Bus Decarbonisation Taskforce

Energy Infrastructure Meeting

29 April 2021

Meeting Papers

Agenda

Item	
1. Welcome and progress on actions	(20 minutes)
2. Electricity Networks (Paper 3.1)	(35 minutes)
3. Energy Supply (Paper 3.2)	(20 minutes)
4. Hydrogen (Paper 3.3)	(35 minutes)
5. Summary of agreement reached and next steps	(10 minutes)

For ease of reference, the Taskforce's agreed vision is:

Bus operators are exclusively running zero-emission battery-electric and hydrogen fuel-cell buses; the bus sector provides an excellent service meeting passengers' day-to-day needs; people enjoy travelling on buses and knowing that doing so is one of the most climate-friendly choices they can make; there are vibrant ownership and leasing markets for buses which benefits operators, manufacturers and the finance sector; the smart technology on buses enables them to be operated in the most energy efficient way; there is an even stronger and diverse domestic manufacturing sector and supply-chain comprised of high-quality skilled jobs with continued innovation reducing manufacturing and supply chain emissions; energy networks, bus operators and Local Government are used to working together to ensure depots are powered/fuelled and all potential users are able to benefit from the energy provision centred at depots and on-route charging infrastructure; buses and infrastructure are fully recycled at the end of asset life contributing to the circular economy, reducing waste and supporting further decarbonisation efforts; after an important period of support, the Government has ceased subsidising battery-electric and hydrogen fuel-cell buses, but continue to support innovation in new zero-emission fuels and technologies of the future; Scotland is recognised the world over as a leader in the design, manufacture and operation of high quality zero-emission buses and other large road vehicles, and associated green finance solutions.

Paper 3.1 Electricity Networks: Regulation, capacity and connections

This paper sets out how electricity networks are regulated and the rules that they are bound (through licence conditions) to adhere to.

The taskforce are invited to consider:

a) how all parties (electricity networks, bus operators, local and regional transport authorities and others) can improve communication and collaboration in relation to infrastructure planning over the coming months and years.

b) how best to engage with the forthcoming RIIO-ED2 process to maximise anticipatory investment opportunities to prepare the network for bus decarbonisation.

c) how best to maximise the use of technological solutions to reduce network reinforcement costs.

Introduction

The role that electricity networks play is crucial to meeting Government's decarbonisation objectives. Scotland's net zero pathway, as laid out in Government's Climate Change Plan Update (2020), includes a fully zero carbon electricity system in Scotland by the end of this decade.

Electricity networks will play an essential role in this transition and investment decisions made by these companies over the next 5 years (as part of ED2) will be critical for the Scottish 2030 interim targets.

In order to support the industry to account for devolved policy, Government has worked closely with Ofgem and network companies to agree a number of principles that should be adopted through the price control process and reflected in regulatory decision making.

Government's vision is that 'electricity and gas networks should support an efficient and effective process of decarbonisation across the whole energy system and should support broad societal and economic ambitions'.[1]

Background

Electricity and gas networks operate, with some notable exceptions relating to connections, as natural monopolies within specific regions. This is due to the nature of electricity and gas network infrastructure which is costly. The overall GB energy network is split into three areas:

- Transmission: this transports electricity and gas at high voltage/pressure from generation/import points to large industrial users and to distribution network offtakes. In Scotland the transmission network is owned, maintained and improved by two transmission owners: Scottish and Southern Electricity Networks (SHE Transmission) in the north of Scotland and SP Energy Networks (SP Transmission plc) in the central belt and south of Scotland.
- Distribution: electricity and gas is transported at lower voltage/pressure to homes, businesses and industrial users. Increasingly distribution networks are also a point of entry for smaller scale electricity generation (e.g. small scale solar can put power back onto the grid at a distribution level). In similarity to transmission, the distribution network in Scotland is owned, maintained and improved by two distribution owners: Scottish and Southern Electricity Networks (SSEN) in the north of Scotland and SP Energy Networks (SPEN) in the central belt and south of Scotland.

[1] A Vision for Scotland's Electricity and Gas Networks: Summary 2019-2030 (www.gov.scot)

- System Operator: the system operator does not own any electricity or gas infrastructure but is responsible for ensuring that the system is in balance (supply is capable of meeting demand). The SO does this by entering into contracts with generators to make sure the system operates within agreed limits.

As regional monopolies, electricity and gas network companies are regulated by the independent energy regulator, the Office for Gas and Electricity Markets (OfGEM) to ensure that consumers both current and future (gas and electricity bill payers) are charged fairly for the costs of transporting gas and electricity and provided with a safe and secure network. These costs make up almost 24% of the average dual fuel (gas and electricity) bill with the RIIO 1 regulatory framework (in operation from 2013-2021 and for electricity distribution from 2015-2023) estimated to be valued in the region of £100 billion.[2]

Network Regulation (RIIO)

To ensure the protection of current and future consumers (a statutory duty under the Utility Act 2000) and the delivery of a safe and efficient network OfGEM regulates the gas and electricity network companies using the RIIO (Revenue = Incentives + Innovation + Outputs) framework.

