Aberdeen City Region Hydrogen Strategy & Action Plan

2015 - 2025

EXECUTIVE SUMMARY

A significant opportunity exists for Aberdeen to become a leading European region in the early deployment of hydrogen fuel cell vehicles, as well as becoming the hub for hydrogen technologies in Scotland. To this end, Aberdeen City Council (ACC) has already made significant efforts to engage with hydrogen technology: today the **city boasts Europe's largest fuel cell bus fleet and Scotland's first facility for hydrogen production via water electrolysis**. The launch of the Strategy Framework "A Hydrogen Economy for Aberdeen City Region" in 2013 reflects Aberdeen's ambitions in the sector.

The hydrogen refuelling infrastructure in the City has the capability to cope with a considerable expansion of the existing fleet of hydrogen vehicles. Given the significant investment in vehicles and infrastructure, as well as the need to allow the investments to prove themselves, the time is now right to focus initially on nurturing **other non-Council end-users** to adopt the technology whilst ensuring that **renewed investment is available** in the medium-term (2018) to fund additional bus and hydrogen refuelling station (HRS) deployments.

Hydrogen vehicle technology is commercialising rapidly, however there remain considerable uncertainties in the rate at which the technology will mature. A hydrogen vehicle strategy for ACC has been developed which secures and increases demand on existing infrastructure in a measured fashion, whilst managing the financial exposure for the Council (by relying primarily on external sources of funding) and allowing the pace of the intervention to be dictated by the rate of increase in confidence in the technology.

An infrastructure strategy has also been developed, which envisages an expansion of the existing network in line with and contingent on a growing regional hydrogen demand. Once sufficient confidence has been established from both bringing vehicles to market and end-users adopting vehicles, the timely deployment of refuelling stations with sufficient dispensing capacity can be economical. This is only justified with demand towards 100's of kg per day per station (equivalent to >500 cars or 15 buses serviced by a single refuelling station). This suggests that any early investment in stations can see returns when viewed over a long enough time horizon.

Consultation with regional fleet operators supported an assessment of the regional appetite for adopting hydrogen vehicles and willingness to pay. Based on this and associated ownership costs, a technology uptake scenario was developed, estimating 94 hydrogen vehicles deployed by 2020.

The aim of this strategy is therefore to maintain and build on Aberdeen's existing lead in order to achieve the long-term goals associated with hydrogen rollout and being the leading hub in Scotland. This strategy and action plan outlines how these aims can be achieved in the short, medium and long term, in order to cement Aberdeen's position and achieve the overall aims of the Strategy Framework - grounded by rational analysis of the opportunities available. **Overall this strategy looks to secure investment for further vehicle deployments initially, followed by new infrastructure investment from 2018 when capacity will be maximised**. The action plan identifies a series of measures required to achieve this, across seven key objectives:

1	Vehicle Deployments	A range of local stakeholders deploy hydrogen vehicles.
2	Renewable Hydrogen	Hydrogen produced from renewable energy sources is widespread throughout the region.
3	Refuelling Infrastructure	An accessible, convenient and safe refuelling infrastructure network is deployed across the City and beyond.
4	Non-Transport Applications	Non-transport applications are tried and tested including stationary power.
5	Supply Chain / Market Development	A robust, local hydrogen supply chain is developed which utilises the areas existing energy expertise
6	Communication & Education	A greater understanding and acceptance of hydrogen technologies encourages widespread adoption
7	Policy & Regulation	Hydrogen technologies are embedded in all relevant areas of policy and supported at a national level.

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HyTrEc Hydrogen Transport Economy for the North Sea Region
The Interreg IVB North Sea Region Programme

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FOREWORD

Aberdeen has a long history of innovation and expertise in energy technology - from the early industries like paper and textiles, powered by hydro, through to being at the centre of a global energy industry in oil and gas over the past four decades, and now also developing a low carbon economy in line with ambitious national targets.

The City Council recognises that hydrogen can support these targets, and has a vision for Aberdeen City Region in 2020 being a world-class energy hub leading a low carbon economy and at the forefront of hydrogen technology in Europe.

The Council sees opportunities for hydrogen to support economic growth in the region through inward investment, business development and job creation. We see that hydrogen presents a chance to diversify the existing energy industry in the longer term, create a local supply chain and add a long term demand for the transferable skills the city has in oil and gas as many of the components in hydrogen technologies are the same or similar to those used in the oil and gas sector.

We want to reinforce our place as the energy city, and be a leader in a low carbon economy - the Council has created a variety of transnational partnerships, just as the city's global energy sector also does and we recognise the importance of collaboration and co-operation in succeeding in innovation and in emerging sectors.

The region has tremendous capacity for renewable energy generation, but is constrained by energy storage issues and grid capacity - a key reason for our interest in hydrogen.

The opportunity to lead Europe's biggest fuel cell bus demonstration project was really where we started, but at the same time we recognised a strategic approach was needed. Therefore we have been working with Element Energy on developing this detailed strategy to steer our priorities over the next ten years, along with a modelling tool to help us strike the right balance between infrastructure and vehicles.

We're proud of the strong global and local partnerships that have developed as part of our hydrogen projects and see this collaboration as a key to our continuing success.

Aberdeen City Council sees a crucial role for itself as a facilitator and early adopter of hydrogen technologies, but in leading the way we now need others to follow on and get involved in the sector.

Councillor Jenny Laing, Council Leader

Angela Scott, Chief Executive

ENDORSEMENTS

Gordon McIntosh, Director, Aberdeen City Council
"Aberdeen is an Energy City which has built itself around oil and gas over the last 40 years. Today the City exports its goods and services throughout the world and it is important to stay at the forefront of this from an economic development perspective. Hydrogen and fuel cells gives us another string to our bow and allows us to diversify our economy further. We have the key skills in the City that can take this industry forward.

Energy is important to Aberdeen; renewable energy will be a key part of our future."

Ben Madden, Director, Element Energy
"Aberdeen City Council's targeted investments in hydrogen transport have led to significant new private sector investment and European funding for the region. ACC's support so far and the projects that have been initiated have been very successful in putting Aberdeen on the map as one of the leading early European deployment hubs for hydrogen transport-related activities. The refuelling and support infrastructure, as well as the fleets deployed to date, have created the conditions required for expansion of the non-Council vehicle fleet as well as new private investment in hydrogen production and fuelling capacities."

Nigel Holmes, CEO Scottish Hydrogen & Fuel Cell Association
"Hydrogen and Fuel Cell technologies can make a unique contribution towards delivering Scotland's low carbon and renewables ambitions. Low carbon technologies will improve resource efficiency, support new low carbon business models, and deliver productivity and growth.

This Action Plan will help to develop the market sectors where Hydrogen and / or Fuel cells are likely to make significant contributions include efficient decentralised stationary power, sustainable transport applications, and energy storage and energy balancing applications linked to increased renewable energy deployment.

Scotland offers compelling and distinctive advantages, and this Action Plan will be a key factor in helping the 'Energy City' of Aberdeen to be a successful player not just in the oil and gas sector, but also in emerging global large scale Hydrogen and Fuel Cell markets."

PART 1 - ABERDEEN'S ROLE IN A HYDROGEN ECONOMY

Introduction

In 2013 Aberdeen City Council launched the 2020 Strategy Framework "A Hydrogen Economy for Aberdeen City Region" which outlined a vision and high level actions for the City to achieve a hydrogen economy.

This strategy builds on the framework, providing a detailed action plan to help realise the vision to be "a world-class energy hub leading a low carbon economy and at the forefront of hydrogen technology in Europe".

In July 2014, the Council commissioned Element Energy to undertake detailed analysis and stakeholder engagement to underpin the next phases of development. During the strategy development phase, a range of local fleet operators and key stakeholders were contacted in order to understand potential hydrogen vehicle demand in the region.

Why Hydrogen?

Hydrogen is the world's simplest, lightest and most abundant element. Very little of it is in a freely available form on Earth however, where most hydrogen is in the form of compounds like water and hydrocarbons such as fossil fuels.

Scotland and the north east has a long history of producing and using hydrogen in the energy industry. It is mainly produced industrially through steam reforming of natural gas and used for processing crude oil into refined fuels such as petrol and diesel, as well as in producing fertilizer, treating metals, welding and processing foods.

Hydrogen is also produced from electrolysis of water. This involves running an electrical current through water in an electrolyser to split the water (H_2O) into hydrogen (H_2) and oxygen (O_2). By using electricity from renewable sources in this process, the hydrogen can be produced with very low carbon emissions.

The hydrogen acts as an energy storage medium, being compressed and stored until it is needed for a wide range of uses, including being converted back to electricity through a fuel cell in vehicles, generators or in principle, anything that requires electrical energy to operate. Hydrogen can also be used in an internal combustion engine.

When the electricity that is generated from intermittent renewables such as wind is used to produce hydrogen, then it can have the effect of taking the energy that cannot be fed into the electricity grid and storing it for use as required. Thereby helping to balance supply and demand for renewable electricity and ensuring renewable energy plays a bigger part in a low carbon future.

Policy Drivers

Advancing the adoption of hydrogen technologies is supported throughout Government policy. Whilst there is no specific hydrogen strategy for the UK or Scotland as yet, there are ambitious policies to reduce green house gas emissions, increase the proportion of energy coming from low carbon sources and increase security of energy supply. In addition, the desire to decarbonise transport is also based on a variety of legally binding environmental drivers including:

- EU legislation which seeks to limit emissions from new vehicles, for example fleet average emissions of 95gCO_2/km by 2021 for new cars;

- Both UK and Scottish Government's have stated an ambition for mass market transition to ultra low emission vehicles, an approach consistent with the commitment to reduce cross-sector greenhouse gas emissions by 42% by 2020 and 80% by 2050 (relative to 1990 levels);

Switched On Scotland:
A Roadmap to Widespread
Adoption of Plug-in Vehicles, Transport Scotland, 2013

In addition to the clear environmental benefits, the decarbonisation of the transport sector offers a range of benefits, which are in themselves strong drivers for deploying low carbon transport technologies, including:

Energy security: through reduced demand for fossil fuels, reliance on foreign oil imports is reduced; thereby reducing the geo-political risks associated with often unpredictable parts of the world; European Energy Security Strategy, Energy Act 2013 (UK)

Long-term affordability: by reducing oil imports to fuel the transport sector, significant improvements to the balance of payments can be achieved - this is particularly relevant for alternative fuels produced locally, e.g. renewable electricity, hydrogen and certain biofuels; Energy Act 2013

Expansion of renewables capacity: widespread deployment of alternative fuelled vehicles that use electricity as their main feedstock (e.g. electric vehicles, hydrogen vehicles) creates significant additional demand on the electricity grid, thereby enabling the deployment of additional renewables capacity - a key policy goal for Scotland; European 2020 targets, Climate Change Act (2008)

Energy storage: Scotland's renewable energy targets include 100% electricity demand equivalent from renewables by 2020 of intermittent renewable electricity generators to the grid (e.g. wind), unpredictable production patterns can lead to severe grid balancing issues in supplying electricity at times of low demand, or an inability to supply sufficient electricity at times of high demand. Low carbon transport technologies such as batteries and hydrogen are able to contribute towards grid balancing through offering options for energy storage at times of low demand, and re-generation at times of high demand;

Air Quality: significant local and national air quality benefits can be derived from the deployment of low carbon vehicles offering zero emissions, reducing harmful pollutants such as nitrogen oxides (NOx) and particulate matter (PM10).

