



HFC Opportunities and Energy Policy

The Future of Energy in Scotland



Nigel Holmes, SHFCA. Birmingham FCH2 31st May 2017


- Scotland’s journey to a Low Carbon Economy
- Scottish draft Climate Change Plan (RPP3)
- The new ‘Future of Energy in Scotland’ Strategy
- Exemplar H&FC Projects – 3 Case Studies
- Links with the HFC Roadmap
- H&FC Opportunities...



Scotland’s Transition to Low Carbon

Scotland’s transition to Renewable Energy

- Local Energy Systems & Distributed Power
- Energy Strategy – Whole Energy System Approach
- Hydrogen use for energy balancing & storage
- Scotland’s electricity now almost ‘carbon free’




Scotland’s last coal fired power station closed in March 2016



Scotland’s Ambitions for Reducing CO₂

- Reduce CO₂ emissions by 42% in 2020 (compared to 1990 baseline)
- Generate 100% of Scotland’s power* from Renewables
- Install 1 GW of Locally Owned Renewables

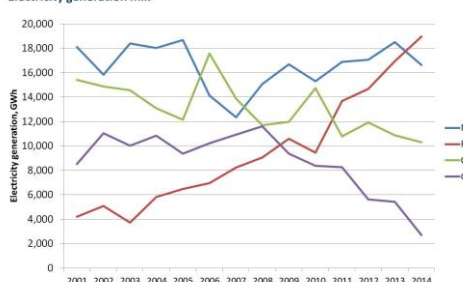


42%
(the answer to life, the universe and everything)

* In 2015 Scotland generated over 50% of its annual electrical demand from Renewables, and the CO₂ reduction was 46%

Scotland’s Power Generation Mix

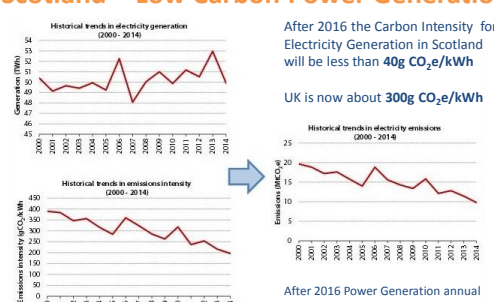
Electricity generation mix



Source: DECC

Footnote: No coal power generation in Scotland after April 2016

Scotland = Low Carbon Power Generation



After 2016 the Carbon Intensity for Electricity Generation in Scotland will be less than **40g CO₂e/kWh**

UK is now about **300g CO₂e/kWh**

After 2016 Power Generation annual emissions will be ~1.7 M tonnes CO₂e

Figure 2.1. Historical Trends in Electricity Generation, Emissions Intensity, and Total Emissions 2000-2014. From the 5th Report by the CCC on Scotland’s Progress towards meeting Emission Reduction Targets (published September 2016). Link: <https://documents.theccc.org.uk/wp-content/uploads/2016/09/Reducing-emissions-in-Scotland-2016-Progress-Report-Committee-on-Climate-Change.pdf>

Carbon Intensity of UK Grid

Figure 5.4 The carbon intensity of British electricity, showing the average and range for each week [187].

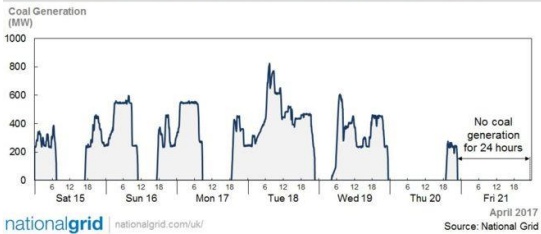


From HFC Supergen White Paper 'HFC in Future Energy Systems'

UK's First Coal-Free Power Day

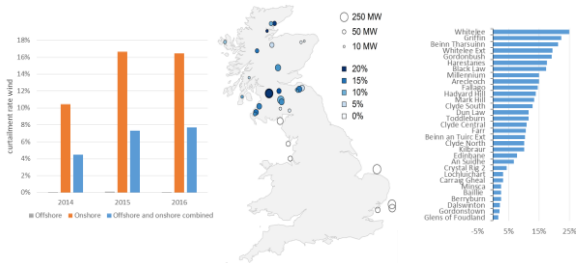
Great Britain goes without Coal Generation for 24 hours

Friday 21st April 2017 was the first 24-hour period since the 1880s where Great Britain went without coal-fired power stations.