The frameworks are split into 4 different parts (although there is similarity overall):

- RIIO T = for electricity and gas transmission
- RIIO GD = for gas distribution
- RIIO SO = for the electricity system operator
- RIIO ED = for electricity distribution

[2] Understand your gas and electricity bills | Ofgem; July_open_letter_working_version (ofgem.gov.uk) - £96 billion of revenues to network companies

The framework is used to protect current and future consumers by limiting the amount network companies can charge and setting clear key performance indicators (outputs) for companies to meet. The framework also rewards network companies for operating in the most efficient manner (incentives) and provides opportunities to test solutions that could improve operations/meet Government policy objectives (innovation).

To plan for new regulatory periods network companies set out business plans detailing expected expenditure. This is reviewed by OfGEM and used to set the revenues that company can recoup from bill payers in a set period of time. Broadly speaking the more certainty a network company is able to provide on its future plans (for example in relation to readying the network for decarbonisation) the better.

While network companies are expected to ensure their business plans include a reasonable degree of planning it is recognised that it is not possible to accurately predict all eventualities (e.g. if Government policy changed mid-way through a regulatory period). In this event 'uncertainty mechanisms' can be used by the network companies in the event of unexpected expenditure (although depending on cost some uncertainty mechanisms require OfGEM approval).

It is worth noting that OfGEM only regulates network companies in Great Britain. Northern Ireland has a separate regulatory system and the legislation governing Northern Ireland's energy systems is devolved (where as electricity and gas legislation is, in Great Britain, reserved to the UK Government).

RIIO ED2

As set out above Distribution Network Operators (DNOs) are currently in the process of preparing business plans for the next regulatory period RIIO-ED2 which is expected to commence 1 April 2023.[3]

The RIIO ED2 process covers the development of the majority of the electricity distribution network. For example it provides allowances for DNOs to invest in their networks to meet general demand growth across an area and to maintain and update their network.

However, it does not cover the specific costs associated with connecting new customers to the network or upgrading an existing connection. These costs are passed onto the connecting customer via 'connection charges'. This is covered in more detail in the next section.

Future planning is key to an efficient allocation of decarbonisation cost. It is vitally important, therefore, that stakeholders continue to engage with the RIIO ED2 consultation process as this will allow DNOs to better understand the needs, views and ambitions of the network users and plan appropriately.

The DNOs are currently seeking views from stakeholders as part of the RIIO-ED2 planning process. There are a number of different ways stakeholders can engage, with consultation events and survey's listed on the links below

Details on how to engage are available www.spenergynetworks.co.uk/pages/our_riio_ed2_business_plan.aspx and www.ssenfuture.co.uk/

[3] The RIIO 2 settlements for transmission, gas distribution and system operation have already been completed with the new framework launched on 1 April and running until 2026.

Figure 1: outline of RIIO-ED2 planning timeline.[4]

Independent Distribution Network Operators (IDNOs)

While the majority of the functions required from the electricity networks are carried out by the monopoly network companies there are some areas where competition has been introduced. This tends to be in the last-mile public network connecting a domestic or commercial development to the regional DNO network. The owners and operators of these commercially provided networks are known as IDNOs. As part of this IDNO's often own the customers' connection – the cable that connects a customer's electricity meter to the public network.

The value of the connections market is in excess of £500 million a year and IDNOs can compete with the monopoly network companies to complete some connections activity.[5] This provides those seeking connection with an alternative to using a DNO proposed solution and can, in some cases, be more cost effective.

OfGEM holds a list of the registered IDNOs who provide connection services.[6]

[4] Home | SSEN (ssenfuture.co.uk)
[5] Competition in connections | Ofgem
[6] Independent Distribution Network Operators | Ofgem

Meeting local electricity demand

Nationally, there will be sufficient zero-carbon electricity supply to meet the demand of a zero-carbon bus fleet (battery-electric and/or hydrogen fuel-cell), but at a local level the network capacity required to deliver that electricity to end users can vary significantly. Network companies are expected to make use of existing network capacity before taking forward network reinforcement work which, in the event new demand does not materialise, will have a detrimental impact on consumer bills.

There are a number of factors that will affect the size of connection a customer needs and early engagement with DNOs can mean early identification of the most cost effective solution.

Whether or not a customer's power needs can be meet within existing network capacity plays a big role in the cost of any connection offer (and the time it will take to be delivered). This is because the user of that connection is expected to pay a proportion of connection costs in order to protect energy bill payers.

Factors affecting network capacity requirements

As OfGEM rules dictate that networks must utilise existing network capacity first there can be quite a large divergences in available capacity at local levels. For example if a factory closed in one area this would free up capacity on that part of the network, however a new factory would reduce available network capacity in the local area around the new site.

Therefore, while at a national level there is confidence that supply can meet demand, local network constraints can make it harder to get power to where demand is and network reinforcement may be required. As the above example demonstrates network constraints are not always in the same place and available capacity at a local level can be changeable depending on the changing needs of that area.

Importantly, an agreement to provide power (including how much) can only be guaranteed once contracted (i.e. by entering into a Connection Agreement with the DNO). There is no ability to informally ‘reserve’ capacity and the DNOs are not permitted to guarantee a certain amount of power to a customer without a formal connection agreement in place.

In addition to the above there are several additional factors that impact on the cost of obtaining a connection:

- Depot locations
- No of buses operating at each depot
- Existing authorised capacities and current usage
- Location of charging infrastructure (at depot, en-route or destination)
- Charging profiles (peak, off peak or timed)
- Local network constraints (both at a local lower voltage level and a higher voltage level)

This means that charging capacity requirements (and the associated costs) are likely to be unique to each site/depot and assessments will need to be made by the network company on a site by site basis.