There are three air quality management areas (AQMAs) in Aberdeen: the City Centre, Wellington Road between Queen Elizabeth II roundabout and Balnagask Road and the Anderson Drive/Haudigan/Auchill Road corridor. The AQMAs were declared due to exceedances of national air quality objectives for nitrogen dioxide (NO2) and particles (PM10). The EU NO2 objective is also exceeded and the UK government is at risk of substantial EU infringement fines should air quality not improve. High levels of both PM10 and NO2 are associated with impacts on the respiratory and cardiovascular systems of vulnerable people and increased hospital admissions. Every year an estimated 29,000 people die early in the UK as a result of poor air quality.

An Air Quality Strategy for Scotland will be introduced by the Scottish Government in 2015 detailing the Scottish Government's approach to improving air quality. Additional duties will be placed on local authorities to implement measures to reduce emissions. The national Air Quality Strategy will not be limited to emissions directly impacting on health, but will also include transport, climate change, energy and planning development measures to reduce congestion, improve traffic flow and create urban areas that are more pleasant spaces to move around and spend time in. The requirements of the Air Quality Strategy will therefore support the deployment of hydrogen technologies;
EU Clean Air Policy Package, National Air Quality Strategy (UK),Local Air Quality Management Areas.

Hydrogen transport has the ability to touch on all of these policy issues, as well as others and as a result this strategy mainly focuses on the transport applications for hydrogen as an energy vector however hydrogen is a versatile energy carrier which can interlink a range of energy sources and uses as shown in Figure 1.

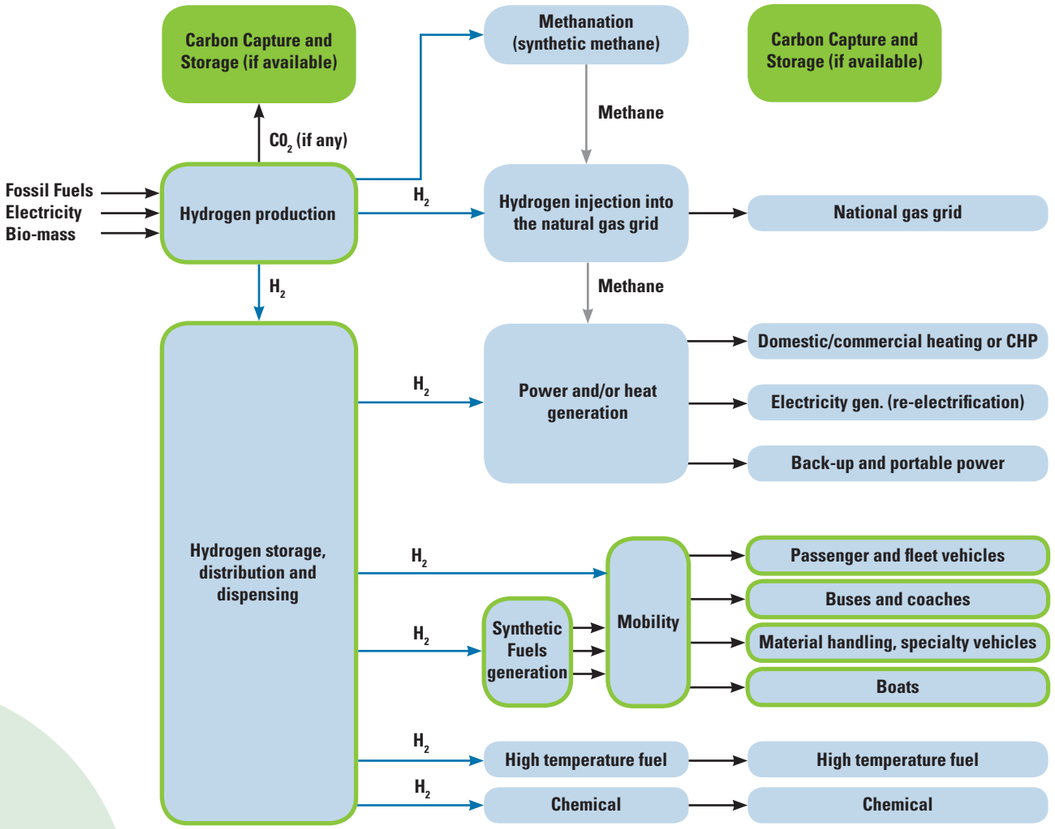


Figure 1: Hydrogen Production, Storage and Use Concept

The Global Market for Hydrogen

In 2010, the McKinsey report "The Power-trains for Europe" highlighted hydrogen fuel cell vehicles as a unique low carbon transport option offering long range, quick refuelling and zero exhaust emissions. The study, which was backed by leading vehicle manufacturers, energy companies and industrial gas suppliers, provided a fact base for decision making on investment in hydrogen fuel cell, battery electric and hybrid electric vehicles.

The report identified hydrogen fuel cell electric vehicles (FCEVs) as the only viable pathway to achieving low carbon transport for longer range, larger vehicles. Thus vehicle manufacturers have invested heavily in developing FCEVs and today a number of manufacturers are looking to commercialise their technologies, which is seen as one of the first sectors to reach commercial maturity. As part of this, many manufacturers are seeking early launch markets. An opportunity is therefore presented for early adopter regions to attract early deployments through supportive local policies and building out the infrastructure assets required - thereby helping to unlock the long-term regional benefits.

Figure 2: The McKinsey report "A portfolio of power-trains for Europe" showed that Battery Electric Vehicles (BEVs) and FCEVs can achieve significantly low CO_2 emissions and quicker refuelling with BEVs showing limitations in range and longer recharging times.

Other technical solutions for example plug in hybrid electric vehicles and biofuels are expected to feature in the transition to zero emission transport. However, their role in the long term is likely to be limited due to the requirement for a fully decarbonised transport sector.

In the long term zero emission transport will require a combination of both BEVs and FCEVs, two technologies with distinct characteristics. The key advantages and disadvantages are summarised in Table 1.

Table 1: Key Characteristics of Battery and Fuel Cell Electric Vehicles

	Battery electric vehicles (BEVs)	Fuel cell electric vehicles (FCEVs)
Advantages	• Existing recharging infrastructure largely in place (electricity grid) • Well suited to smaller vehicles and shorter trips • High grid-to-wheel efficiency, low p/km fuel costs	• **Long range** possible (400+ miles) • **Refuel in c.3 minutes** - comparable to conventional vehicles, no compromise in customer offer • **Wide range of primary sources of energy** for hydrogen fuel
Disadvantages	• Limited range based on existing battery technology • Long recharge times (6-8 hours standard (c.3kW), c. 30 minutes fast charge (c.50kW)). • Generally require off-street parking for home recharging	• Need national network of refuelling stations • Lower grid-to-wheel efficiency compared to BEVs when using hydrogen produced from renewable electricity

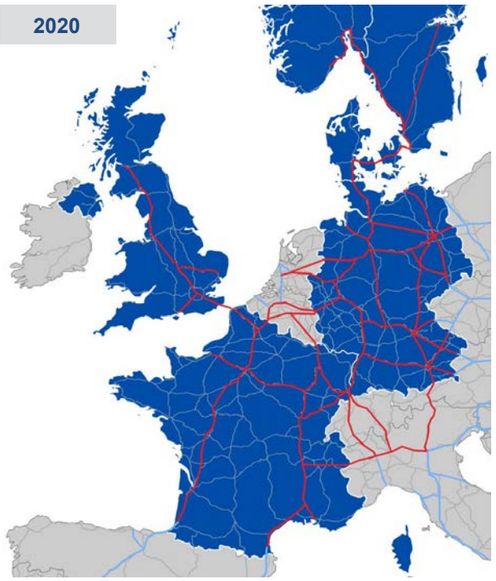
Numerous global initiatives are underway to support hydrogen technology with the main developments occurring in the USA (in particular California), Germany, Japan, the UK and China.

Through a number of public-private partnerships, Governments are working together with industry to establish the rollout scenarios and funding pathways required for widespread deployment of these technologies. These programmes include H_2 Mobility in Germany, UK H_2 Mobility in the UK, H_2USA and H_2 Mobility France. Figure 3 shows an overview of some of the H_2 Mobility programmes currently underway.

Figure 3: Overview of H_2 Mobility Programmes underway in Europe

Likely implementation of the network by 2020 (>80 kg/day stations)

2020



Scandinavia
The Scandinavian network will have deployed 35 - 40 hydrogen refuelling station (HRS) by 2020

UK
The UK will have deployed 60 - 70 hydrogen refuelling station (HRS) by 2020

Germany
The German network will have deployed over 100 hydrogen refuelling station (HRS) by 2020

France
The French network will have deployed up to 50 hydrogen refuelling station (HRS) by 2020

Key:

- Major Roads covered by HRS
- TEN-T Corridors
- TEN-T Corridors linked by early HRS
- Nations with H_2Mobility initiatives
- Nations without H_2Mobility initiatives

TEN-T is a European transport infrastructure initiative to connect the continent between East and West, North and South by building a network of transport corridors.

National Hydrogen Developments

The UK H2 Mobility project is a partnership of UK industry leaders and Government, working to develop a rollout strategy for FCEVs and supporting infrastructure in the UK from 2015. The analysis and network modelling undertaken within the project indicated that 65 stations across the UK could provide sufficient initial coverage to start the market, covering major population centres (with more than one HRS) and connecting roads

A UK infrastructure rollout plan has been defined from 2015

A **nationwide infrastructure network has been mapped out,** based on population, income and traffic densities

Early rollout phase of 65 stations to cover the major UK urban centres and intercity driving **by 2020**

Figure 4: UK H_2 Mobility planned roll out

H_2 ABERDEEN - A STRATEGIC HYDROGEN PROGRAMME

Under H_2 Aberdeen, the Council's strategic hydrogen programme, a series of targeted investments are being made to secure a position as a leading deployment centre for hydrogen technologies.

Aberdeen City Council's (ACC) 2020 Strategy Framework "A hydrogen Economy for Aberdeen City Region" frames the city's ambitions to become a high-profile, world-class energy hub across multiple energy vectors, leading to a low carbon economy and to be at the forefront of hydrogen technology in Europe.