UK's First Coal Free Day: 22nd April 2017

But Wind Increasingly Constrained



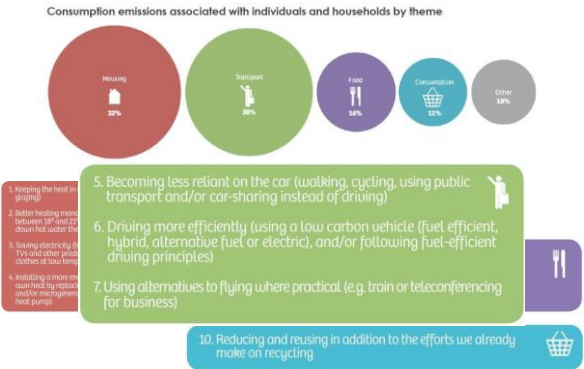
From Joos & Staffell “Short term integration costs of variable renewable energy: Wind curtailment and balancing in Britain and Germany”

New Climate Change Plan (RPP3)

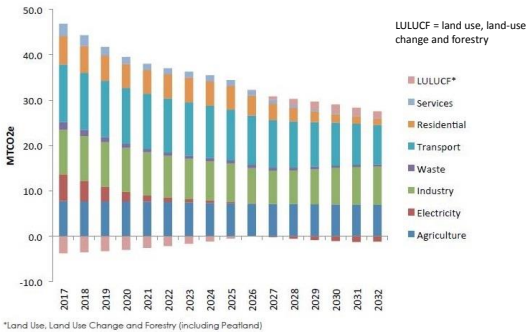
- Released 24th Jan 2017
- 2017-2032 plan
- 66% CO₂ reduction
- From 1990 baseline
- New Draft Energy Strategy to Support Climate Plan



CO₂ Emissions & Behaviour Change



Climate Plan Targets for 2032



CO₂ Reduction Pathway to 2032 (Climate Change Plan, January 2017)

CO₂ Reduction Targets by Sector

Table 2-1: Pathway to 2032 (envelopes in MCO₂e)

	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
Agriculture	7.8	7.7	7.7	7.7	7.6	7.5	7.4	7.3	7.2	7.2	7.1	7.1	7.0	7.0	7.0	6.9
Electricity	5.9	4.5	3.2	2.2	1.4	1.0	0.7	0.6	0.4	0.1	-0.2	-0.5	-0.9	-1.1	-1.3	-1.2
Industry	9.8	9.9	9.8	9.7	9.5	9.2	8.9	8.7	8.5	7.8	7.3	7.5	7.7	8.1	8.3	8.4
Waste	1.7	1.4	1.1	0.9	0.7	0.7	0.7	0.7	0.7	0.7	0.6	0.6	0.5	0.5	0.5	0.5
Transport	12.7	12.6	12.5	12.3	12.2	12.0	11.8	11.5	11.2	10.9	10.5	10.2	9.8	9.4	9.1	8.7
Residential	6.3	5.9	5.6	5.3	5.3	5.3	5.4	5.4	5.2	4.4	3.6	3.0	2.4	1.9	1.6	1.5
Services	2.7	2.4	1.9	1.6	1.4	1.3	1.3	1.4	1.3	1.1	0.9	0.6	0.4	0.3	0.1	0.1
LULUCF*	-3.8	-3.5	-3.3	-3.0	-2.6	-2.2	-1.7	-1.1	-0.5	0.1	0.8	1.3	1.7	1.9	1.8	1.5

*Land Use, Land Use Change and Forestry (including Peatland)

Targets informed by Scottish TIMES model and then agreed between departments where joint impacts likely

Climate Plan RPP3 Ambitions

Strengthened ambition of the Scottish Government to tackle climate change

The Scottish Government is committed to achieving the climate change targets set by the 2009 Climate Change (Scotland) Act – some of the most stretching ambitions in the world.