In order to fully understand additional capacity requirements (and therefore propose the most cost effective solution) DNOs will require information on how any battery electric vehicles will be charged (i.e. peak/off peak, how many vehicles charging at the same time etc).

Principles of Network Connection Costs

Network companies are expected to adopt a ‘cost reflectivity’ principle to requests for new electricity network connections. Broadly speaking it is expected that the organisation/company benefitting from the connection should bear some, if not all, of the costs of that connection. It is important to note that the costs passed on by the DNO to connecting customers are governed by the methods which are agreed with Ofgem and should be applied in the same way across all parts of Great Britain. Therefore DNOs have very little flexibility in allocating costs associated with a particular connection request.

There are 3 parts to a connection:

- **Customer's own direct connection:** the customer assets, including cables, transformers and switch gear, between the electricity meter and the public network. **In general the connecting customers will pay 100% of this cost.**
- **Network Reinforcement in the local area (if required):** in some cases reinforcement/upgrade work to the local distribution network might be required to meet the connection request. **The costs of this shared between the connecting customer and other users of the network. However, if you are the sole user of this connection there is the potential that you will be responsible for the full cost.**
- **Upgrade of wider distribution and transmission networks:** Should upgrades of the wider distribution and/or transmission networks be required (unlikely for a single connection unless very large but several connections in a small area could trigger this) then **these costs are socialised in their entirety across all users of the distribution/transmission network in that part of the country.**

Importantly, there is no hard and fast rule on which connection requests will require network reinforcement. It all depends on the available (i.e. uncontracted) capacity of the local network and can vary considerably between relatively short distances. Where costs are socialised, they are covered by the DNOs price control agreements. Where the costs are paid by connecting customers they are subject to strict rules as set out in the industry charging methodologies

How can network reinforcement costs be minimised?

A standard electricity network connection would involve contracting with the DNO for the maximum demand you expect to use and for that capacity to be available at all times. Therefore, for a bus depot, this would involve connecting with the full capacity of all bus chargers along with the other electricity demand on the depot. Because this requires the DNO to ensure sufficient capacity is available at all time, including peak, it has the potential to involve significant expenses which, under the connection regulations, the DNOs may be required to pass onto the connectee. An alternative is to consider a **flexible** connection which considers both the installed capacity and how that capacity might be used.

There are a number of flexible solutions that those seeking a connection can consider to minimise network reinforcement costs. For example, the installation of on-site energy storage and demand management systems can help to reduce the network capacity required. However, the economics and space requirements for this type of installation would need to be carefully assessed by operators on a site-by-site basis.

Timed connections offer another option and allow operators an authorised capacity for their depot which meets their daytime needs, but which can be increased outwith peak times to accommodate the increased vehicle charging demands.

This type of connection was adopted for the Waterloo bus depot in London allowing the customer to draw their maximum power requirement of 2.5MW in the off-peak hours and a reduced capacity of 0.5MW during the day for charging a smaller number of standby buses.

In short, DNOs can work with operators to consider how to achieve a reduction in overall demand which could mitigate, or even avoid, the need for network reinforcement. Early engagement, however, with DNOs combined with a full analysis of a depots/sites needs is key.

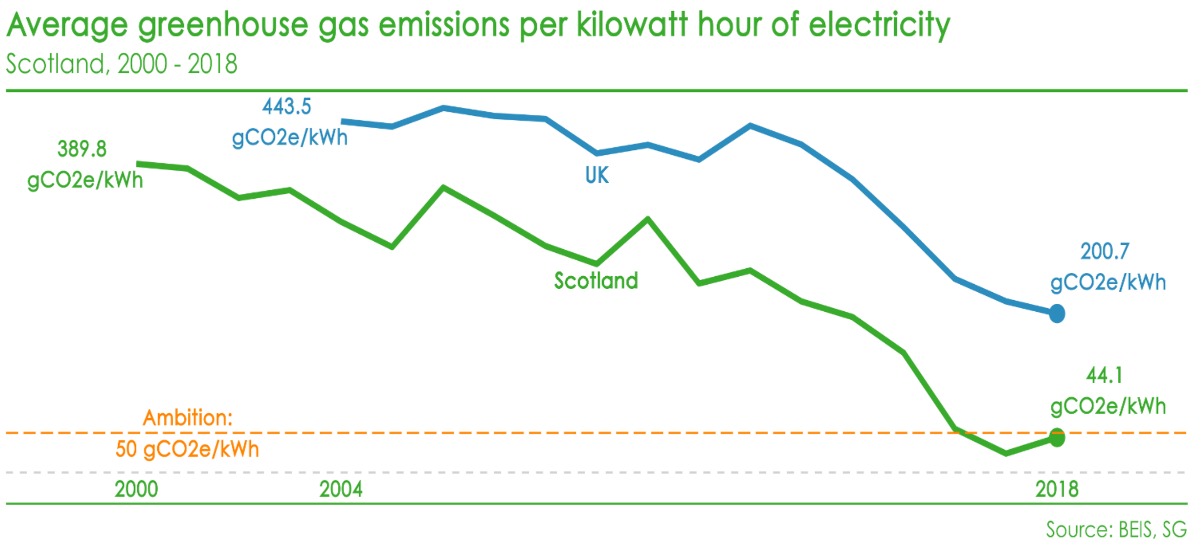
Paper 3.2 Energy Supply

This paper sets out the progress to date and strategy for continued decarbonisation of Scotland's energy supply, the ability of supply to meet demand, and projected costs of refuelling buses with electricity, hydrogen and diesel.

