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Aberdeen Hydrogen Hub: vision and business case for establishing scalable renewable hydrogen supplies in the city

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In late 2019, Aberdeen City Council, Opportunity North East and Scottish Enterprise commissioned Element Energy to explore in detail the case for a renewable Hydrogen Hub in Aberdeen. A report and Action Plan for delivery of this vision has now been reviewed and the background, overview and summary of next steps recommended by Element Energy are set-out below.

Background

Following the successful demonstration of hydrogen in a range of applications, Aberdeen is well placed to become the exemplar for deployment of the technology at a city scale with a first "Hydrogen Hub".

Over the past five years, Aberdeen has established itself as a centre of excellence for hydrogen and fuel cell technologies. A wide range of initiatives has been implemented, including; the deployment of ten fuel cell buses (one of the largest fleets in Europe to date); introduction of fleets of light duty fuel cell vehicles into Council fleets and a local car sharing club; trials of hydrogen-fuelled refuse trucks and road sweepers; commissioning of a megawatt-scale stationary fuel cell at The Event Complex Aberdeen (TECA), and two refuelling stations operating with extremely high availability levels since 2015. These successful deployments have been led by Aberdeen City Council, working closely with industry stakeholders to make Aberdeen one of Europe's most advanced hydrogen cities.

With an expansion to the fleet of fuel cell buses (up to 25 new generation buses), the Council, Opportunity North East, and Scottish Enterprise are seeking to initiate the broader scale-up of hydrogen activities by developing a Hydrogen Supply Hub which will provide low cost, low carbon hydrogen to the buses and other emerging hydrogen applications over the next decade. With the right policy conditions and sufficient demand certainty, this Hub will be a commercially attractive opportunity for private sector investment which could (i) catalyse the growth of hydrogen mobility from demonstration activities to applications at a city scale and beyond, and (ii) further cement Aberdeen's leading position in hydrogen, offshore renewables, and offshore energy services, attracting further inward investment and generating significant opportunities for clean growth in the region.

Hydrogen demand growth in Aberdeen

Hydrogen demand in Aberdeen from buses, cars, vans and municipal vehicles alone can reach 3.5 tonnes per day by 2030.

Transport applications represent the highest value markets, due to the relatively high price of current transport fuels compared to natural gas. Hydrogen fuel use in transport is relatively mature: buses, cars, vans and refuse trucks have been operating in Aberdeen for several years, and initial deployments of hydrogen trains, trucks and boats are now beginning in other global markets. In contrast, hydrogen for heat and industrial energy are still at early stages with significant regulatory changes required before the technology can be deployed widely.

The higher value and maturity of transport applications mean that they are likely to offer the best opportunities for private sector investment in hydrogen production and retailing infrastructure in the next five years. By the mid-2020s, under the right conditions hydrogen transport demand could grow

significantly, increasing the scale of opportunity. Heat and industrial applications could then also present significant demand opportunities for hydrogen suppliers in the Aberdeen region if hydrogen is available at a competitive price.

The business case for a Hydrogen Hub in Aberdeen has been based on a conservative level of demand growth, in orderto design the case for investment in the hydrogen infrastructure that will be the backbone of the Hub. Figure 1 shows the total projected hydrogen demand, reaching 3.5 tonnes per day in 2030, based on a total deployment of 145 buses, 800 cars and c70 HGVs (Heavy Goods Vehicle) in Aberdeen.