Aberdeen has to date initiated three major hydrogen-related deployment projects, including:

1. Europe's largest hydrogen fuel cell electric bus (FCEB) deployment project, with 10 buses deployed, supported by a large hydrogen refuelling station (HRS) and a dedicated maintenance facility within the city centre;

2. Deployments of two H_2 - ICE dual-fuel hydrogen/diesel Transit vans and two fuel cell range extended electric light commercial vans;

3. The planned deployment of a second publically accessible hydrogen refuelling station to support further hydrogen vehicle deployments to the city.

In addition, Aberdeen City Council is taking a leading role in:
The HyTrEc (Hydrogen Transport Economy in the North Sea Region) project - which looks to support the validation, promotion and adoption of innovative hydrogen technologies across the North Sea Region (NSR). The project provides a platform to support the collaborative development of strategy and policy initiatives and that will inform and shape the development of infrastructure, technology, skills and financial instruments to support the application of hydrogen based technologies;

The Scottish Cities Alliance (SCA) Hydrogen Action Group which has to date delivered the SCA Hydrogen Economy Strategy. This strategy recommends four strands of work that the seven Scottish Cities should focus on. These include:

1. Large scale fuel cell electric bus deployment;
2. Hydrogen refueling infrastructure development;
3. Fuel cell electric vehicle deployment to Council fleet;
4. Renewables based "green" hydrogen production.

In mid-2014 a Scottish Cities Alliance Project Officer was recruited (hosted by ACC) to take forward the four strands of the strategy primarily concentrating on the coordination of a large scale fuel cell electric bus project which will see 500-1000 buses introduced across Europe. This will involve developing a Scotland wide business case in partnership with the Fuel Cell and Hydrogen Joint Undertaking (FCHJU) as part of the Europe wide FCHJU Fuel Cell Bus Commercialisation Project.

The Council is also investigating the public perceptions of hydrogen through the Hyacinth (Hydrogen Acceptance in the Transition Phase) project funded by the FCHJU. This project aims to understand public attitudes and perceptions and levels of acceptance of hydrogen technologies in various EU countries.

Ed Davey, Secretary of State for Energy and Climate Change launching Aberdeen's Hydrogen Strategy Framework, May 2013

CASE STUDIES - HYDROGEN VEHICLES IN ABERDEEN

Aberdeen Hydrogen Bus Project

The Aberdeen hydrogen bus project has seen key industry and public sector players join forces to fund and deliver Europe's largest demonstration of hydrogen fuel cell buses in Aberdeen, realising an aspiration to become a leading city for low carbon technology.

The £19 million project deploys ten fuel cell buses on operational routes throughout the City. These buses emit only water vapour, reducing carbon emissions and air pollution, as well as being quieter to run. The project is part-funded by Europe under the FP7 innovation funding as well as contributions from UK Government, Scottish Government, Innovate UK, SSE, SGN, Scottish Enterprise, First, Stagecoach and Aberdeen City Council.

To fuel the vehicles a state of the art hydrogen production and re-fuelling station has been built producing high purity, low carbon hydrogen onsite via electrolysis. Using an electrolyser means hydrogen can be produced from electricity and water, onsite with no local emissions. No transport is required; the hydrogen is produced and dispensed at the same site. The next phase of the project will look to produce the electricity from renewable sources (making the entire process ultra-low emissions) but to start with grid electricity on a green tariff will be used. The refuelling station provided by BOC Linde Group is situated in the centre of the city at Aberdeen City Council's Kittybrewster depot.
In addition a hydrogen safe maintenance area is being integrated into the working maintenance facility onsite at Kittybrewster which will allow the buses to be serviced, maintained and refuelled on the same site.

Hydrogen Fuel Cell Buses

- Ten low floor, 13m fuel cell hybrid (hydrogen fuel cell and battery) buses made by Van Hool
- Buses will be operated in the City Centre by both First Group and Stagecoach
- Ballard 150 kilowatt FCvelocity®-HD6 fuel cell module - warrantied 15,000 hours
- Siemens electric motors
- Regenerative breaking system
- 10 hydrogen tanks containing a total of 40kg pure electrolytic hydrogen (gas) at 350bar.
- Range of up to 260miles (350km) under typical urban transit cycle and loads.

Hydrogen Refuelling Station

- Hydrogen generated onsite by three electrolysers capable of producing 360kg of hydrogen per day;
- Will meet the demands of the ten buses;
- Ability to refuel a bus in ten minutes.

Hydrogen Hybrid Vans - a bridging technology

In June 2014, Aberdeen City Council added two new hydrogen vehicles to the fleet as part of the HyTrEc project (Hydrogen Transport Economy in the North Sea Region). Two Ford Transit vans, customised with ULEMCo's H_2ICED conversion technology, run on a hydrogen-diesel dual fuel blend. ULEMCo a subsidiary of Revolve Technologies has developed an innovative process for modifying a regular diesel engine to use compressed hydrogen gas as the main fuel with small quantities of diesel as the ignition catalyst. Whilst internal combustion engines are less efficient than fuel cells (burning the hydrogen rather than using it in a chemical process) these hybrid conversions are a cheaper alternative to fuel cell vehicles at present and therefore act as a bridging technology.

A range of operational data is being collected for example fuel consumption, routes driven and location which will be used to analyse vehicle performance and will aid the development of the next generation of the technology. These vehicles are also being trialled in Swindon & London.

Engine and Fuel System features:
- Duel-fuel selection switch (H_2/Diesel);
- There are 3 operating modes using different concentrations of hydrogen and diesel;
- The engine will always initially start on diesel fuel. It will then automatically switch to H_2 if pre-selected, once the engine reaches normal operating temperature (after approx. 2 miles);
- Compressed hydrogen with electronic fuel injection;
- 350 bar refuelling pressure
- Familiar driving and operating characteristics;

Hydrogen Tanks:
- Manufactured by Dynetek Industries Ltd;
- 2 or 3 x 74 litre carbon-fibre reinforced H_2 storage tanks mounted underneath the vehicle;
- 3.6-5.4 kg of hydrogen fuel giving a total driving range of of over 300km;
- H_2 tanks are subjected to the following tests: pendulum impact, drop test, bonfire test, armour piercing bullet penetration, extreme temperature cycling and environmental fluids exposure;

Safety Features:
- Side impact-absorbing framework around hydrogen tanks;
- Leak Detection - the vehicle is fitted with a safety leak alarm which will monitor hydrogen pressure;
- Hydrogen tanks located underneath vehicle allowing gas to escape quickly and efficiently in the unlikely event of a leak;
- No design or structural changes have been made nor any safety features changed to seat-belt systems, airbags, braking system, or locking systems.

Benefits over conventional-fuelled vehicles:
- Improved environmental performance with a 70% reduction in carbon dioxide emissions and a 40% reduction in nitrogen oxide emissions;
- Promotes renewable energies (if H_2 from a renewable source);
- Improves corporate social responsibility for fleet operators;
- Attracts business benefits from lower road and fuel taxes;
- A lower emission vehicle solution with tailpipe emissions of 59g/km CO_2 under test conditions.

Plug-in Hybrid Fuel Cell Electric Vans

Two plug in hybrid fuel cell electric vans have been added to the Council's operational fleet as part of the HyTrEc project (Hydrogen Transport Economy in the North Sea Region). Two electric Renault Kangoo Maxi Z.E. vans have been converted by SymbioFCell to include a hydrogen fuel cell range extender which doubles the original vehicle's driving range with only water emitted from the exhaust.

Benefits:
- Improved environmental performance without a reduction in payload;
- A lower emission vehicle solution with only water emitted from the exhaust;
- Double the driving range compared to the Kangoo ZE (electric only);
- Promotes renewable energies (if electricity and H_2 from a renewable source);
- Improves corporate social responsibility for fleet operators;
- Attracts business benefits from lower road and fuel taxes;
- Familiar driving and operating characteristics;

Engine and Fuel System features:
- Range extender system added without any structural modification of the vehicle;
- The fuel cell produces electricity, heat and water. Electricity produced by the fuel cell is used to charge the battery. Heat delivered through water at 80°C is used to heat the vehicle cabin in winter, without inducing extra power consumption (combined heat and power). The fuel cell produces heat as well as electricity;
- With the range extender kit, battery lifetime is increased. Increased driving range reduces the frequency of deep battery discharge which degrades the battery;
- The range extender kit can be dismounted and re-mounted in a new vehicle.

Hydrogen Tanks:
- 74 litre hydrogen tank with 15 year service lifetime;
- 350 bar pressure;
- 1.8 kg H_2 per 360 km (NEDC) equivalent to 0.5 kg H2 / 100 km;
- Refuelling time is less than 3 minutes;

Safety Features:
- The fuel cell system is fixed to the vehicle chassis;
- Hydrogen tanks are positioned in the middle of the car.
- Tanks are EC 79 validated and resistant up to 2.5 times their working pressure;
- Hydrogen sensors detect any potential leak. The fuel cell can be disconnected from the rest of the system and can discharge in less than two seconds for optimal security

PART 2 - THE STRATEGY

Vision, Aims and Objectives

The Aberdeen City Region Hydrogen Strategy will focus on promoting hydrogen technologies as a low carbon alternative to fossil fuels and as an energy vector to facilitate the deployment of renewable energy sources. Hydrogen has a number of different applications such as transport, stationary power and as an energy storage medium. The main focus will be on transport applications however other uses will be considered within this strategy.

The aim of this strategy is therefore:
To reinforce our place, now and in the future as the energy city by further enhancing the region's economic competitiveness, maximising the capacity and value of renewable energy and giving greater energy security by being at the forefront of a hydrogen economy.

To achieve this, the objectives of the strategy are to:
Objective 1:
Promote vehicle deployments by a range of stakeholders in the region;

Objective 2:
Expand production and distribution of renewable hydrogen;

Objective 3:
Develop hydrogen refuelling infrastructure;

Objective 4:
Explore the roll-out of other tried and tested or innovative hydrogen uses;

Objective 5:
Encourage the development of the hydrogen economy's supply chain, seeking opportunities for the region's existing energy expertise to diversify and benefit from this growing industry;

Objective 6:
Promote a greater understanding and acceptance of hydrogen technologies through communication and education activities;

Objective 7:
Ensure strategy and policy development at all levels of government are supportive of hydrogen technologies.

To assist in meeting the aim and associated objectives, a number of actions have been developed for each objective. The action plan is outlined in **Part 3.**

OBJECTIVE 1:

Promote vehicle deployments by a range of stakeholders in the region

There are three key things that are needed for successful introduction of fuel cell electric vehicles; the vehicles themselves, the hydrogen refuelling infrastructure to support them and a reliable, cost-effective source of hydrogen. A minimum number of each is necessary to support demand for the other. Therefore, initial industry deployments will focus on local authority fleets, return to base vehicle operations as well as high-end consumer car markets. In addition to using hydrogen for transport there are a number of other applications which are available such as stationary applications.

Fuel cells have been tested in various kinds of vehicles including forklifts, buses, boats, cars, vans, motorcycles and bicycles. A number of vehicle manufacturers have been investing heavily in fuel cell technology developments in recent years and commercially produce fuel cell vehicles are starting to be deployed in small numbers across the world, however only certain vehicle types and makes will be available to the UK market in the near term.