The taskforce is invited to consider whether the provision of future zero-emission energy supply is likely to pose any hurdles for achieving the Taskforce's vision, and if so how those hurdles can be overcome.

Introduction

Scotland has made world leading progress in decarbonising its energy supply with greenhouse gas emissions from this sector reducing by 70% from 1990 to 2018. This is due to the closure of carbon intensive coal fired power stations and the increased use of renewable power.

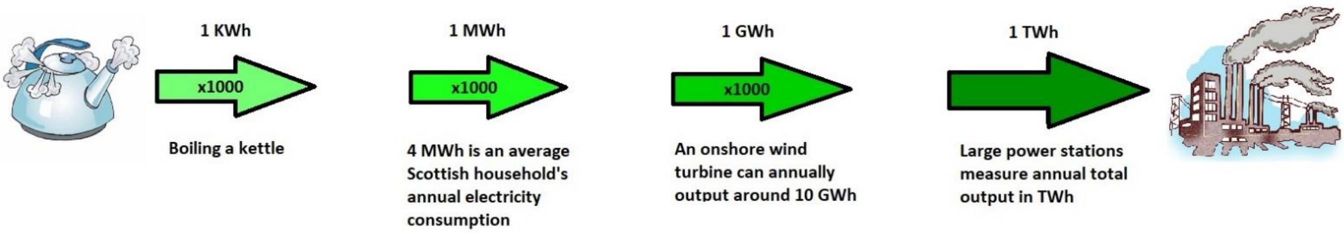


The Updated Climate Change Plan (2020) set out over 100 new policies and proposals to achieve 75% reduction in greenhouse gas emissions across Scotland's economy by 2030, a 90% reduction in greenhouse gas emissions by 2040 and Net Zero by 2045.

Scotland's climate change targets mean that Scotland needs to continue its progress, and move from a low to a zero carbon electricity system. There is also a need to address the substantial challenges of maintaining security of supply and a resilient electricity system. Operating a zero carbon electricity system will mean finding new ways to provide a range of technical services and qualities currently provided by fossil fuel and nuclear generation.

Electricity

Figure 2: a brief explanation of power terminology



In 2020 Scotland's renewable generation capability was able to meet the equivalent of 97% of Scotland's gross electricity consumption.[7] There is currently around 12 GigaWatts (GW) of renewable generation capacity installed across Scotland[8] and offshore wind capacity could grow by between 8-11 GW by 2030.[9]

Scotland is a net electricity exporter with electricity transmission cables linking Scotland with England, Wales and Northern Ireland. These cables allow electricity to flow bi-directionally but in the main they operate to

[7] Scotland+Energy+Statistics+Q4+2020.pdf (www.gov.scot)
[8] update-climate-change-plan-2018-2032-securing-green-recovery-path-net-zero (8).pdf
[9] Securing a green recovery on a path to net zero: climate change plan 2018–2032 - update - gov.scot (www.gov.scot)

export power from Scotland. In 2020 Scotland's net electricity exports amounted to 19.3 terawatt hours (TWh).

Hydrogen

There are three main methods of hydrogen production:

- **Grey Hydrogen:** is produced from the reforming of natural gas (steam methane reforming). This produces both hydrogen and carbon emissions.
- **Blue Hydrogen:** made the same as grey hydrogen but aligned with Carbon Capture and Storage to capture most of the emissions and store them (in depleted oil fields for example).
- **Green Hydrogen:** produced from electrolysis of water (splitting water into its parts – hydrogen and oxygen). When renewable electricity is used to do this the process is zero emission.[10]

Producing hydrogen, particularly green hydrogen, and using it to meet energy demand, will play an important part of the next stage of the energy transition.

With an estimated 25% of Europe’s offshore wind capacity (in addition to resources for Grey and Blue hydrogen) Scotland has many of the key natural resources to grow a strong hydrogen economy and is committed to positioning itself as a global leader in hydrogen technology.[11]

In order to facilitate large scale production of hydrogen the Scottish Government is engaging with the UK Government to ensure policies and market mechanisms are developed to support the needs of the emerging sector. Many of the regulatory and legislative levers required are determined at a UK level. We will also work with industry, the investment

[10] Scottish Government Hydrogen Policy Statement - gov.scot (www.gov.scot)
[11] Securing a green recovery on a path to net zero: climate change plan 2018–2032 - update - gov.scot (www.gov.scot)

community, Scottish National Investment Bank (SNIB) and Scottish Futures Trust to explore business models that could support the growth of a hydrogen economy.[12]

The Scottish Government's hydrogen policy statement, published in December 2020, committed to:

- £100 million of funding towards the development of a hydrogen economy over the next five years.
- Supporting hydrogen production capacity to meet an ambition of at least 5GW of renewable/low carbon hydrogen by 2030 and at least 25GW by 2045.
- Seek international collaboration in the development of a hydrogen economy and explore hydrogen export capacity.
- Support the demonstration, development and deployment of hydrogen and its emergent role in the sustainable decarbonisation of critical industry functions and processes, transport and heat in buildings.
- Support the transition and growth of the supply chain, including in the development of skills and manufacturing capacity.[13]

Estimated Energy Usage of a Future Decarbonised Bus Fleet

Using the *Scottish Bus Electrification Commercial and Economic Content* report from September 2020 and figures on hydrogen obtained from taskforce members, the energy needs of a zero emission bus fleet can be estimated using the size of the current fleet, assumptions on fleet turnover and average mileage, charging times and projected electricity demand.