The 2016 Programme for Government commits the Scottish Government to a new Climate Change Bill, in response to the increase in global ambition in the UN Paris Agreement and including a new and more testing 2020 emissions reduction target.

RPP3 mentions Hydrogen more times than either Diesel or Petrol...

Building on our investment in both the Aberdeen H2 bus project and the Levermouth community energy project, we will continue to work with key partners to investigate the use of hydrogen as a transport fuel, as well as exploring wider environmental and economic opportunities of using hydrogen for energy applications – especially in promoting renewables, energy balancing and storage.

Policy outcome 2: Technologies critical to further industrial emissions reduction (such as carbon capture and storage, carbon capture and utilisation, and production and injection of hydrogen into the gas grid) are demonstrated at commercial scale by 2030.

There is one proposal which will contribute to the delivery of policy outcome 2.

‘The Future of Energy in Scotland’

Supports the Climate Plan with three main themes:

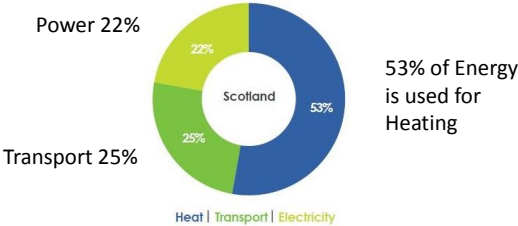
- 1. A stable, managed energy transition
- 2. A ‘whole-system’ view of the challenge
- 3. A local vision for energy provision

Uses a whole energy systems approach with supporting Scottish TIMES model.



Scottish Final Energy Demand

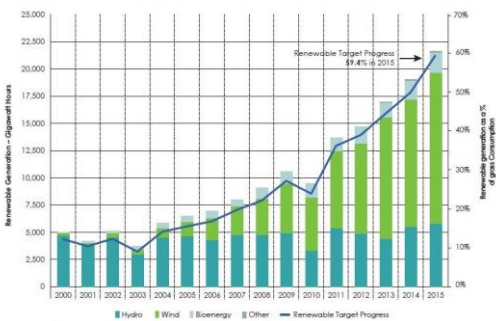
Diagram 6: Energy demand in Scotland



Source: <https://www.gov.uk/government/collections/total-final-energy-consumption-at-sub-national-level>

Growth in Renewable Energy

Diagram 4: Electricity generated (GWh) from renewable sources, Scotland, 2000-2015



Heating and Household Energy Use

Diagram 7: Primary heating fuels in Scotland

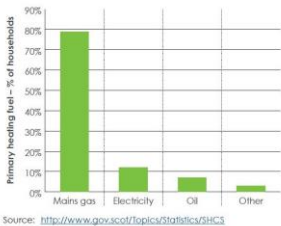
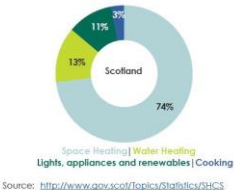
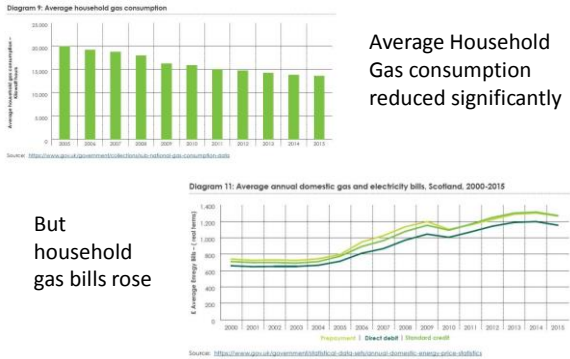