State-of-the-art market overview

There is a range of vehicles available to Aberdeen end-users in the near term. A number of passenger car companies will introduce their first series produced vehicles from 2015. Hyundai is currently leading the roll out with introduction of the ix35 fuel cell vehicle which is available in limited numbers to customers in early markets. Around 1,000 vehicles will be produced and leased over a period of 4 years in the next 1-2 years; these models will be left hand drive only to begin with. These early market vehicle releases come at a price premium (up to four times more expensive than a diesel equivalent) however the price for the second generation vehicles (available 2017) is likely to reduce rapidly as other competing vehicles come to market.

As these vehicles are being released in small numbers to begin with, it is important for Aberdeen to show readiness and willingness to take these early vehicle deployments. It is important to engage early with Original Equipment Manufacturers (OEMs) in order to showcase Aberdeen as being the second UK deployment centre, after London. Aberdeen City Council has already started the engagement process with several OEMs including Nissan, Honda, Toyota and Hyundai.

Analysis of commercialisation trajectories and total cost of ownership for each vehicle type reveals that buses offer the lowest cost means of increasing hydrogen demand in the region, supplemented by captive fleets of vehicles from non-OEM manufacturers, both of which have large, predictable fuel requirements and demonstrate the principle of the technology in new areas.

End-user Consultation

A range of local fleet operators and key stakeholders have been consulted in order to understand potential hydrogen vehicle demand in the region. Discussions focussed largely on cost and total cost of ownership parity with internal combustion engine vehicles. The majority of organisations consulted have an interest in decarbonising their fleet and would consider paying a small cost premium (approximated £5-10k) for a trial project (1-2 vehicles) but most would want cost-parity for any wider deployments.

A small number of organisations would be interested in significant (>10 vehicle) deployments should the correct funding source be identified. Therefore it is essential for Aberdeen City Council to take a facilitators role to enable interested stakeholders to deploy hydrogen vehicles.

Therefore, it is expected that, with sufficient practical support from the Council (for example implementation of policy incentives and formation of a hydrogen partnership grouping) and financial support from various sources, a range of public and commercial fleet operators could deploy small fleets in the pre-2020 period, whilst the Council continues to act as an early adopter as new vehicles come to market.

Based on the end-user consultation with regional fleet operators an assessment of the regional appetite for adopting hydrogen vehicles and willingness to pay was undertaken. Based on this and associated ownership costs, a technology uptake scenario was developed, estimating 94 hydrogen vehicles deployed by 2020

End-user ambition				UK H2Mobility rollout	Bus operators
	Major	Moderate	Minor		
Medium	ACC operates 2 Ford and 12 Kangoos All 'Major' stakeholders deploy further 20 x vehicles	4 x vehicles until 2018 - both public and private sector	No deployment	50% of Aberdeenshire and City pro-rated rollout from 2015	Continue operation of existing buses beyond 2018 New larger project to deploy 15 buses in 2018

Figure 5: Technology uptake scenario for Aberdeen

Actions:

Extend operation of the 10 buses beyond 2018 as this provides the most cost-effective way of securing long-term demand for continued operation of Kittybrewster HRS;

Deploy a second HRS with 350 & 700 bar capability; in order to attract early releases of passenger cars;

Secure additional hydrogen demand to ensure greater than 50% utilisation of the second hydrogen refuelling station; extending operation of the existing 10 buses beyond 2018 does not create a large enough hydrogen demand to justify deployment of a second hydrogen refuelling station pre-2020;

Deploy more H_2 buses in the near term as this is the most cost-effective way to create demand, ideally supplemented by captive fleets of vehicles from non-OEM manufacturers, both of which have large, predictable fuel requirements and demonstrate the principle of the technology in new areas. In the long-term, the major source of demand is expected to come from private sales of passenger cars and vans. The pace of this rollout is dictated by OEM behaviour (and customer acceptance) and cannot be influenced by the Council;

Seek external funding/subsidy to support the rollout of significant numbers of additional hydrogen vehicles pre 2020. All stakeholders conclude that achieving close to/better than total cost of ownership (TCO) parity is required for significant uptake;

Establish a hydrogen stakeholder group to bring together interested end users and help facilitate further vehicle roll outs.

OBJECTIVE 2:

Expand production and distribution of renewable hydrogen

Overview of locally available production pathways

Five hydrogen production pathways (see Figure 6) have been assessed as potential sources to supply any new hydrogen refuelling station in Aberdeen, with four out of the five options being considered as green hydrogen i.e. coming from a renewable energy source.

Source	Chemistry	Description	Local availability
Steam methane reforming	Methane reformation $CH_4 + H_2O \leftrightarrow CO + 3H_2$ Water gas shift (WGS) reaction $CO + H_2O \leftrightarrow CO_2 + H_2$	Methane reformation to produce syngas and subsequently H_2 following the WGS reaction is the most common H_2 production pathway	No large centralised SMR production nearby Peterhead CCS CO_2 pipeline could facilitate a new 'green' SMR H production facility
Renewable energy & water electrolysis	Water electrolysis (WE) $2H_2O \leftrightarrow O_2 + 2H_2$	WE systems split water into H_2 and O_2 Cheap electricity can be sourced from local renewable generators	Significant grid-constrained renewables
Waste gasification	Municipal solid waste gasification $CH_xO_y + \alpha O_2 + \beta H_2O \leftrightarrow \gamma CH_4 + \delta CO_2 + \mu CO + \sigma CH_xO_y + \rho H_2O + \varepsilon H_2$	Plasma reactors used to convert non-recyclable landfill waste into syngas which is treated for impurities Syngas can be combusted for electricity generation, or purified to give H_2	Currently no active projects in the region New waste processing plant coming online c. 2020
Chemical plant by-product	Brine electrolysis $2NaCl + 2H_2O \leftrightarrow 2NaOH + H_2 + Cl_2$ Naptha (ethane) cracking $C_2H_6 \rightarrow C_2H_4 + H_2$	Many processes in the chemical industry produce H_2 as a by-product Often this H_2 is recycled on-site via combustion	Mossmorran ethylene cracking plant is the major regional producer
Anaerobic digestion (AD)	Overall Process $(CH_2O)_n \rightarrow \frac{n}{2}CH_4 + \frac{n}{2}CO_2$ Methane reformation $CH_4 + H_2O \leftrightarrow CO + 3H_2$	Bacteria used to convert biodegradable waste into biogas (CH4 and CO_2) CH4 product can be reformed to produce H_2	Small AD projects, inc. at AECC development due to come online in 2018

Figure 6: Overview of five possible hydrogen production methods for Aberdeen.

Short-term production options analysis (2015-2018)

From 2015-2018 water electrolysis is the only option considered for Aberdeen in the early years due to local availability, lower carbon emissions and its support of renewable energy deployment. Only a single source of Steam Methane Reformation based Hydrogen (with sufficient capacity and purity for transportation) exists in the UK (Cheshire) however, this is not considered green hydrogen unless it is coupled with carbon capture and storage plus costs of transportation via existing tube trailer technology is prohibitively expensive.

Water electrolyser utilisation is dependent on the availability of electricity from the grid or private wire connection and the economics are improved by maximising system utilisation. It is therefore important to consider the economics of sourcing a stable electricity supply from the grid compared to an intermittent, but potentially cheaper, electricity supply from constrained renewable generators in the region. Securing low cost electricity significantly impacts hydrogen production costs via water electrolysis therefore it is important for Aberdeen City Council to minimise exposure to high electricity prices.

Medium to long-term production options analysis (2018-2030 and beyond)

Three commercial technologies are available for the conversion of municipal solid waste into useful energy products - incineration, gasification-pyrolysis and anaerobic digestion (see Figure 7). These present a number of production opportunities for future investigation.

- In the long-term, waste gasification could produce up to 8 kilo tonnes per annum of hydrogen from municipal solid waste collected in Aberdeen and surrounding regions. Although the technology is commercially proven, the constant monitoring of heterogeneous waste input and complex gas stream production may act as a deterrent for adopting this over a simpler alternative for example incineration.

- Plans to deploy a 5 megawatt anaerobic digestion plant at the new Aberdeen Exhibition and Conference Centre could produce up to 0.3 kilo tonnes per annum of 'green' hydrogen. Methane from biogas could be supplied to a hydrogen refuelling station with on-site reformation equipment.

- Exxon Mobil own and operate a large ethylene cracking plant in Mossmorran, Fife which produces over 4,000 tonnes per annum of by-product Hydrogen that could be purified for Aberdeen once sufficient demand exists. The hydrogen is currently used to generate heat on-site but could be made available for other uses. Therefore even though it is produced from hydrocarbons using the by-product could render it as a 'green' source.

Hydrogen refuelling station at the logistic centre of Belgian retailer Colruyt. Hydrogen is produced via electrolysis using renewable wind energy. This station has been operational since February 2012.

Process	Description	Product
Incineration	Involves direct combustion of waste in presence of O_2 to produce heat or electricity This is the most mature technology for extracting energy from waste but has no capability for H_2 production	**Heat** or **electricity**
Gasification /pyrolysis	Involves heating of pre-treated waste with limited O_2 (or no O_2 in the case of pyrolysis) to produce syngas for which requires purification or electricity generation via combustion on-site H_2 can be extracted via the WGS reaction and subsequent PSA purification >10 UK demonstration deployments of the technology on a medium-scale (30-140 ktpaMSW) and only Air Products' two 350 ktpaMSW gasification plants in Teesside on a large-scale	**Syngas** (carbon monoxide and hydrogen)
Anaerobic digestion	Involves controlled biological breakdown of waste in the absence of O_2 to produce biogas ($CH4 + CO_2$) Purification techniques can extract methane from the biogas for supply to an HRS with on-site reformation capabilities to produce H_2, or the H_2 can be extracted on-site	**Biogas** (carbon dioxide and methane)

Figure 7: Commercial technologies available for the conversion of municipal solid waste into useful energy products

Distribution mechanisms

Multiple hydrogen distribution mechanisms are available (see Figure 8) but only transportation by tube trailer is likely to be available in Aberdeen in the short-term.

The economics of producing hydrogen offsite and delivering to hydrogen refuelling stations in Aberdeen e.g. through grid constrained renewable energy developments has been investigated. It is important to identify sufficient demand to load up the envisaged distribution system in order to make off-site production cost effective.

The optimum scenario would be if onsite, high load factor, 'green' hydrogen sources are co-located with a hydrogen refuelling station near the city centre. However, if long term contracts for very low cost electricity can be secured at wind farms (at a much lower cost than is available in the city), this would suggest the principle of distributing Hydrogen across the city may be worth considering.

Hydrogen distribution via a pipeline has also been investigated. Installing a new hydrogen distribution pipeline in Aberdeen requires considerably larger demand than is forecasted to 2030 therefore this option would be considered as a long term option. However a point-to-point pipeline over a relatively short distance could be an attractive proposition for sufficient volumes of Hydrogen in the shorter term.