It is assumed that the initial size of a battery electric bus battery is 350 KWh for a single deck and 380 KWh for a double deck, and that in a

[12] Scottish Government Hydrogen Policy Statement - gov.scot (www.gov.scot)
[13] Scottish Government Hydrogen Policy Statement - gov.scot (www.gov.scot)

typical day of operation, 90% of this charge will be used.[14] This suggest annual energy use of 0.115 GWh for a single deck bus, and 0.125 GWh for a double deck bus.

If the overall fleet is 4,200 buses, 55% single deck and 45% double deck, then the total energy draw of an entirely battery electric fleet would be 0.5 TWh per annum. 0.5 TWh is 1.6% of Scotland's total renewable energy output in 2020.

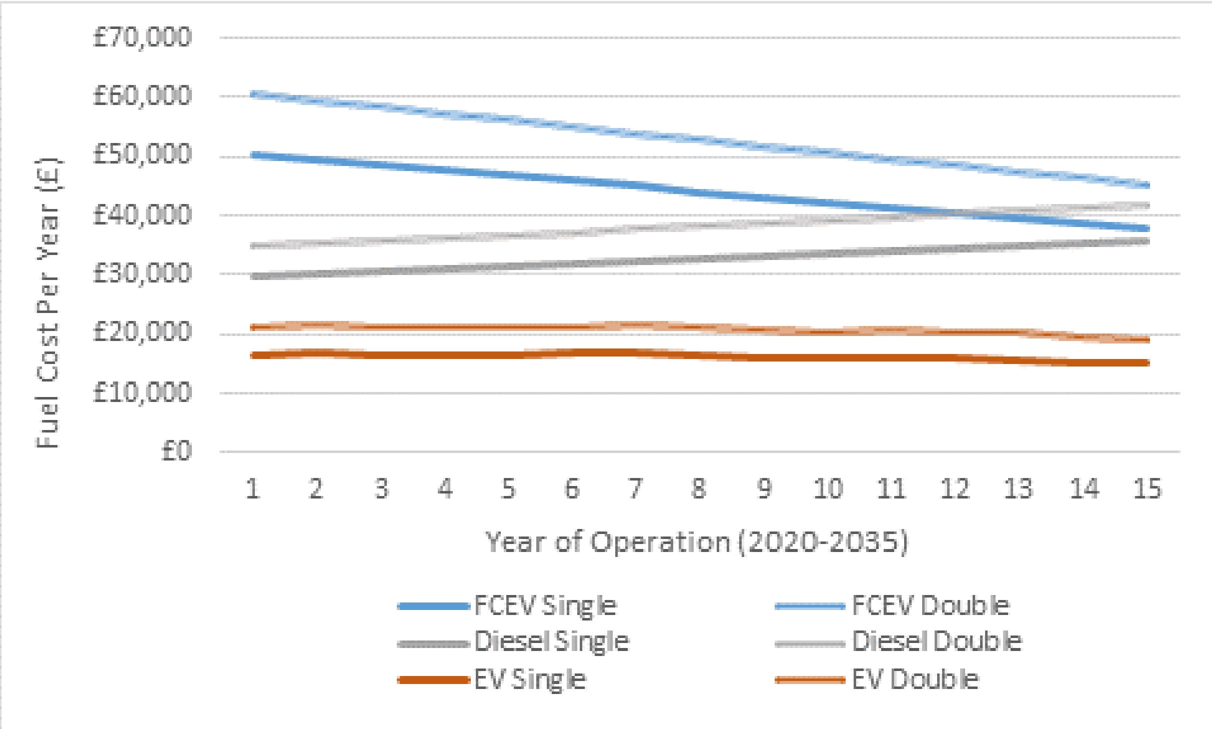
The total energy draw of an entirely hydrogen fuel-cell fleet would be 1.15 TWh. This estimate is based on a single deck bus using 11.5 kg of hydrogen a day (for 130 miles) and a double deck using 13.8 kg; 60 Kwh of energy is the standard amount of electrical energy needed to create one kilogram of hydrogen. This gives the daily electrical intensity of a single decker at 690 Kwh and a double decker at 828 Kwh. 1.15 TWh is 3.6% of Scotland's total renewable energy output in 2020.

Refuelling costs

The costs of diesel are projected to rise over the coming years, while the costs of electricity and hydrogen are expected to fall. UK Government forecasts suggest a fall in electricity prices of 12.2%, and an increase in diesel fuel costs of 18.6% by 2035.[15] Costs for hydrogen are more challenging to project and have a much wider range of uncertainty. The data shown in Figure 4 are estimated retail prices for hydrogen based on production costs and a multiplier, x 3, to account for the costs added between production and sale. Hydrogen produced on site will be less costly.

[14] EY report September 2020
[15] Annex M: Growth assumptions and prices (publishing.service.gov.uk) – Fuel and Electricity Prices

Figure 3: Estimated Yearly Fuel Cost Comparison by Bus Type



Paper 3.3 Hydrogen

The taskforce is invited to discuss:

- what opportunities are there for the bus sector to invest in and benefit from hydrogen supply and/or hydrogen refuelling infrastructure

- are the 3 actions from the hydrogen for road transport workshop, paraphrased on page 23, the right actions for supporting bus decarbonisation and if so, who is best placed to deliver them.

