Evidence submission Professor Stuart Haszeldine, University of Edinburgh 25 Sept 2017
Energy in Scotland: Royal Society of Edinburgh EnergyInquiry@theRSE.org.uk
Stuart Haszeldine FRSE is Professor of CCS, researching in coal, oil, gas, nuclear, carbon storage, and energy

Summary

Scotland is engaged in a transition from almost complete dependence on fossil fuels, to almost complete independence from fossil fuels. Progress has been excellent since the 2009 Holyrood Climate Act, and is creating tens of thousands of jobs which replace the fading offshore hydrocarbon employment. But to achieve net-zero carbon emissions by mid-century will require substantial innovation and change. Important aspects are:

- Complete net-zero emissions appear possible and affordable for Scotland by 2050
- To decarbonise energy and economy means moving beyond more renewables
- Renewables with storage could enable most changes, but at large infrastructure cost
- Vectors such as hydrogen (from methane or from renewable electrolysis) may be of use
- Negative Emissions (NET) needed to balance Green House Gases (GHG) across economy
- NET can be delivered by BECCS, mineral weathering, or air capture. Innovation is required
- Carbon Capture and Storage (CCS) is a persistent need to balance industry, heat and NET
- Whole system analysis of energy is needed, to make prices and tradeoffs explicit

Background

The Committee on Climate Change decarbonisation presentation and report (25 Sept2017) makes clear that Scotland is leading in the UK, and that the UK is amongst the leading nations worldwide engaged in GHG emissions reduction and in radical transformation of energy towards a low-carbon future. And. The presentation webstreamed by Chris Stark of Scottish Government on 19 Sept makes it clear that practical energy transformation is also about strategic leadership, recognising fair pricing for a morally just transition, and is especially about changes of infrastructure at large-scale and long-duration.

To solve the political, policy, scientific and technological equations for Scotland requires that adequate answers are gained to two interlocked simultaneous questions. How can the carbon and GHG emissions budget be balanced to reach net-zero by mid-century? How can sources, distribution and use of energy be entirely transformed from over 90% hydrocarbon, to less than 10% hydrocarbon? Whilst also creating manufacture, and growing skills.

Scotland has very successfully decarbonised from 1990 to be ahead of targets in 2017, and barring unexpected changes of UK policy, will meet its 2020 GHG target. This is an almost incredible achievement, based on foundations of unwavering Scottish Government policy, ambition set by the 2009 Climate Act, annual reporting, and a 5 year review period.

Success to 2017 has been based on "easy" gains of closures of centralised industries, and abandonment of coal, then gas for centralised electricity generation. The transition to low-carbon renewable electricity is almost within grasp. What remains to achieve, is to capture much more of the manufacturing and maintenance wealth now created by domestic renewable electricity generation. That needs to be much more actively assisted by the Scottish business development agency. The second half of decarbonisation will be much more challenging, and will require radical changes to heat, to transport, and to carbon balancing. That can be achieved by GHG crossover between energy and other parts of the economy. Innovative decarbonisation holds immense opportunities for Scottish innovation and creation of new businesses and new models to underpin and enable disaggregated and new centralised, energy provision and distribution. As a global leader, Scotland should expect during the next 40 years to invest multiple tens of £Millions in pilot projects to grow new energy industries in Scotland, instead of losing invention to England or the USA. This can be a bottom-up re-industrialisation into a zero-carbon world.

It is necessary to abandon some cherished beliefs. The coal industry has gone. The offshore oil and gas industry is in decline due to inevitable depletion of commercial reserves by 2025-2030, and global price competition from low cost Arabian and shale oil. There are signs that the primary market for liquid fuels, surface transport, may transition to electricity and hydrogen much faster than anticipated. Some in Scotland hope to replace North Sea wealth with a bonanza of production from onshore shale hydrocarbon. But in my opinion it is unlikely that significant resources are retained beneath the Midland Valley, because maximum oil generation was some 60 Million years ago, and abundant geological faults, fractures and uplift has enabled hydrocarbons to leak off - there are no significant oil or gas fields remaining. Exploitation of a new hydrocarbon source would be both unethical, and illegal, inevitably leading to legal action as in the USA, given todays knowledge of climate change forcing by GHG.