Method	Description
Gaseous H_2 via trucks	Compressed H_2 can be transported on road via tube trailers Linde/BOC operate the largest tube trailer technology available with a capacity of 1.1 tonnes at 400 bar Air Products recently deployed two state-of-the-art high pressure tube trailers with 0.8 tonne capacity at 500 bar under the HyTEC demonstration project Two options are available upon arrival at destination: either the H_2 can be decanted from the trailer into storage or H_2 can remain in the trailer on-site from which the customer may extract as and when needed
Gaseous H_2 via pipeline	The majority of UK's domestically produced H_2 is consumed near its point of production and delivered via short pipeline networks, in industrial applications While capital costs are high, operating costs and carbon emissions are significantly lower than for road transport
Liquid H_2 via trucks	Liquefied H_2 can be transported on road via trucks supporting up to four times more H_2 than the largest tube trailer equivalents (up to 4 tonnes/delivery can be transported via a liquefied H_2 truck) Liquefaction plants require significant scale (40-200 tonnes/day) to be cost effective - no current UK network
Metal hydrides	Demonstration technology, H_2 adsorbed onto magnesium hydride nanostructured composites Provides 140% and 40% higher volume density than compressed or liquid storage respectively
Liquid organic H_2 carriers	Demonstration technology, H_2 reversibly bonded to organic molecules easily transportable at ambient pressure and temperature Very early stage technology, requires significant heat input to remove H_2 from carrier

Figure 8: Hydrogen Distribution Methods

Production economics

Combining low cost electricity with high equipment load factors could provide attractively priced hydrogen production in the short to medium-term.

A trade off needs to be made between the costs of production for on-site refuelling stations in convenient locations compared to the cost of production and distribution from remote electrolysers to more conveniently located refuelling stations.

Actions:

Minimise exposure to high electricity prices; investigate opportunities for accessing lower electricity costs;

Research best options for siting additional HRS whether at the point of production, or distributing to them from remote renewables-connected electrolysers; as each option will depend on the ability to establish a well-managed and cost-effective distribution system;

Investigate options for point-to-point pipeline distribution over relatively small distances (e.g. < 5km) in the medium-long term but only as overall demand volumes ramp up (e.g. >1,000 kg/day);

Explore alternative distribution mechanisms for example solid hydride and liquid; as these may provide an alternative opportunity for lower distribution costs in the medium term;

OBJECTIVE 3:

Develop hydrogen refuelling infrastructure;

Opportunities for economic optimisation of existing and planned infrastructure

It is important to optimise the economics of any hydrogen refuelling station. Opportunities for optimising the economics include securing cheaper electricity and offering services to balance the grid which could provide up to 20% savings on production costs.

Current electricity price negotiated for Kittybrewster is a commercial rate, therefore there is reason to believe that a lower price could be achieved which could lower hydrogen production costs, making the economics more favourable. Other opportunities are outlined in Figure 9.

Charge	Description	Size	Ability to lower costs
Unit electricity price	Price of electricity on the open market **Varies continuously** based on supply and demand	6.1-7.6p/kWh	Operating at times of low demand or high generation, or by connecting directly to a renewables generator
Distribution use of system charges (DuoS)	Charges applied by Distribution Network Operators (DNOs) as payment for using their distribution networks DuoS charges are time dependant and have a capacity (per kW) as well as a usage (per kWh) component	0.4-6.8p/kWh	Charges can be reduced by avoiding 'red' congested periods at peak times Charges can be avoided by connecting at grid transmission point, or using a 'private wire' off-grid connection to a renewable electricity generator
Transmission use of system charges (TuoS)	Charges applied by transmission systems operators (TSOs) as payment for using their transmission networks TuoS charges based on the location on transmission system, and import requirements	0.5-1p/kWh	Charges can be avoided by connecting using a 'private wire' off-grid connection to a renewable electricity generator
Other charges and levies	Other charges are associated with the provision of incentives (e.g. RO, FIT, etc.), or billing customers, or climate change	1-2p/kWh	Charges can be avoided through using a 'private wire' connection.

Figure 9: Opportunities for lowering hydrogen production costs at Kittybrewster refuelling station

Opportunities for Aberdeen City Hydrogen Energy Storage (Second refuelling station under development)

Opportunities for optimising the second refuelling station are less restricted due to the project being in its early stages therefore the following opportunities will be explored:

- Price optimisation strategies such as improving the Power Purchase Agreement and offering grid balancing services;
- Negotiate a lower electricity price prior to completing contractual agreements with the energy supplier;
- Low cost electricity sources within the City including excess combined heat and power (CHP) electricity, grid constrained rural wind generation and new solar generation projects.

Opportunities for economic optimisation of future infrastructure

For additional future hydrogen refuelling stations, larger refuelling stations offer better economics, if sufficient demand can be secured. Whilst smaller stations may reach higher loading in early years, larger stations will breakeven with lower relative utilisation rates due to economies of scale. In addition, hydrogen distribution costs will also be lower for delivery to fewer, larger stations.

Therefore, when planning the expansion of Aberdeen's hydrogen refuelling network it is essential to consider the expected loading (demand throughput) in order to understand utilisation rates in relation to size.

In addition, when planning the future expansion of the network, we must look wider than the City boundary because for fuel cell vehicles to be deployed successfully; a Scotland wide refuelling network must be built. Therefore opportunities will be pursued to work with areas out with the City to expand the infrastructure network and encourage the take up of hydrogen technologies across Scotland.

Actions:

Existing Kittybrewster Hydrogen Refuelling Station

- Develop an electricity price minimisation strategy, within the constraints of the grid supply agreement at Kittybrewster.
- Investigate opportunities to reduce hydrogen production costs through providing grid balancing services; accessing Short Term Operating Reserve(STOR);
- Upgrade station to dispense hydrogen at 350 and 700 bar by 2018.

Planned second Hydrogen Refuelling Station

- Secure long-term guaranteed low cost electricity; this is important to achieving attractive production costs;
- Investigate all opportunities for low cost electricity; for example from the planned solar PV array at the decommissioned Ness landfill site;
- Develop a price minimisation strategy;
- Investigate opportunities to reduce hydrogen production costs through providing grid balancing services; accessing STOR or other reserve-related revenues;

Additional future Hydrogen Refuelling Stations

- Pursue opportunities for securing low cost electricity;
- Investigate optimal hydrogen production/distribution model; the decision whether to produce hydrogen on-site or to have hydrogen delivered will be made based on the location and economics of new production sources identified and the costs of delivering hydrogen from more remote sources to the evolving hydrogen refuelling network;
- Investigate opportunities to reduce hydrogen production costs through providing grid balancing services; accessing STOR or other reserve-related revenues.
- Pursue opportunities to work with areas out with the City to expand the infrastructure network and encourage the take up of hydrogen technologies across Scotland.

OBJECTIVE 4:

Explore the roll-out of other tried and tested or innovative hydrogen uses

Whilst this strategy primarily focuses on transport applications, other applications for hydrogen have been investigated including stationary power for buildings.

The use of fuel cells for combined heat and power (CHP) is an area of active interest worldwide and in particular for Aberdeen due to the City's well established district heating system.

Fuel cells have a higher electrical efficiency than conventional thermal generators and hence have the potential to improve the economics of CHP systems. They also offer longer life, lower maintenance and less noise, as the electrochemical reactions have many fewer moving parts. Very few of these units use hydrogen directly. Instead they are fuelled by natural gas or biogas and so less relevant to the creation of a hydrogen demand in Aberdeen.

As with automotive technology, fuel cells for CHP are maturing and technology costs remain high for most applications. There are two main applications outlined in Figure 10.

MicroCHP (0.5-10's of kW)	Large CHP (>100kW))
A fuel cell for micro CHP would replace or supplement a boiler in a home or small commercial property Over 80,000 fuel cells have been installed for micro-CHP in Japan, where significant incentives boost uptake Ene.field is the largest European demonstration project of residential micro-CHP. It will deploy 1,000 FC heating systems across 12 key member states over a period of 5 years As of Summer 2014, 30 micro-CHP have been deployed in Europe and a rapid ramp-up in deployment is expected over the next 6 months Technology developers include: Baxi, Vaillant, Panasonic, Toshiba, IE CHP, Elcore, Dantherm	Larger fuel cells also have a potential application in conventional CHP. 100's of units have been installed world-wide Early market traction has been seen for a limited number of suppliers including Fuel Cell Energy, CLearEdge and Bloom Energy. Of these only Fuel Cell Energy offers units in the UK

Figure 10: Overview of the two main fuel cell CHP applications

Whilst the economics of stationary fuel cell systems do not justify their widespread deployment in the near term (2015-2018) for most areas, the economics could be improved by strictly enforcing the energy efficiency of building regulations particularly for large commercial developments as they often find it difficult to achieve the required carbon reductions. Fuel cell CHP can offer developers a way of meeting these high targets and this is being demonstrated in London with many Boroughs insisting on the use of fuel cell CHP in new developments.

In the long term (2020 and beyond) they could offer a number of benefits to the City including:

- Improved electrical and thermal efficiencies for combined heat and power applications and thus improved overall efficiency (up to 90% efficiency is said to be achievable);
- Improved energy efficiency of Aberdeen's residential stock, as well as in large CHP applications in the city.

As fuel cell CHP applications are typically fuelled by natural gas, which does not complement the overall hydrogen strategy a watching brief will be kept on stationary application developments.

In the meantime a number of high-profile demonstrator opportunities exist within the City such as the expansion of the combined heat and power network, the redevelopment of the Aberdeen Exhibition and Conference Centre, and the planned expansion of the NHS Grampian site at Forresterhill. The developers of both these sites will be engaged to discuss options around the use of fuel cell CHP systems at each site.

Actions:

Engage developers in discussions for a stationary fuel cell demonstrator project within the City;
work with Aberdeen Heat & Power, the new Aberdeen Exhibition and Conference Centre and Aberdeen hospital.

The Transport for London, Palestra building boasts the largest capacity fuel cell operating in London. The fuel cell forms part of an integrated tri-generation system providing electrical energy, heat and cooling to the building.

OBJECTIVE 5:

Encourage the development of the hydrogen economy's supply chain, seeking opportunities for the region's existing energy expertise to diversify and benefit from this growing industry

Hydrogen presents an economic opportunity for the City Region both in the short and medium term (2015-2020) through local supply chain development as a result of the operation of hydrogen production, distribution and refuelling infrastructure in the area as well as vehicle support infrastructure and in the longer term (2020 and beyond) though diversifying the oil and gas sector.

Within the next 30-35 years it is predicted that oil reserves in the North Sea will be fully exploited therefore there will be a need to diversify the employment opportunities in the Aberdeen City region. It is important to act proactively now to ensure the economic readjustment required by the City over this period is positive and hydrogen presents an opportunity for this.
The City Council will use its current hydrogen deployment activity to promote nearer term growth opportunities in the region such as working with private sector organisations to maximise local benefits (for example establishing local support centres or new assembly or training facilities) whilst also having an eye on the longer term goal of industry diversification.