Introduction

Scotland has been an early adopter of hydrogen in transport and the technical viability of hydrogen has been demonstrated in a range of transport applications.

The recent creation of the Hydrogen Accelerator programme at the University of St Andrews, coupled with the Michelin Scotland Innovation Parc in Dundee, has created a unique prospectus for innovation in hydrogen technologies and the supporting skills and knowledge base. Cities and regions across Scotland, including Aberdeen, Glasgow and Dundee, are driving forward coordinated strategies to harness the opportunities for linking up transport demand, green energy generation and innovation in product developments in the application of fuel cells to a growing range of vehicles types and transport modes.

The Scottish Hydrogen Assessment indicates that the transport sector, alongside industry, will most likely form the initial areas of high demand for hydrogen in Scotland and could underpin a market of sufficient size to enable low-cost hydrogen production, with fuel cell markets developing or emerging in areas such as HGV’s, buses, trains and shipping.

Hydrogen transport

Rail

The Zero Emission Train project underway at Bo’ness is converting a withdrawn ScotRail Class 314 electric train to hydrogen fuel cell traction. Hydrogen powered traction options will be required where electrification of rail is not appropriate, such as across rural areas to the north west of Inverness and West Highland lines. Two of the main objectives of the Zero Emission Train project is to demonstrate the technology by operating the train on closed rail network by autumn 2021, and build up local supply chain capability for hydrogen rail technology.

Marine

The HyDIME (Hydrogen Diesel Injection in a Marine Environment) Project, funded by Innovate UK, is trialling the use of green hydrogen as a fuel for a commercial ferry operating between Shapinsay and Kirkwall in Orkney. The project design and physical integration of a hydrogen injection system on a commercial passenger and vehicle ferry will be the first of its kind worldwide.

A Norwegian consortium has begun work on a Hydrogen Fuel Cell/Battery hybrid ferry that can operate for 48hrs between bunkering, which presents opportunities for Northern Isles sailings from Aberdeen and longer west coast services.

Aviation

Orkney's European Marine Energy Centre has developed an end-to-end hydrogen refuelling solution for ZeroAvia’s hydrogen fuel cell powered electric test flight programme. Delivery of the refuelling solution is a key milestone in the Aerospace Technology Institute and Innovate UK funded “HyFlyer” project, aiming to decarbonise medium range small passenger aircraft by demonstrating hydrogen fuel cell powertrain technology.

Glasgow

Green Hydrogen for Glasgow is an “end-to-end” green hydrogen refuelling network led by a partnership including Scottish Power Renewables, BOC/Linde and ITM Power. The project aims to develop a 10MW electrolyser at Scottish Power’s Whitelee Wind Farm near Glasgow to service the city and surrounding region with green hydrogen fuel within two years. Glasgow City Council’s Fleet Decarbonisation Strategy emphasises hydrogen. In 2019 Glasgow announced plans to convert 23 gritters to hydrogen dual fuel as a first step towards the introduction of zero emission vehicles throughout its fleet by 2029. The city has secured funding for 19 fuel cell refuse collection vehicles.