Diagram 8: Household energy use in Scotland

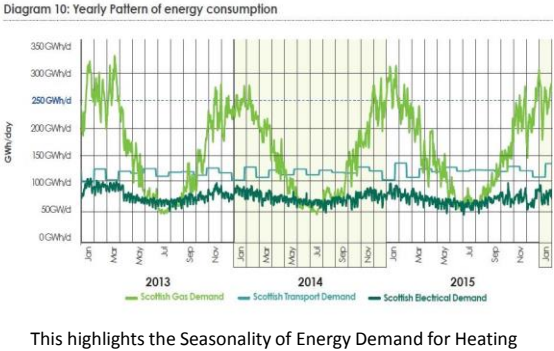


79% of heating is by gas, with 74% used for space heating

Household Gas Use & Utility Costs



Seasonal Demand Challenge...



30% Less Energy Consumption by 2030?

ENERGY CONSUMPTION TARGET

12%

reduction in total final energy consumption by 2020

In 2014, final energy consumption was

15.2%

lower than baseline 2005-2007

Given the integrated nature of energy systems, we are keen to ensure that the Scottish target is consistent with ambition across the EU energy system, and we would like to seek views on whether we should set a new 2030 energy efficiency and how best to reflect the EU's ambition to implement an EU-wide 30% energy efficiency improvement by 2030.

Although our previous target was based on final energy consumption, we are considering whether it is more appropriate to set a new target that captures changes in the intensity of our energy use which takes account of the effect of, for example, economic cycles, energy prices and weather patterns on our energy consumption patterns²¹.

Scottish Policy: 3 Case Studies
Aberdeen Example

Building on our investment in both the Aberdeen H2 bus project and the Levenmouth community energy project, we will continue to work with key partners to investigate the use of hydrogen as a transport fuel, as well as exploring wider environmental and economic opportunities of using hydrogen for energy applications – especially in promoting renewables, energy balancing and storage.

Aberdeen’s Hydrogen Fleets

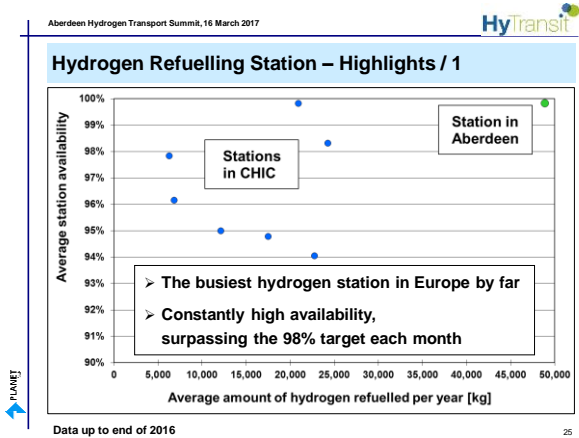


Europe’s Largest Fleet with 10 Hydrogen Fuel Cell Buses launched in Aberdeen March 2015, EU Supported

Hydrogen produced on Site



Hydrogen is produced for the first Aberdeen (bus) refueller at Kittybrewster by electrolysis of water.



Like many cities, the centre of Aberdeen is an Air Quality Management Area with NOx and Particulates (mainly from Diesel) causing health issues. Hydrogen vehicles are helping to address this problem

Second Refueller now Operational



2 of Aberdeen's 10 Toyota Mirai Fuel Cell Vehicles at the cove 700 bar facility

Policy: Levenmouth Example

Projects funded through Scottish Government schemes

Levenmouth Community Energy Project in Fife uses electricity produced locally by a 750kW wind turbine, supplemented by solar, to produce green hydrogen by electrolysis. The hydrogen it produces will fuel one of the largest fleets of dual fuel hydrogen-powered vehicles in Europe. Powered at site and by an additional dispenser at Bankhead, the system is utilised by the council's own fleet of hydrogen vehicles.

The Levenmouth project builds on the success of the Hydrogen Office development, and was made possible by the Local Energy Challenge Fund.