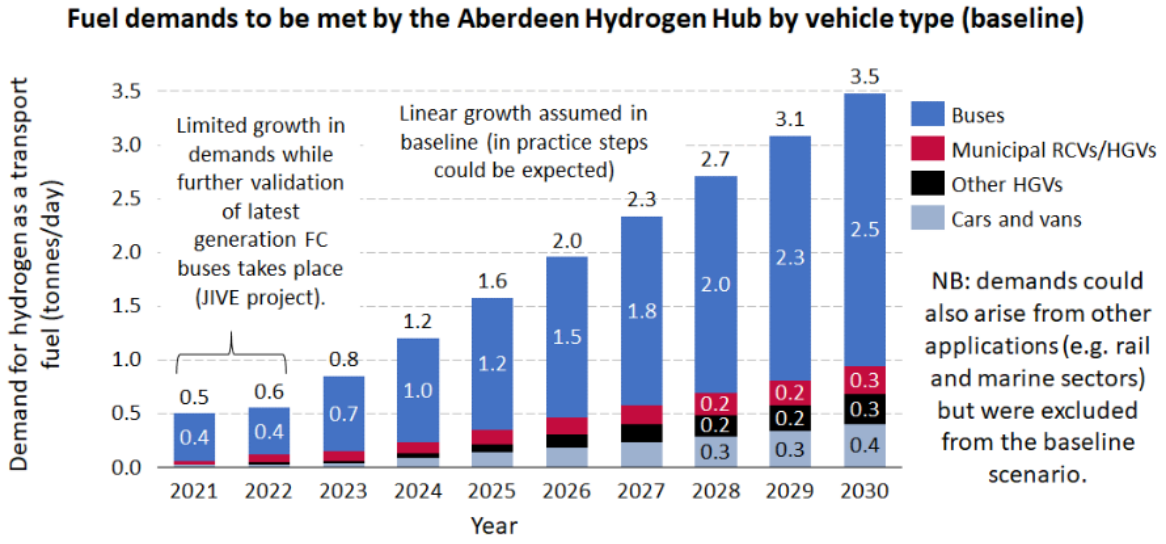

Figure 1: Fuel demands to be met by the Aberdeen hydrogen supply hub (by vehicle type)

As part of wider ambitions to transition to net-zero operations, buses dominate the projected hydrogen demand with bus operators initiating a rolling replacement to a 100% hydrogen fleet. In this scenario, bus operators would need to commit to expanding their fleets after one to two years' experience with the current 'new' generation of hydrogen buses. Once satisfied by the performance of the vehicles, the bus operators can then commit to a hydrogen future for the city, with the support of public sector stakeholders.

Other vehicle types such as trucks, ships and trains have great potential to increase hydrogen demand in the city before 2030. However, further development work is needed for each vehicle type before a fully mature product is available. As a result, the Hydrogen Hub demand strategy is built up with a relatively conservative view on the rate of development of these vehicles.

Local Hydrogen Supply

While there are several options for low carbon hydrogen in Aberdeen, the Hub is based on production of hydrogen from electrolysers directly coupled to renewable generators.

Several options exist for low carbon hydrogen production in Aberdeen, including production from fossil fuels with carbon capture, utilisation and storage (CCUS), and production from a renewable electricity source through electrolysis.

The Aberdeen Hydrogen Hub is a near term initiative, and as such is based on technologies and market conditions available today. The most viable production option for quick deployment will be based on electrolysers co-located with renewable electricity sources. These lead to the lowest cost hydrogen: the electrolyser can access low-cost electricity from the renewable generator, and a single large, centralised plant can be built, enabling economies of scale. This option also supports the Scotland-wide ambition of increasing the deployment of renewable electricity generation.

The Hub will not remain tied to a single production method: in future, other production options are also likely to mature. One of the key advantages of establishing a Hub with growing Hydrogen demand will be that Aberdeen will be able to develop and then utilise new hydrogen production options as they mature.

Several potential sites have been identified where renewable electricity from offshore windfarms close to Aberdeen could be provided directly to electrolysis via a private wire, and where the production capacity could be increased over time. The production site for the Hub will expand in two stages. A first stage will be built to meet the initial demand and will also include sufficient civil works and planning consents to meet the anticipated demand in 2030. As demand certainty increases, a second larger phase can be deployed in 2023, which will then meet the growing demands for hydrogen in the city.

With hydrogen production infrastructure in place, the Hub operator will distribute hydrogen to refuelling stations across the city using tube trailers to carry compressed hydrogen. As demand grows, the Hub will expand to include further new hydrogen refuelling stations. As such, the Hub will comprise modular electrolysers converting renewable electricity into hydrogen, buffer storage, modular compressors, and mobile hydrogen storage as part of a hydrogen logistics system (Figure 2).

