrogen production and application technology in the UK.

Some government-led mechanisms have been helpful to innovation in the green hydrogen sector – namely, the Scottish Government's £100m capital allocation to support the hydrogen sector, and the UK Government's Road Transport Fuel Obligation Scheme (RTFO) and BEIS Hydrogen Business Support Model. However, these schemes have either not been specifically targeted at growth in the hydrogen economy or they have been limited by design – and they do not come close to the vast support programmes being mobilised in the EU such as the Clean Hydrogen Partnership and H2 Global initiatives and the US Inflation Reduction Act.

As a result, there is a danger that hydrogen-related innovation and development will accelerate faster outside of the UK, allowing overseas companies to scale and develop technology and therefore outcompete Scottish and UK companies in our own markets. This is what happened with the development of wind turbine technology and the same is starting to happen in relation to clean hydrogen technologies.

The rapidly developing market for 'Carbon Credits' has the potential to play a significant role in supporting investment in green hydrogen production if the price were to continue to rise and become more stable and predictable. Initiatives from governments and their agencies to support this objective would be valuable.

Conversely, Carbon Taxes could also play a role. Given the current stage of development and scale of production, distribution technology and infrastructure, green hydrogen is significantly more expensive on an energy equivalent basis than fossil fuels. While PlusZero's own experience indicates that there are many early adopter customers willing to pay the additional costs to enable them to decarbonise their activities, the extra cost compared to fossil fuels will act as a barrier for many.

The use of incremental carbon taxes on fossil fuels is a potential mechanism that will encourage companies to continually review their use of fossil fuels and consider alternative clean fuels such as green hydrogen as they become more widely available.

- **Skills development**

Scotland's supply chain already has many of the general industrial and chemical engineering, design and operational skills needed to support the development of a

hydrogen economy, but the experience of the workforce in hydrogen directly is limited.

If Scotland is to capture as much of the economic value chain associated with the development of a hydrogen economy, then it is essential that Scotland's educational establishments work with industry to deliver the specific hydrogen technology-related courses and skills development necessary to create a workforce that can support the growth of our existing companies in the sector and attract new companies to invest in Scotland.

The focus on creating a low carbon transport development hub at the Michelin Scotland Innovation Parc in Dundee is an example of the kind of industry, government and educational partnership that will play an important role in identifying and addressing the hydrogen skills shortage. PlusZero considers that there is significant space to support similar cross-sector 'centre of excellence'-type initiatives.

The University of the Highlands (UHI) Outer Hebrides in Stornoway has also been very proactive in linking with industry and developing the first three SQA-certified hydrogen technician courses. This type of local hydrogen specific technical training will be critical for PlusZero's own workforce expansion plans in the Outer Hebrides. To further support this, PlusZero in partnership with UHI and the Western Isles Council submitted a proposal to the Scottish Government's Emerging Energy Technologies Fund to develop a training facility at an expanded hydrogen production facility at the Council's Creed waste processing centre.

Scotland already has a very strong Modern Apprenticeship structure in place and this should allow for the rapid development of a technically skilled workforce if the right course content can be developed in partnership with industry over the coming years.

Question 7. Given the generation potential [of the offshore and onshore wind strategy], and market ambition, is there a risk of oversupply if options for use of surplus electricity (e.g. green hydrogen production) do not become reality?

PlusZero is ambitious about Scotland's green hydrogen future, and is already demonstrating that green hydrogen presents an offtake solution where onshore and offshore wind-generated power would otherwise be curtailed.

Scotland has some of the most significant onshore and offshore renewable energy generating potential in Europe for wind, wave and tidal, which - if governments are prepared to work closely with industry to address the challenges set out in this response - can be harnessed to develop a green hydrogen production sector in Scotland that is of global significance.

As highlighted in our response to Q3, we believe that there is a strong argument for government to pay a role in supporting the type of strategic, whole system-based cost benefit, economic analysis and strategic optimisation, matched by appropriately designed incentive schemes, that will be required to ensure Scotland's energy system and sectors develops in a way that will accelerate the decarbonisation of our energy system as quickly and cost effectively as possible. A range of renewable energy based dispatchable storage systems (green hydrogen, battery and pumped hydro) will play a key role in achieving such an outcome and maintain the balance between supply and demand that will be needed.

Question 8. How much of the Scottish Government ambitions for 5 GW of hydrogen production capacity by 2030, and 25 GW by 2045 should come from green hydrogen?

PlusZero believes it is not unrealistic to suggest that with a clear focus and partnership between the hydrogen sector and the UK and Scottish Governments, that the Scottish Government's hydrogen targets, and indeed the UK target to reach 10GW of 'low carbon' hydrogen production capacity by 2030, could be met by Scottish green hydrogen alone.

This could allow for an increase in the overall UK target once other Scottish blue hydrogen, and UK green and blue hydrogen initiatives were added into the mix.

However, the critical bottle-neck that will slow down the development of a vibrant hydrogen sector in Scotland and the UK is lack of green hydrogen production capacity, as outlined in detail in response to question 4.

Question 9. What are the key infrastructure barriers to building a hydrogen economy in Scotland and how should they be addressed?

As above, PlusZero considers that there is a critical need for investment in green hydrogen production capacity. Ideally, establishing production capacity close to demand sites for heavy transport (transport hubs and high-volume routes) should be incentivised as far as possible, as it will significantly reduce the transport costs associated with moving hydrogen from production to demand locations, and improve the overall energy efficiency of the system.

However, given the location of much of Scotland's renewable energy assets, much of Scotland's production assets will be some distance from heavy transport demand locations. Investment in infrastructure is therefore needed in order to move hydrogen around the country. The following are considered to be the initial key requirements:

- **Marine-based transport infrastructure**

Given the role that the Outer Hebrides, Orkney and Shetland (and other Scottish Islands and Coastal areas) play in generating renewable energy, transportation of large volumes of green hydrogen (initially compressed, but potentially liquified or converted to other chemical carrier methods such as green-ammonia or hydride compounds as volumes increase) will be required.

This will require investment in port infrastructure to support the safe handling of green hydrogen. Custom-built bulk carriers or adapted ships will also be required to carry containerised hydrogen storage or transport systems.

- **Transport by rail network**

Given the weight of the pressure vessels that transport compressed hydrogen in bulk, the rail network could be a cost effective and low-carbon route for moving large volumes of hydrogen from remote production sites to areas of high demand both in Scotland and the rest of the UK. Such a solution would require investment in rail depot infrastructure that supports local storage, loading and unloading of

containerised hydrogen storage units into rail transport, and/or gas transfer on and off specialist hydrogen gas transport rail trucks.

- **Pipelines**

Pipelines could also offer a cost-effective mechanism for moving large volumes of hydrogen from production to demand sites. Pipelines would operate at much lower pressures than is required for other transport mechanisms for hydrogen gas, and therefore reduce the energy needed for compression compared to other current transport means. For heavy vehicle use, the hydrogen would ultimately need to be compressed to 350 bar at the local level, but the overall system efficiency is likely to be better compared to transporting large volumes of high compression hydrogen by road or rail.

The UK Government is already supporting work by the Gas Distribution companies to determine the feasibility of switching the existing UK gas grid from natural gas to hydrogen, which would allow a very significant existing infrastructure asset to potentially be used to support the roll-out of a hydrogen economy. However, the existing grid was developed to move natural gas from the North Sea to UK cities and therefore is not ideally located for many of the likely new green hydrogen production sites. In some circumstances, new investment in local pipelines may be cost effective to transport green hydrogen from large scale rural production sites to centres of demand.

David Amos
Managing Director, PlusZero
April 2023
www.pluszero.co.uk