Building on our investment in both the Aberdeen H₂ bus project and the Levenmouth community energy project, we will continue to work with key partners to investigate the use of hydrogen as a transport fuel, as well as exploring wider environmental and economic opportunities of using hydrogen for energy applications – especially in promoting renewables, energy balancing and storage.



The Hydrogen Office in Methil

Hydrogen Office – Levenmouth Project

- Renewables: 750kW Wind
- & 160kW Photo-Voltaic
- 250kW PEM electrolyser
- 45kg Hydrogen storage
- Power from 100kW fuel cell
- Toshiba Energy Management System
- Private wire network to 9 buildings
- 2 x 24kg/day Vehicle Refuellers
- Fleet of 17 Hydrogen vehicles



Fleet of 17 Hydrogen Vehicles

- 10 Renault Kangoo electric vans, with hydrogen FC range-extender
- 5 Ford Transits owned by Fife Council, run on a mix of hydrogen and diesel
- 2 Refuse collection vehicles also owned by Fife Council, also running on a mix of hydrogen and diesel – these are a world-first
- All vehicles are dual-fuel, and so can operate even if hydrogen supply interrupted



Levenmouth Fleet – with 2 RCVs

- World first H2-ICE Refuse Collection V
- Diesel-hydrogen flex fuel
- Carry 5kg of hydrogen at 350 bar

Energy Strategy: Orkney Islands

Orkney's 'Surf and Turf' and 'BIG HIT' projects demonstrate a fully integrated energy model where hydrogen is produced using electricity from tidal and onshore wind turbines, stored in a fuel cell, and used to provide low carbon heat, power and transport. The projects will benefit the community through providing employment and training as well as reduced harbour electricity costs and increased revenue.

The Orkney Islands & BIG HIT

- Now generating more than 100% of Orkney's power* from Renewables
- Over 50MW of installed renewable capacity
- Hosts the European Marine Energy Centre



By 2014 Orkney was generating over 100% of its annual electrical demand from Renewables

EMEC Electrolyser : Surf 'n' Turf



High pressure PEM electrolyser supplied by ITM Power



Surf 'n' Turf is one of the first 'Local Energy Challenge Fund' supported innovative community renewables projects. Generate hydrogen from wind and tidal, to avoid grid limitations and develop local use.

Announced May 2016 : BIG HIT

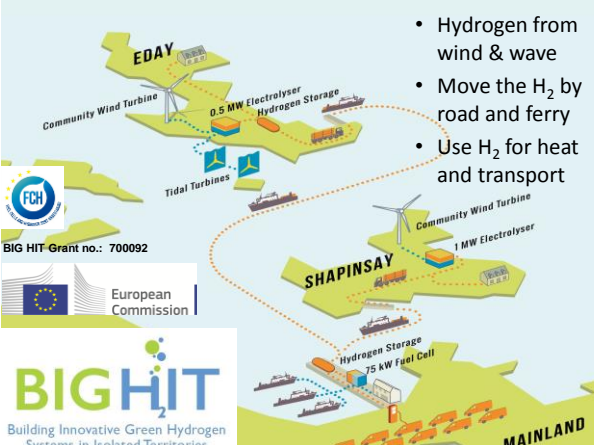


Shapinsay's 0.9MW local wind turbine

Announced in May 2016, using hydrogen made from renewable electricity and 1MW electrolyser to supply heat and transport (10 hydrogen vehicles in Kirkwall) and help overcome local grid constraints in Orkney. With €5m EU grant support for the BIG HIT project, funded by FCH 2 JU.