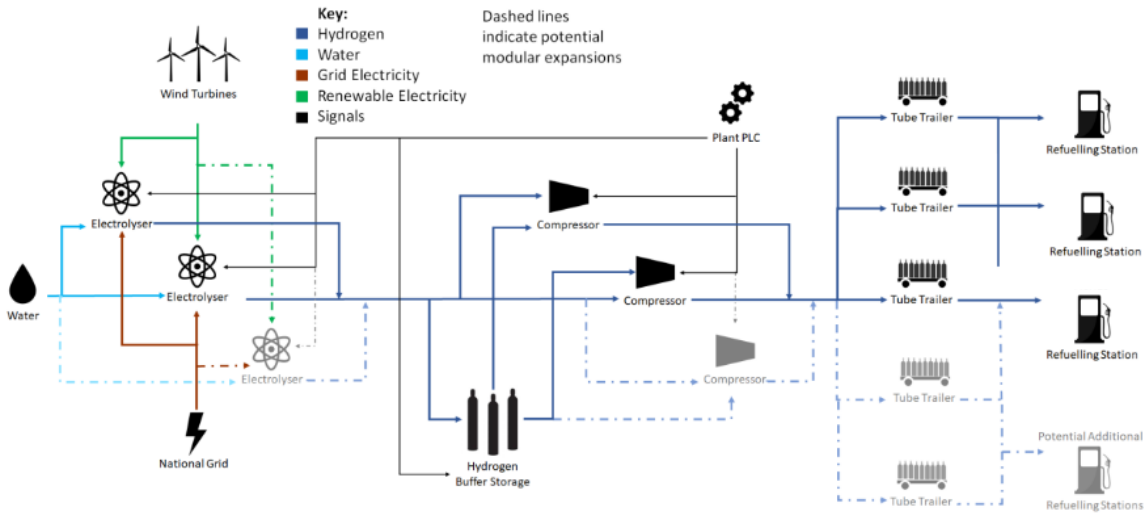

Figure 2: Schematic representation of the Hydrogen Hub

The business case

The Aberdeen Hydrogen Hub can provide a positive return for investors when viewed over 12 years. However, risks in the early phases, and the wider positive impacts on the Scottish economy justify public sector support.

The business case for the Hub has been assessed on investment in the two phases of its expansion, over a 12-year period. The initial investment now will provide the hydrogen production and supply infrastructure for the first years of demand growth, and in 2023 this infrastructure will be expanded to meet demand through to 2032, bringing the total installed electrolyser capacity to at least 8MW, and requiring at least three refuelling locations.

Customers consulted agreed that to make hydrogen vehicles commercially viable for them, the sale price of hydrogen to end users – such as bus operators – must be equivalent to or below that of diesel on a per kilometre basis. For the Hub operator, this effectively caps the revenues available directly from the customer, to around £6/Kg in the case of buses.

In addition to this, the owner of the Hub can benefit from policy mechanisms such as the Renewable Transport Fuel Obligation which will support the sale of renewable hydrogen as a transport fuel and provide additional revenue for each unit of hydrogen sold, in the form of Renewable Transport Fuel Certificates (RTFCs). The baseline business case for the full expansion in demand indicates that over 12 years, a well-utilised Hub receiving RFTCs provides a return on investment.

An investment with this potential can be attractive to a range of private sector investors, including hydrogen and energy industry players and infrastructure investment funds. However, it is subject to risks, including:

- Demand – the investment case is built on an expansion in demand; if this demand does not materialise, the investment case will become poor and non-viable.
- The availability of RTFCs for the renewable hydrogen being produced.
- The price of electricity from the renewable generator being available at a price below £45/MWh, which is consistent with current market rates, but inevitabley somewhat uncertain.
- Competitors for the supply of hydrogen emerging as demand grows – to mitigate this risk, some form of exclusivity is required for the early investor.

These factors necessitate the requirement for the public sector to support the early stages of roll-out with an upfront capital contribution.

<u>Realising the opportunity</u>

Demand certainty is needed for the benefits of the Hub to be realised, and the policy environment in Aberdeen and in Scotland will be fundamental to achieving it.

One of the key conditions for the Hub to be an investible opportunity is achieving certainty around future demand growth. Buses will be the main source of demand for at least the initial phase of investment, so it will be essential to secure a commitment from bus operators in Aberdeen to replace their existing fleet with hydrogen buses over the next decade. In addition to achieving fuel cost parity with diesel, the cost of the vehicles to the bus operator must also be equivalent to buying new diesel buses. Also, to ensure that demand for bus services is sufficient to justify the continued replacement of existing vehicles, measure to encourage use of bus services will be crucial.