From discussions with members of the oil and gas sector it is evident that the existing skills base is well placed to capitalise on the opportunities presented by an emerging hydrogen sector. Areas of overlap between oil and gas skills and the hydrogen sector include:

- Gas storage and distribution;
- Safety planning, regulation and enforcement for hazardous gases;
- Handling of high pressure gases;
- Design and production engineering;
- Manufacture of storage vessels, compressors, balance of plant;
- Plant maintenance.

Actions:

Encourage the development of a local hydrogen supply chain by:
- Ensuring vehicle and infrastructure deployments are supported by local staff trained in hydrogen maintenance;
- Support OEMs in establishing hydrogen vehicle support centres at local dealerships;
- Engage with Aberdeen's Universities, North East College and oil and gas training organisations to support the provision of training and education in the hydrogen field, as well as vocational skills relevant to the sector;
- Work with the wider region to identify areas where investments may be more attractive or the development of the supply chain may be feasible earlier, when skills shortages or high supply chain costs are seen as barriers against inward investment.

Maximise the involvement of the oil and gas industry
- Engage early with the oil and gas supply chain to encourage involvement;
- Encourage the transfer of relevant skills, for example handling of compressed gases, storage etc.

OBJECTIVE 6:

Promote a greater understanding and acceptance of hydrogen technologies through communication and education activities

Educating and raising awareness to stakeholder groups will be a significant factor contributing to successful commercialisation and acceptance of hydrogen technologies. Aberdeen City Council is committed to educating key target audiences that will play a role in achieving a hydrogen economy including the general public, teachers and students, national and local government representatives, safety and code officials, and potential commercial end-users. An educated and skilled workforce is essential to building a regional hydrogen economy and will need to be trained to manage, build and maintain hydrogen infrastructure and equipment.

Through the projects already underway, up-skilling of the workforce is taking place, with staff being trained to drive and maintain hydrogen vehicles. In addition the inaugural Aberdeen Schools Hydrogen Challenge took place in 2014. This was a partnership project between Aberdeen City Council, First Group and Arcola Energy to support the roll out of hydrogen buses in Aberdeen. Pupils from nine secondary schools across Aberdeen had the opportunity to engage with fuel cells, challenging them to design the most fuel efficient miniature hydrogen powered vehicle. In ten 90 minute workshops, teams of students worked with custom-designed Lego kits and 1.5W hydrogen fuel cells to engineer efficient vehicles. Through the creative application of science and technology, students develop scientific enquiry skills and knowledge about the role hydrogen will play within a future low-carbon society.

Aberdeen Hydrogen Schools Challenge 2014 Winners, Dyce Academy

Actions:

Identify the skills and training needs of the current and future hydrogen sector and develop educational materials where appropriate, particularly for early adopters;

Support the take-up of hydrogen technologies by the public, businesses and government agencies through communication of high profile demonstration projects such as the Aberdeen Hydrogen Bus Project;

Work with the EU and other partners to become a centre of excellence for hydrogen and fuel cell technologies;

Work with education providers to integrate hydrogen into the curriculum for excellence; through activities such as the Aberdeen Hydrogen Schools Challenge;

Undertake a public engagement / outreach programme to raise the profile of H_2 Aberdeen activities, improve levels of awareness of hydrogen technologies and encourage widespread acceptance;

Be an active partner in the HYACINTH (hydrogen acceptance in the transition phase) project; to gain a deeper understanding of the social acceptance of hydrogen technologies across Europe as well as to develop a communication and management toolbox;

Increase awareness of the opportunities for local companies presented by hydrogen by delivering a programme of stakeholder events; In particular, engage oil and gas industry;

Work with research and development organisations to address key market barriers to the use of hydrogen as an energy vector; including composite materials testing, making more robust fuel cells and remote power opportunities for the oil & gas sector.

Rachel Sharp, HyTrEc Project Manager presenting at the Hanover Messe, Group Exhibit Hydrogen, Fuel Cells and Batteries, April 2014

OBJECTIVE 7:

Ensure strategy and policy development at all levels of government are supportive of hydrogen technologies

Policy and regulation are key instruments to encourage early adoption of hydrogen technologies. It is essential for policy and regulation at all levels (European, National and Local) to support low emission vehicles including hydrogen technologies in order to help to decarbonise road transport and the grid, reduce greenhouse gas emissions and improve air quality.

Actions:

Ensure hydrogen technologies are considered and where appropriate supported in all appropriate local policy and guidance including the:

- Aberdeen Air Quality Action Plan;
- Aberdeen City & Shire Strategic Development Plan;
- Aberdeen City Council Carbon Management Programme;
- Aberdeen City Local Housing Strategy;
- Aberdeen Local Development Plan;
- Aberdeen Regional and Local Transport Strategies;
- Energetica Corridor Development Guidance;
- Sustainable Urban Mobility Plan.

PART 3 - DELIVERING THE STRATEGY

The existing investment in Aberdeen's hydrogen projects (particularly in infrastructure) places Aberdeen in a strong position where there is no need to worry about the "chicken and egg" situation common to most areas; that is what comes first the vehicles or the refuelling stations.

The development of the second refuelling station means that sufficient infrastructure will be in place to allow the build-up of demand from vehicle deployments, before demand justifies any future infrastructure investment. Therefore, near term actions will focus on securing a hydrogen demand for example by ensuring bus operation beyond 2018 as well as adding new Council and private fleets, followed by new infrastructure investment from 2018 when capacity will be maximised.

The Council has already committed over £3.4 million towards hydrogen and fuel cell projects and this has resulted in over £21 million investment to the City. To meet the objectives of the strategy further significant investment will be required however it is envisaged that the majority of funding will come from external sources with Aberdeen City Council working in partnership with both the public and private sector to deliver the aims of the strategy. Aberdeen City Council will continue to secure additional funding sources for example from Government, the private sector and other alternative outlets some of which are outlined in Table 2 Potential Funding Sources.

Source	Description	Likely Size of Funding	Timescales
FCH JU (FCH 2 JU)	Public-privatepartnership between EC and industry, to advance the commercialisation of hydrogen and fuel cells	Up to 70% under Horizon 2020 with an overall budget of more than €1.3 billion, to be invested between 2014–2020	Annual calls for proposals 2014-20
TSB / Innovate	UK Government-run body to help fund innovation in a range of technology areas	Up to 60% forSMEs (50% otherwise)	Regular calls for proposals
Structural funds	EU funds for encouraging development across a range of thematic objectives	Up to 40% of project value	Annual calls for proposals 2014-20
UK Government	UK Government Ultra-Low Emissions Strategy – Ultra-Low Emissions Strategy launched in 2013 -£11m initial funding to support H_2 rollout in the UK	£2m funding for public sector vehicles, £9m for up to 15 HRS by end of 2015	Details of spend announced late 2014
Scottish Government	Has provided ad-hoc funding in the past, e.g. for the Aberdeen hydrogen bus project	Funding would be on an ad-hoc basis	N/A

KEY PRIORITIES (2015-2018)

The key priorities for the period 2015-2018 are detailed below.

Project	Outline	Delivery	Resource
Build a second Refuelling Station - Aberdeen City Hydrogen Energy Storage project	Build a second station with 350 & 700 bar capability in order to attract early releases of passenger cars	Aberdeen City Council,	**Total Budget: £1.9million (excluding civil works costs)** • Aberdeen City Council: £1.136 million • European Regional Development Fund: £758,000 **Civil works funded by:** Interreg North Sea Region Programme and Transport Scotland.
Deploy a small number (<5) of OEM first generation vehicles.	Engage with passenger car manufacturers to attract them to the region. Work with local partners to demonstrate the potential of these vehicles.	Aberdeen City Council, external funders to be confirmed	At the EPI Committee on 4th Sept 14 Aberdeen City Council approved the estimated expenditure of £250,000 for up to 2 Hyundai ix35 fuel cell electric vehicles from external grants with no cost to the Council. Committee Report: EPI/14/249 – 4th September 2014
Council deployment of an expanded fleet of range extended fuel cell vans ~10	Act as an early adopter for new vehicle types by expanding the fleet of range extended vehicles from 2 to 12.	Aberdeen City Council, external funders to be confirmed	At the EPI Committee on 4th Sept 14 Aberdeen City Council approved the expenditure to purchase up to 10 hydrogen plug in fuel cell electric vehicles with an estimated expenditure of £366,000. It was noted that the cost of 5 of the 10 hydrogen plug in fuel cell electric vehicles will be purchased by the Council as part of normal fleet replacement (an estimated £71,000) with the balance coming from an external funding source (an estimated £295,00). Committee Report: EPI/14/249 – 4th September 2014
Work with bus operators to ensure a second major bus deployment from 2018	Aberdeen City Council is a partner in the FCHJU's 'Bus Commercialisation Study' which could expand the bus fleet in the city from 2017/8. A target deployment of 15 buses by 2018 supporting a third major HRS in a strategic location. This deployment is subject to a) cost reduction for fuel cell buses (<£500k) and b) successful operation of the initial deployment of 10 buses	Aberdeen City Council, Scottish Cities Alliance, Transport Scotland, Scottish	The Scottish Cities Alliance has funded a one year fixed term post to take this project forward. This post is hosted by Aberdeen City Council. **Total Budget: £68k Scottish Cities Alliance** Bus deployments will be supported by proposed match funding from the FCH JU of up to €200,000 per bus, €1m per refuelling station.

ACTION PLAN

A range of well-timed deployment and engagement activities are required to secure the ambitious aims of this strategy.