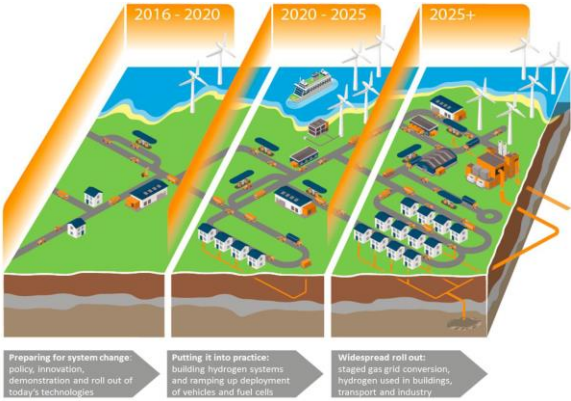
1MW balancing electrolyser



Hydrogen Moved by Tube Trailer



UK HFC Roadmap for Delivering Low Carbon Energy Targets (Nov 2016)



UK HFC Roadmap helped to shape energy policy thinking in Scotland

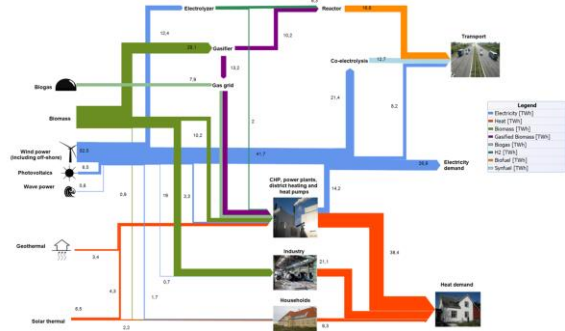
HFC Supergen White Papers

Four White Papers prepared by UK academic institutions



Intended as reference documents for policymakers

Energy Systems - Denmark 2050 Vision

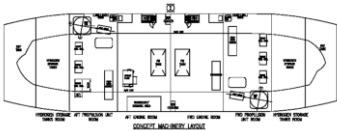


What next? Not just Road Transport



CMAL's MV Hallaig diesel-electric hybrid ferry undergoing sea trials in August 2013

- CMAL's diesel-electric hybrid ferry – built in Port Glasgow, Scotland
- Capable of carrying 22 cars or 2 large lorries
- Hydrogen evolution design is underway...



V2G : Toyota Mirai as ‘Vehicle to Grid’

- Energy stored as hydrogen in fuel tank (about 60kWhr)
- Fuel cell delivers electricity
- Connect to local grid
- Provide back-up power
- Use output socket, up to 9kW
- Can fills in gaps from intermittent wind and solar



Energy Into FCV Tank



Energy output to Grid

Hydrogen for Low Carbon Heat

- Hydrogen gas at scale will most likely require natural gas (methane) as the source feedstock and as such in order to be low carbon, carbon capture and storage facilities will be a necessary system requirement. Scotland is therefore uniquely placed to support an emerging hydrogen economy.
 - These proposals, at national scale, have the potential to substantially reduce the total system cost of decarbonisation, but they will require further innovation in technology, high-volume hydrogen production at an acceptable cost, and a carefully managed hydrogen ‘switch over’ – as with the switch to natural gas in the 1970s.
 - Coordinated activity by the public and private sectors over the next five to ten years will be essential to achieve any large-scale roll out of hydrogen and fuel cell technologies from the mid-2020s.
- 1.3.4 Some of these alternative energy sources may, for example, have the potential to reduce both the cost and the delivery barriers of policies or proposals in the current draft Plan, such as the replacement of natural gas by 100% pure hydrogen for space heating in some areas of the gas network.

Hydrogen and fuel cells mentioned in both Energy Strategy and Climate Change Plan.

Recognises that more work needs to be done in this area.

The Future of Energy in Scotland

10. The Scottish Government's 2050 energy vision is aligned to three themes:



Hydrogen and Fuel Cells can make a significant contribution to all 3 themes of the Energy Vision, and help deliver the 66% CO₂ reduction by 2032 as set out in the Climate Change Plan.

H&FC Opportunities

Many areas for further H&FC activity are set out in the new Scottish Climate Change Plan and draft Scottish Energy Strategy:

- collaborate with UK government, local government, industry and academia on the UK hydrogen routemap, establishing the strategic basis for hydrogen in the energy system, whilst continuing to fund innovative projects involving hydrogen.

Thanks for listening – Any Questions?

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