Aberdeen

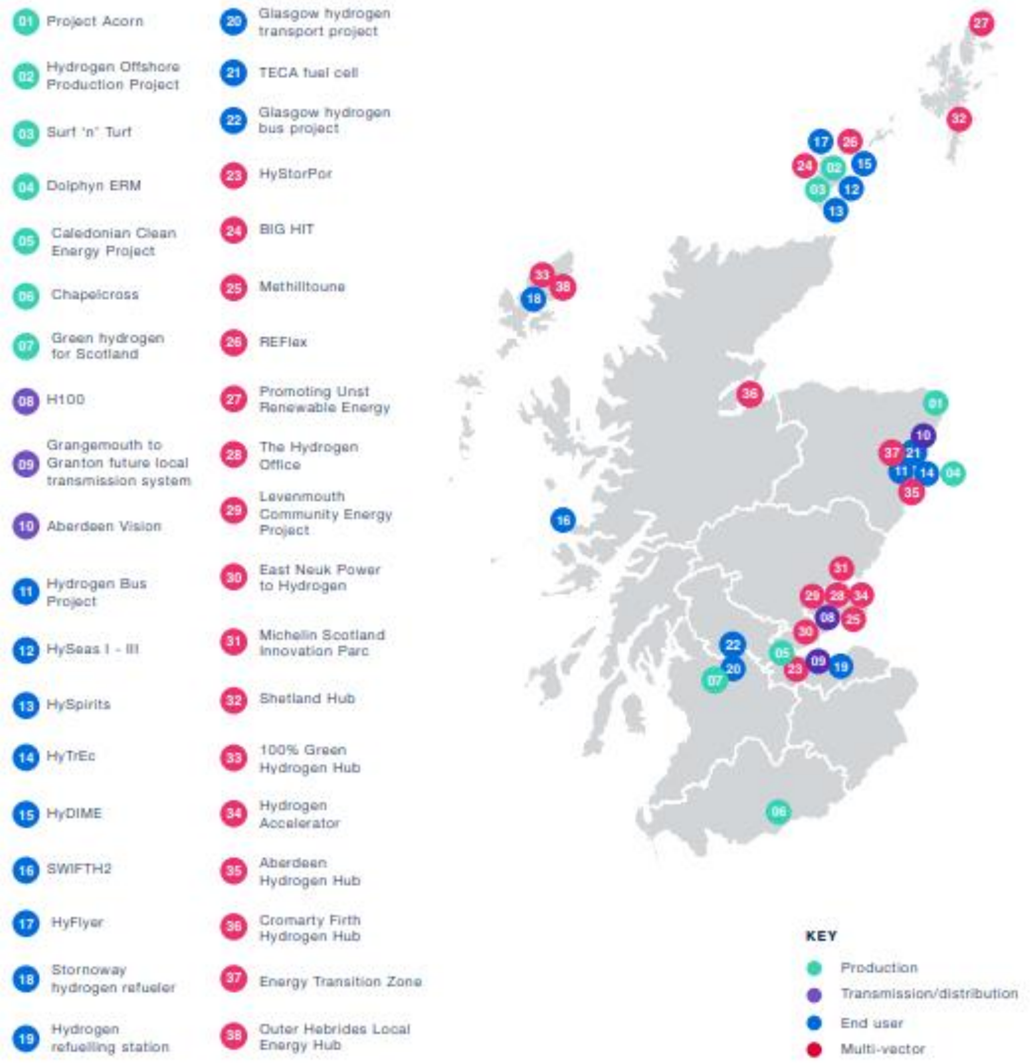
The Aberdeen Hydrogen Hub is a regional collaboration proposal, involving Aberdeen City Council, Scottish Enterprise and Opportunity North East, taking a whole-system approach to hydrogen production and demand to drive scale and economic growth. It aims to deliver a commercially scalable and investable, growth-focussed hydrogen production site making use of the region’s offshore wind resources. This will kick start growth of the hydrogen sector in the region, initially for transport, with further opportunities for growth in heat, industry and beyond in the future. If successful, this is a model which could be suitable for replication in various regions of Scotland. The Hub is one of the projects being supported the Scottish Government’s £62m Energy Transition Fund (ETF). The project has so far been awarded £4.5m from the ETF enabling the procurement **of an additional ten hydrogen double decker buses to add to the existing hydrogen bus fleet in Aberdeen.** This brings the total fleet to 25 buses, which will help to anchor hydrogen demand and enable future buildout phases of the Hub.

Dundee

A fleet of hydrogen fuel cell buses is being introduced in Dundee with supporting refuelling infrastructure being installed at the Michelin Scotland Innovation Parc as part of the development of facilities to test, demonstrate and operate sustainable mobility technologies.

Refuelling infrastructure for buses

Hydrogen can transported into bus depots, either by pipe or tank, or it can be produced onsite by electrolysis driven by electricity from the network or e.g. a wind turbine or solar panels installed specifically for the purpose. Hydrogen produced on site needs to be compressed and then stored. The optimal solution will depend to a large extent on the proximity of the bus depot to existing hydrogen production plant or hub.



Hydrogen for road transport workshop

The focus now needs to turn from demonstration of hydrogen fuel-cell buses to scaled-up roll-out, and the capitalisation of opportunities across sectors and transport modes.

The Zero Emission Mobility Industry Advisory Group commissioned KPMG to hold a workshop on hydrogen for road transport on 23 March 2021. A full report of the workshop, including objectives and attendees, is given in the annex. There are 3 points from the summary of particular pertinence to the Bus Decarbonisation Taskforce. These, slightly edited, are:

- Demand forecasting exercise is essential: This will help to provide confidence in investment for the required infrastructure and fuel cell solutions. Engagement with industry stakeholders to better understand future fleet needs / requirements would be of significant benefit in this respect
- Help industries to understand how hydrogen can be applicable to them, and how to go about incorporating it: creation of a toolkit could help by providing guidance. This will help inform decarbonisation transition strategies and provide a view of base loads in regions, but also by fleets.
- Stimulating demand relies on breaking down information barriers and asymmetries. This includes sharing of lessons learned from trials and demonstration projects.

ANNEX: IAG Hydrogen for road transport workshop

Purpose of the workshop

The purpose of the workshop was to:

- Discuss the strengths, weaknesses, opportunities and threats for Scotland, a vision for Scottish Industry Participation in the hydrogen powered (road) transport value chain, and key barriers to achieving this vision.

Delegates were asked to provide comments across a range of discussion points including:

- The identification of use cases for the application of hydrogen to road transport, and the supply chain for hydrogen fuel cell vehicles.
- An assessment of existing and required capabilities, across the supply chain to realise use case applications;
- Agreement on a vision for Scottish enterprises in the hydrogen and road transport value chain; and,
- The identification of appropriate actions required to build on strengths, convert opportunities, address weaknesses, mitigate threats, and remove barriers to deliver the vision.

Draft summary of key points made at the workshop:

- **Continuing to primarily support creation of supply-side infrastructure is not sustainable:** Focus needs to be also placed on the demand side of the equation. This should not be a “build it and they will come” scenario. Doing so should help reduce the need for public funding in the medium-long term.

- **Demonstration of applicability of hydrogen and confidence in its use** is important. Scottish Government is in a good position to help promote and demonstrate the capabilities of hydrogen in the transitioning of its own fleet, and supporting the transition of public sector fleets.