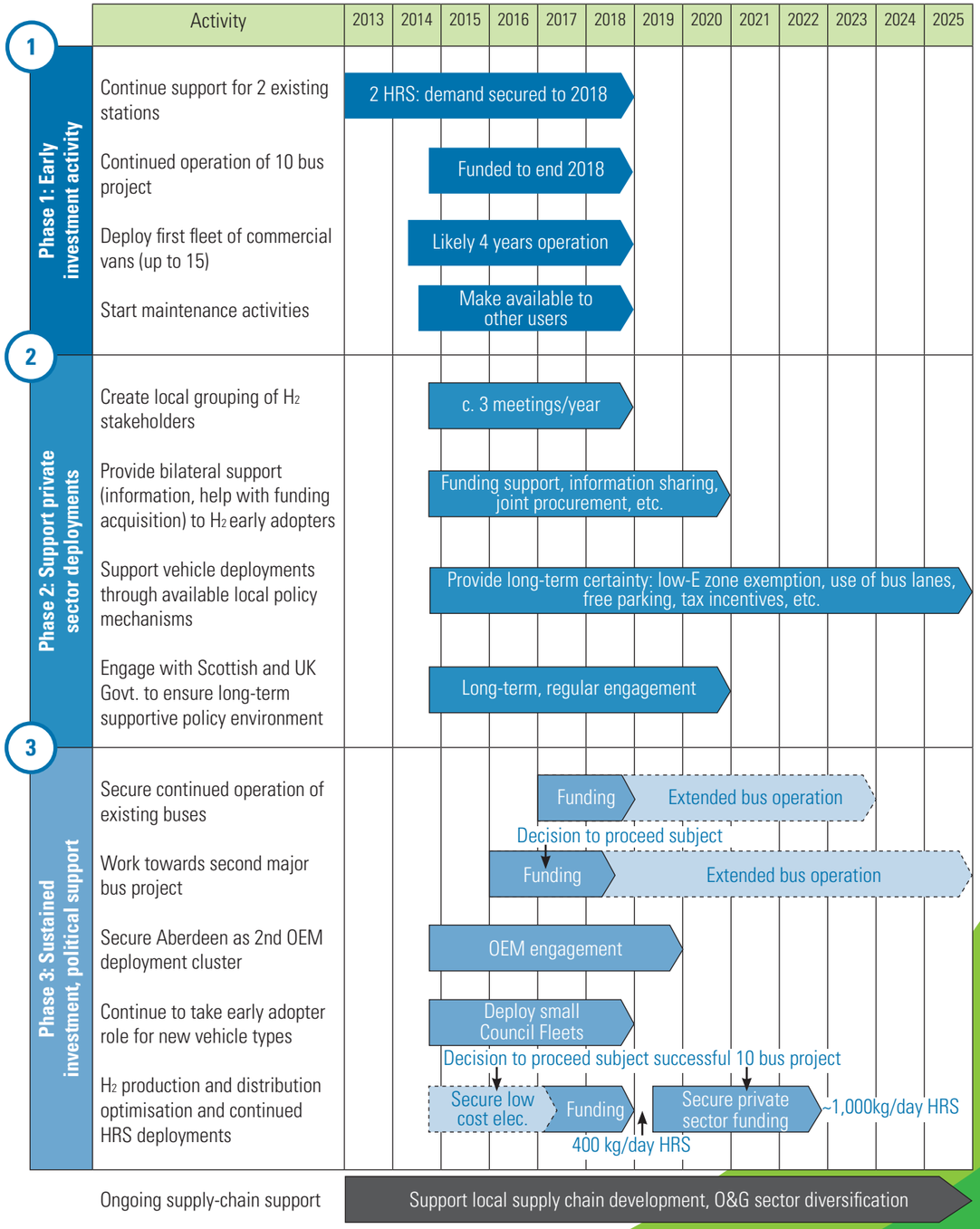


Figure 12: Phased implementation plan

To assist in the delivery of this Strategy and Action Plan progress will be monitored via the indicators and regular reports will be provided to the Council and its stakeholders. The Aberdeen City Region Hydrogen Strategy will be updated every 5 years.

VEHICLE DEPLOYMENTS							
Objective 1: Promote Vehicle Deployments by a range of stakeholders in the region							
Actions		**Sub Actions/Tasks**		**Delivery Partners / Stakeholders**	**Resource Implication / Funding**	**Timescale / Target**	**Indicators**
1.1	**Establish a H_2 Aberdeen stakeholder group**	1.1.1	Create dialogue among key industry and local stakeholders by establishing regular communication channels. Use this forum to update on latest progress in the region, agree priorities and build a consensus for deploying vehicles to the region.	ACC, vehicle manufacturers, fleet operators, public sector organisations, car clubs	Officer time	2015-2025	Number of stakeholders involved per year
		1.1.2	Provide a platform for project development, discussing common issues and funding bids	ACC	Officer time	2015-2025	Number of new projects initiated
		1.1.3	Establish a programme of events to share knowledge, skills and experiences.	ACC	Officer time	2015-2025	Number of events held
		1.1.4	Define and assist in the development of industry and government policy and regulation to support a hydrogen economy	ACC, Scottish Government, UK Government, Transport Scotland, Office of Low Emission Vehicles (OLEV)	Officer time	2015-2025	Input to the national hydrogen strategy
		1.1.5	Create public awareness with industry, academia, and government regarding the benefits and uses of fuel cell and hydrogen technologies use efficiency through	ACC, Scottish Hydrogen & Fuel Cell Association	Officer time	2015-2025	2015-2025 Number of stakeholders involved per year
1.2	**Provide bilateral support to interested parties**	1.2.1	Ensure potential end-users have access to first-hand advice from existing end-users – including through the H_2 stakeholder grouping	ACC	Officer time	2015-2025	Literature developed and distributed to potential end users.
		1.2.2	Offer potential end-users the support of the Council in any external initiatives to deploy H_2 vehicles, e.g. through sharing lessons learned/best practice, supporting planning or funding applications, etc.	ACC	Officer time	2015-2025	
1.3	**Support potential end-users in evaluating external funding options**	1.3.1	Work with interested parties to guide them through the process of preparing any applications for external funding, or considering developing joint procurement initiatives	ACC	Officer time	2015-2025	Number of interested parties assisted by ACC
		1.3.2	Provide best-practice guidance on accessing different funding sources e.g. Fuel Cells & Hydrogen Joint Undertaking, Transport Scotland, Structural Funds, etc.	ACC	Officer time	2015-2025	Amount of external funding secured by end-users
		1.3.3	Provide political support and buy-in to funding applications	ACC	Officer time	2015-2025	
		1.3.4	Support joint procurements through hosting 'brokerage' events, or putting potential partners in contact with each other	ACC	Officer time	2015-2025	
1.4	**Support vehicle deployments through available policy mechanisms**	1.4.1	Explore options for providing a supportive regional and national policy framework for adopters of H_2 vehicles, e.g. through allowing H_2 drivers to access free parking, use bus lanes, enter restricted zones, other tax incentives, etc. Where possible, measures adopted should provide long-term certainty to adopters of H_2 vehicles.	ACC, Transport Scotland, Scottish Government	Officer time	2015-2025	Options appraisal of potential policy incentives
1.5	**Engage with UK Government and UK H_2 Mobility**	1.5.1	Engage with UK partners to ensure that Aberdeen is on the map as a leading early adopter region following deployments in the South East around London	ACC, Transport Scotland, Department for Transport, Office of Low Emission Vehicles	Officer time	2015-2025	Input to the national hydrogen strategy
		1.5.2	Encourage a dialogue with UK to ensure a close alignment of Aberdeen regional policies and strategies with the UK-wide policy framework	ACC, Transport Scotland Department for Transport, Office of Low Emission Vehicles	Officer time	2015-2025	
1.6	**Coordinate with other regions deploying Hydrogen**	1.6.1	Work closely with other regions (e.g. North East England) to create a 'hydrogen highway' linking South East England to Aberdeen through the major road network, thereby allowing early national corridors and supporting the attractiveness of H_2 vehicles in Aberdeen	ACC, Scottish Cities Alliance, Scottish Government, Transport Scotland, UK Government.	Officer time	2015-2025	Number of hydrogen refueling stations in operation along the East Coast
1.7	**Extend operation of the 10 buses**	1.7.1	Identify budgets to fund the re-furbishing of fuel cells and continued operation of the current fleet of hydrogen buses from 2018	ACC, bus operators, Transport Scotland, Scottish Government.	Officer time Explore external funding options	2015-2018	Number of fuel cell electric buses from the original fleet in operation post 2018
1.8	**Work with bus operators to ensure a second major bus deployment from 2018**	1.8.1	Develop a project to expand the bus fleet in the city from 2017/8, for example through initiatives such as the FCHJU's 'Bus Commercialisation Study'. Target 2018 for deployment of >15 buses to the region, supporting a third major HRS in a strategic location This deployment should be subject to a) cost reduction for FC buses (<£500k) and b) successful operation of the initial deployment of 10 buses	ACC, Scottish Cities Alliance, bus operators, bus manufacturers, FCHJU	Scottish Cities Alliance, FCHJU, Explore external funding options	2015-2020	Number of fuel cell electric buses in operation post 2018
1.9	**Engage with passenger car OEMs to attract them to the region**	1.9.1	Seek to deploy a small number (<5) of OEM first generation vehicles, working with local partners to demonstrate the potential of the OEM vehicles	ACC, CoWheels, vehicle manufacturers	Explore funding options	2015-2020	Number of hydrogen vehicles deployed per year
		1.9.2	Begin direct engagement with early OEMs (Toyota, Hyundai, Honda, Daimler), with the aim of ensuring that they consider Aberdeen as the second obvious cluster for deploying vehicles to the UK after the South East	ACC, Transport Scotland, local stakeholders	Officer time, Travel as per external funding strategy	2015-2025	

1.10	**Act as early adopter for new vehicle types made available to the region**	1.10.1	Council deployment of an expanded fleet of range extended FC vans, ~10 (2015)	ACC, Transport Scotland,	ACC, Interreg IVB (already allocated), Transport Scotland	2015-2020	Number of hydrogen vehicles deployed per year
		1.10.2	Deploy small numbers of new hydrogen vehicle types within council fleets as they become available and as justified by funding/fit with council requirements. Provide access for trials to potential private sector adopters	ACC, vehicle manufacturers, external funders,	Explore funding options	2016-2025	

PRODUCTION AND SUPPLY

Objective 2: Expand production and distribution of renewable hydrogen

Actions		Sub Actions/Tasks		Delivery Partners / Stakeholders	Resource Implication / Funding	Timescale / Target	Indicators
2.1	**De-risk medium term H_2 supply costs and logistics**	2.1.1	Assess the possibility of accessing low-cost electricity prior to any connection to the grid	ACC, local electricity generators,	Staff time	2015-2018	Electricity price
		2.1.2	For future HRS sites, conduct feasibility assessments to compare the option of generating H_2 on-site versus generation off-site linked to stranded renewable resources. In particular, identify and engage with local funded and approved wind generation projects which have not been deployed due to grid constraints or currently operate with constraints, to assess the feasibility of generating and then distributing low cost H_2 from these sites	ACC, local electricity generators	Staff time Explore funding options	2018-2025	Feasibility study into hydrogen generation and distribution options
2.2	**Optimise production and distribution logistics for the region**	2.2.1	Work closely with regional industrial gas distribution companies to understand the supply options available for reliable and low-cost H_2 distribution mechanisms – in particular high-pressure tube-trailer delivery and point-to-point based pipeline distribution	ACC, Gas distribution companies e.g. BOC, Air Products, Air Liquide and Dominion Gas	Staff time Explore funding options	2018-2025	
		2.2.2	Assess the options and costs for co-location of production and refueling stations or offsite production and distribution to centrally-located HRS in Aberdeen – with the aim of optimising overall H_2 production and distribution costs.	ACC, Gas distribution companies e.g. BOC, Air Products, Air Liquide and Dominion Gas	Staff time Explore funding options	2018-2025	
2.3	**Continue to expand in-frastructure deployments**	2.3.1	Continue to support the expansion of Aberdeen's refuelling infrastructure, through promoting engagement with refuelling infrastructure providers and supporting demand from additional vehicle deployments. Any decisions to deploy further HRS should be subject to clear stage gates based on proven demand growth at existing sites and clear signals from bus and car OEMs that affordable vehicles are coming to market	ACC, refuelling infrastructure providers	Staff time Explore funding options	2015-2025	Number of hydrogen refueling stations built