While buses will provide the core demand for the Hub, an increase demand from other vehicles will strengthen the overall business case and bring investment from the private sector. A range of policy measures and local actions are needed to secure certainty of demand growth beyond the initial bus deployment to ensure the attractiveness of the second phase of infrastructure investment. As such,

Scottish Government has a strategic opportunity to increase confidence in the market for zero emission vehicles and allow vehicle operators to commit to replacement plans.

Economic benefits

By 2030, the initial development of the Aberdeen Hydrogen Hub alone will bring 20-30 new jobs and up to £41m in cumulative gross value added (GVA) to the region.

Aberdeen's established presence of offshore and onshore energy industries brings the opportunity for the additional value and jobs generated by the Hub to be developed locally, building on existing expertise in areas such as energy project engineering and design, and gas storage and transport.

Establishment of the Hub will involve a range of engineering, construction and project management roles during the installation phase and subsequent expansion phases as hydrogen demand grows. It will also create permanent jobs relating to the ongoing maintenance and operation of each site, as well as for the delivery of hydrogen between sites. In addition, the wind generation capacity required for hydrogen production will create jobs in the energy and services industries.

Further opportunities exist around the provision of the vehicles using the Hub. Dedicated maintenance workshops and local supply chains for hydrogen specific parts will be established, and with supply chains for hydrogen vehicles in early stages of development, a high level of demand in the region could attract local production and retrofit facilities, providing additional value and employment to the region.

The Aberdeen Hydrogen Supply Hub will be the catalyst that unlocks the wider economic benefits of hydrogen activities in the region, as part of the national net-zero transition.

By initiating the scale-up of hydrogen demand and production, the Hub will bring benefits to the region that go far beyond the immediate economic impacts. The availability of low-cost, low carbon hydrogen and the development of an accessible vehicle supply chain will unlock demand from transport and other applications across Aberdeen and the wider region, enabling additional investment in infrastructure and facilitating the further development of local supply chains expertise. Oil and gas industries and related services in the region will exploit the overlaps in relevant expertise to develop and grow business areas relating to offshore hydrogen production and distribution, and onshore hydrogen infrastructure, ensuring that the industries at the core of the region's economy continue to thrive throughout the transition to net zero. The parallel development of CCUS routes as well as renewable pathways will unlock a multitude of applications and opportunities for the region.

Accounting for uptake of hydrogen as a fuel nationally and worldwide, export market opportunities could lead to the creation of over 700 new local jobs by 2030.

The successful provision of low carbon hydrogen to transport applications at scale will see this model being replicated across other global markets, allowing local expertise to be exported and bringing further economic benefits to the region. Hydrogen retailing and distribution businesses developed in Scotland, along with vehicle retrofit and production solutions, could also expand to meet demand from hydrogen economies across Europe and beyond. The Hydrogen Council predicts global hydrogen production to reach 117Mt/yr by 2030, compared to 67Mt/yr today. Estimates of potential export markets suggest that over 700 full time equivalent positions could be created in Aberdeen in the renewable hydrogen industry, and a cumulative GVA to the region of >£700m by 2030. As demand grows beyond 2030, increasingly from heat and industry alongside transport, so will the scale of

offshore hydrogen production and use of hydrogen pipelines, deepening the synergies with existing offshore energy industries, thus increasing the scale of the economic opportunity for North East Scotland to thousands of potential jobs.

Ensuring the success of the Aberdeen Hydrogen Hub will unlock the pathway to clean growth in North East Scotland

The Aberdeen Hydrogen Hub will be the key to unlocking a host of potential economic and environmental opportunities for the region. The significant offshore and onshore wind resources in Aberdeen and North East Scotland provide huge potential for renewable production of hydrogen, and as a global centre for offshore energy production and services, the city is well placed to leverage existing oil and gas expertise and skills in the transition towards hydrogen production and distribution, both onshore and offshore. In the context of the Scottish Government's ambitious plans to reach net-zero greenhouse has emissions by 2045, and the broader international drive for decarbonisation, establishing Aberdeen as a global exemplar for low carbon hydrogen supply and demand will help to secure the future of the local economy as a leading provider of energy and services for a net-zero future.