- **A demand forecasting exercise is essential**: This will help to provide confidence in investment for the required infrastructure and fuel cell solutions. Engagement with industry stakeholders to better understand future fleet needs / requirements would be of significant benefit in this respect (e.g. what proportion of their respective fleets might they intend to be battery electric vs. hydrogen). A view of the potential demand profile (including scenarios) would be helpful in catalysing interest and investment, and potentially lead to **demand aggregation**.

- **Help industries to understand how hydrogen can be applicable to them, and how to go about incorporating it:** Many industries don't know the best options or have a view of the best options available to them. Creation of a toolkit could help. This could help inform decarbonisation transition strategies and provide a view of base loads in regions, but also by fleets. Better, more consistent and reliable information is needed about the application of hydrogen in transport. A Toolkit and Guide, which maps hydrogen to different vehicle classes, could be helpful, as would a roadmap of when investments may happen – both in the infrastructure but also in vehicle technologies. This should also set out how hydrogen offers not only applications in difficult-to-transition use cases, but also adds resilience to the transport ecosystem.

- Stimulating demand relies on **breaking down information barriers and asymmetries**. This includes sharing of **lessons learned** from trials and demonstration projects - including technical and business model issues - to make industry stakeholders aware of the 'art of the possible', so that they can consider where best hydrogen might fit within their respective plans.

- **Ensure lessons are learned and shared from pilot and demonstration projects**. There is a perception that participants in high-profile, early-stage projects are sometimes reluctant to be candid about the challenges that they faced. However, the difficult experiences are often as valuable, if not more so, than the positive ones in shaping effective models for larger-scale adoption of hydrogen in transport. Pilot projects are supposed to help flush out unanticipated issues. Clarity about these will help identify solutions, increase confidence and improve risk management.

- **Hydrogen is not just an HDV fuel.** It can add resilience in an otherwise battery-electrified market and can have significant benefits for high intensity fleets. The shift to home shopping has led to vastly expanding home delivery and distribution fleets. Work needs to be done to understand opportunities to use hydrogen vehicles in these non-HDV high-intensity areas.

- **Embed hydrogen in Local Transport Strategies:** LTS' could consider and – where appropriate - incorporate hydrogen and discuss the relationships that will be required between the public and private sectors.

- **Making hydrogen vehicles available to the public sector via suitable procurement routes** is crucial. This is being progressed via a recently launched public sector procurement framework, the existence of which should be widely marketed and communicated.

- **Collaborate with other governments who are seeking green hydrogen suppliers:** Scotland needs to continue working with other national governments who wish to purchase green hydrogen (e.g.

Belgium and Germany (which does not support CCUS)), ensuring that we have a healthy off-taking market.

- **Competitors to collaborators:** Modify our view of countries such as Japan, the US, and South Korea as direct competitors and consider them instead as potential partners in our endeavours or clients for our expertise. This would necessitate targeted and thoughtful engagement with government and industries in these countries.

- **Set out a vision for a Hub, Cluster and Spoke ecosystem in Scotland:** Scottish Government could consider a Hub, Cluster, and Spoke model, and set out what this could look like. The trade-off involved in transporting hydrogen, versus energy for electrolysis should be considered as a key element of this planning.

- **Conversion & Distribution R&D:** LOHC (liquid organic hydrogen carriers) and ammonia carrier-media can be used to transport hydrogen over longer distances; however, these remain at a low technology readiness level with some scepticism about their viability. More work is required to determine the most cost effective and appropriate transportation / distribution mechanisms, especially to enable Scotland to facilitate to scale export of Green Hydrogen.

- **Do not demonise those unable to transition – support them:** Support needs to be provided for those unable to transition. This includes not penalising ongoing use of diesel fleets.

- **Skills in Oil & Gas are highly transferrable,** but hydrogen has yet to present itself as a sustainable and attractive employment proposition. Incentivisation is required to transition such staff / resources into a new ‘green’ sector – including bridging expectations in traditional high wages experienced in the oil & gas industry and providing relevant training and qualifications.

- **Safety remains a top priority**. Acknowledge that there have been accidents, and that work is ongoing to prevent these from reoccurring. Communication from major operators using hydrogen (not just the manufacturers) will help address this, as will good news stories (e.g. the success of the Aberdeen trial was due to people not realising they were travelling on a hydrogen bus). Hydrogen fuelling stations need to meet certain criteria but there is no national test for such criteria, and companies are having to take this upon themselves to make sure they can adhere to these safety and operating standards without a designed framework to work from. Introduction of both nationally recognised safety standards, and qualifications (see above) could go a long way to helping improve both actual and perceived safety.

- **Reliability concerns need to be addressed.**

- **Recognise R&D as an opportunity in its own right:** Scotland has the facilities and academic prowess to make R&D (even if not scaled) an export in its own right. Innovation and invention doesn’t necessarily have to be transformed into industrial and manufacturing gains. Scotland can attract inward investment with its intellectual talent.

Organisations represented

Scottish Research Partnership in Engineering

Üv SÜD NEL

Scottish Motor Trade Association

National Express

Logan Energy

Glasgow City Council

BOC

University of St Andrews Hydrogen Accelerator

Technology Scotland

First Group

Scottish Power

ITM Power

Aberdeen City Council

ADL

National Manufacturing Institute Scotland

Road Haulage Association (Scotland)

Skills Development Scotland

SOLACE

H2 Green

Orkney Islands Council

Michelin-Scotland Innovation Parc

Arcola Energy

Stagecoach