2.3	Continue to expand infrastructure deployments	2.3.2	Evaluate business models for continued public sector involvement in new HRS and develop a timeline and conditions for a transition towards new deployments being driven by the private sector	ACC, local stakeholders, refuelling infrastructure providers	Staff time Explore funding options	2018-2020	Business plan for new refuelling stations

INFRASTRUCTURE

Objective 3: Develop hydrogen refueling infrastructure

Actions		Sub Actions/Tasks		Delivery Partners / Stakeholders	Resource Implication / Funding	Timescale / Target	Indicators
3.1	**Leverage existing infrastructure**	3.1.1	Ensure the public availability of affordable and 'green' hydrogen from Kittybrewster and any future stations.	ACC, BOC, hydrogen fuel providers	Funding allocated through the Aberdeen Hydrogen Bus Project / Explore funding options for future stations	2015-2025	Price of hydrogen fuel
		3.1.2	Provide shared facilities for maintenance of hydrogen vehicles by trained technicians, with a view to continued support in existing, or new shared maintenance facilities.	ACC, local vehicle end-users, training providers	Funding allocated through the Aberdeen Hydrogen Bus Project	2015-2018	Operational maintenance facility in the City
3.2	**Deploy a second hydrogen refueling station**	3.2.2	Build a second station with 350 & 700 bar capability in order to attract early releases of passenger cars.	ACC, Hydrogenics, Logan Energy	Officer time, Funding allocated through ACC, EU structural funds, Transport Scotland	2015	Operational refuelling station to the South of the City
3.3	**Minimise exposure to high electricity prices at Kittybrewster**	3.3.1	Evaluate options for optimising operations to secure lower cost electricity for the Kittybrewster site, with a focus on optimising the electrolyser operation with respect to grid prices	ACC, BOC, SSE	Officer time	2015-2018	Lower electricity cost secured
		3.3.2	Investigate options for Kittybrewster electrolysers to attract grid balancing revenues	ACC, BOC, SSE	Officer time	2015-2018	Grid balancing revenues secured
3.4	**Secure low-cost electricity for the second station**	3.4.1	Engage with the most likely enablers of long-term low cost electricity supply in time for the deployment of the second Aberdeen HRS	ACC, local electricity suppliers	Officer time	2015	Low electricity cost secured

3.5	**Pursue opportunities to work with areas out with the City to expand the infrastructure network**	3.5.1	Expanding the infrastructure network will encourage the take up of Hydrogen technologies across Scotland. In particular, continue to work with the Scottish Cities Alliance Hydrogen Action Team	ACC, Transport Scotland Aberdeenshire Council, Scottish Cities Alliance	Officer time, Scottish Cities Alliance, FCHJU Explore further external funding options	2015-2025	Number of hydrogen refueling stations across Scotland.

NON TRANSPORT APPLICATIONS

Objective 4: Expand the roll out of other tried and tested or innovative hydrogen uses

Actions		Sub Actions/Tasks		Delivery Partners / Stakeholders	Resource Implication / Funding	Timescale / Target	Indicators
4.1	**Explore the roll-out of other tried and tested or innovative hydrogen uses**	4.1.1	Engage developers in discussions for a stationary fuel cell demonstrator project within the City; in particular the new Aberdeen Exhibition and Conference Centre	ACC, Henry Boot,	Officer time, Partners, External funding,	2015-2025	Demonstration of a stationary fuel cell within the City

SUPPLY CHAIN

Objective 5: Encourage the development of the hydrogen economy's supply chain

Actions		Sub Actions/Tasks		Delivery Partners / Stakeholders	Resource Implication / Funding	Timescale / Target	Indicators
5.1	**Encourage the development of a local hydrogen transport supply chain**	5.1.1	Ensure vehicle and infrastructure deployments are supported by local staff trained in hydrogen maintenance	ACC, hydrogen sector, training providers	Officer time	2015-2020	Number of staff trained
		5.1.2	Support OEMs in establishing hydrogen vehicle support centres at local dealerships	ACC, Car manufacturers, hydrogen sector	Officer time	2015-2020	Number of vehicle support centres
		5.1.3	Engage with Aberdeen's Universities and oil and gas training organisations to support the provision of training and education in the hydrogen field, as well as vocational skills relevant to the sector	ACC, Aberdeen University, Robert Gordon University, Scottish Enterprise, Oil & Gas sector	Officer time Explore funding options	2015-2025	Levels of training provided
		5.1.4	Identify areas within the wider region where investments may be more attractive or the development of the supply chain may be feasible earlier, when skills shortages or high supply chain costs are seen as barriers against inward investment.	ACC, Aberdeenshire Council, Scottish Cities Alliance	Officer time Explore funding options	2015-2020	Local authority areas identified with potential for hydrogen technologies
5.2	**Maximise the involvement of the oil and gas industry**	5.2.1	Engage early with the oil and gas supply chain to encourage involvement	ACC, Scottish Enterprise, Oil & Gas sector	Officer time	2015-2020	Number of oil and gas companies involved in hydrogen
		5.2.2	Encourage the transfer of relevant skills, for example handling of compressed gases, storage etc	ACC, Scottish Enterprise, Oil & Gas sector	Officer time	2015-2020	

EDUCATION & AWARENESS

Objective 6: Promote a greater understanding and acceptance of hydrogen technologies through communication and education activities

Actions		Sub Actions/Tasks		Delivery Partners / Stakeholders	Resource Implication / Funding	Timescale / Target	Indicators
6.1	**Promote a greater understanding and acceptance of hydrogen technologies**	6.1.1	Identify the skills and training needs of the current and future hydrogen sector and develop educational materials where appropriate, particularly for early adopters	ACC, Hydrogen industry partners	Officer time, External funding e.g. Interreg / HyTrEc 2	2015-2018	Complete skills and training needs assessments
		6.1.2	Support the take-up of hydrogen technologies by the public, businesses and government agencies through communication of high profile demonstration projects	ACC, Aberdeen Hydrogen Bus Project partners, HyTrEc project partners	ACC, Project funding	2015-2018	Complete and Disseminate project case studies. Hydrogen Bus Project Refuelling Station Launch event.
		6.1.3	Work with the EU and other partners to become a centre of excellence for hydrogen and fuel cell technologies.	ACC, National partners, European Union,	Officer time, External funding, UNIDO	2015-2020	Aberdeen City regarded as a Centre of Excellence
		6.1.4	Work with education providers to integrate hydrogen into the curriculum for excellence	ACC, Schools, Colleges, Education providers	Officer time, External funding and sponsorship	2015-2020	Number of pupils taught about hydrogen for example through the Aberdeen Hydrogen Schools Challenge
		6.1.5	Undertake a public engagement / outreach programme to raise the profile of H_2 Aberdeen activities, improve levels of awareness of hydrogen technologies and encourage widespread acceptance.	ACC, project partners, hydrogen industry,	Officer time, Explore sponsorship options	2015-2020	Number of citizens reached and number of events attended.
		6.1.6	Be an active partner in the HYACINTH (hydrogen acceptance in the transition phase) project; to gain a deeper understanding of the social acceptance of hydrogen technologies across Europe as well as to develop a communication and management toolbox	ACC, project partners	Officer time, FCHJU funding	2014-2016	Project objectives met
		6.1.7	Increase awareness of the opportunities for local companies presented by hydrogen by delivering a programme of stakeholder events; In particular, engage oil and gas industry	ACC, Project partners, Industry partners.	Officer time, External funding	2015-2025	Number of stakeholder events held per year

		6.1.8	Work with research and development organisations to address key market barriers to the use of hydrogen as an energy vector; Composite materials testing; Making more robust fuel cells; Remote power opportunities for oil & gas sector etc.	ACC, Robert Gordon University, ULEMCo Ltd	Innovate UK, Energy Catalyst Programme	2015-2025	Number of research and development projects initiated

POLICY							
Objective 7: Ensure strategy and policy development at all levels of government are supportive of hydrogen technologies							
Actions		**Sub Actions/Tasks**		**Delivery Partners / Stakeholders**	**Resource Implication / Funding**	**Timescale / Target**	**Indicators**
7.1	**Ensure strategy and policy development at all levels of government are supportive of hydrogen technologies & infrastructure**	7.1.1	Ensure hydrogen technologies are considered/supported in all appropriate local policy and guidance including the: • Aberdeen Air Quality Action Plan; • Aberdeen City & Shire Strategic Development Plan; • Aberdeen City Council Carbon Management Programme; • Aberdeen City Local Housing Strategy; • Aberdeen Local Development Plan; • Aberdeen Local & Regional Transport Strategies; • Energetica Corridor Development Guidance; • Sustainable Urban Mobility Plan.	ACC, Aberdeenshire Council, NESTRANS, Energetica, Aberdeen City & Shire Strategic Development Planning Authority	Officer time	2015-2025	Number of policies hydrogen is considered in
7.2	**Campaign for FCEV to receive equal treatment with other low emission vehicles / electric vehicles in national incentive schemes**	7.2.1	Input to the development of national hydrogen policy and incentives by Scottish Government and Transport Scotland by contributing our experience and lessons learned to date.	ACC	Officer time	2015-2025	Number of consultations/ policy/ strategy input to
7.3	**Support the case for universal regulations, codes and standards for hydrogen across Europe and beyond**	7.3.1	Support extended across Europe and beyond in areas such as: • Hydrogen purity, so that providers and suppliers can coordinate their products; • Safety protocols, to ensure long term viability and public acceptance; • Fueling stations, to facilitate the spread of infrastructure and encourage consumer acceptance; • Retail applications, to promote widespread deployment.	ACC, industry partners	Officer time	2015-2025	Number of consultations/ policy/ strategy input to

ACC – Aberdeen City Council

BOC – BOC Linde Group Industrial Gases

FCHJU – Fuel Cells and Hydrogen Joint Undertaking

H2 – hydrogen

HRS – Hydrogen Refuelling Station

HyTrEc – Hydrogen Transport Economy project

LTS – Local Transport Strategy

NESTRANS – North East of Scotland Transport Partnership

OEM – Original Equipment Manufacturer

SSE – Scottish and Southern Energy

ULEMCo - Ultra Low Emission Mileage Company Ltd

H2 Aberdeen

ABERDEEN CITY COUNCIL

ABERDEEN INVESTLIVEVISIT aberdeencity.gov.uk/ilv

areg Aberdeen Renewable Energy Group

EUROPEAN REGIONAL DEVELOPMENT FUND

HyTrEc Hydrogen Transport Economy for the North Sea Region

The Interreg IVB North Sea Region Programme
Investing in the future by working together for a sustainable and competitive region