Nuclear power from large central generators requires state underpinning, and looks expensive and inflexible at Hinkley C prices of £106/Mwhr, compared to £57/MWhr for offshore wind. Costs must reduce and a waste solution be discovered if nuclear is to rebuild.

The electricity market of import and export across the Border binds Scotland to England because of the grid infrastructure. Complete independence of electricity is a less effective mirage than the ability to trade, balance, and exchange with neighbours.

Scottish transition in climate and in energy includes the concept of a "Just Transition". This can mean many things: firstly to avoid exploitation of energy suppliers and buyers, secondly to ensure that individuals and communities affected are supported in discovering and creating new worlds of work, business and wealth.

Responses to questions

1) What are significant challenges to the energy landscape?

There are three factors which will affect Scotland. 1) The tailout of North Sea hydrocarbon production before 2030, and its termination around 2050. 2) The radical changes needed to meet Paris climate agreements of net-zero carbon by 2050, and the impending price increase of EU-ETS towards €40/tonCO_2. 3) The positive opportunities to be an early mover in creating new low carbon electricity, heat, transport, products, and the innovation, design, construction, employment, thought leadership, and exports associated with it. This is particularly in the choices about heat - to repurpose existing pipes to carry hydrogen, or the much more difficult task of increasing reliable low carbon electricity delivery.

2) What will energy demand in Scotland be in 2030, 2040, 2050

This doesnt really matter, as long as supplies of electricity, heat vectors and transport vectors are reliably available to meet demand at accessible costs. The overall demand for energy is modelled to increase by 10 to 30% by 2050, depending on economic growth.

Black Start resilience of electricity supply is currently a major un-tested demand issue in Scotland. With the demise of all regional spinning power generation, then Scotland is dependent on imports of electricity from England. If a major outage occurs during a low wind weather period (which can clearly last for 1 to 7 days), then present energy storage (dominated by pumped storage reservoirs) will suffice for only hours. Ofgem have been unclear on the duration to re-power Scotland from the UK grid, but a 2016 report and professional estimates put this as up to 6 days without electricity. Some estimates place this as a 1 in 600 year risk, so the impact of Black Start on a population without power could be both catastrophic and real. Mitigation needs to be enacted - one market method being capacity payments for regional dispatchable supply, as well as embedded carbon content.

3) What are biggest barriers to meeting demand in 2030, 2040, 2050
Uncertainty for investors. The carbon reduction pathway is clear, but UK government continually defers decisive long-timescale planning by ceding to political events. This does mean a benefit of current short-term low prices for consumers of electricity heat and transport fuels. But makes it very difficult to create optimal-cost pathways of radical change through decades. In an energy market, it is likely that demand will always be met - but at a higher price for consumers and industries.

4) Assessing acceptable quantities and origins of energy imports and security risks
Historically Scotland has been self-sufficient in wood, coal, or oil and gas. Those fuels are almost extinct domestically, and so there is a choice of importing fuel for energy, or relying on different energy sources to make vectors. It is very probable that the use of solid and liquid hydrocarbons will rapidly decrease in Scotland - but could persist at a low level for many decades because of the density of storage, ease of transport, and lock-in of existing equipment and machines.

Import of fossil fuel extracted as gas from offshore Norway, or Qatar and the global market, together with greatly increasing oil imports is the default and locked-in method of supplying energy at low cost. But this holds large risks, due to the transfer of wealth to other nations, the extended supply chains competing with other buyers internationally, the continued extraction of fossil fuels - which is untenable climatically unless balanced by emissions storage or mitigation. With the probable increase in low carbon vehicles operating in Scotland from 2030, it is probable that the demand for petrol and diesel will greatly decrease. That will mirror the expected great decrease in oil production from the North Sea, where production at present prices will become very low after 2025 - although a tail a will continue towards 2050. Hydrocarbons or other basic resources may continue to be imported, for example as feedstocks for petrochemicals; this is currently about 5% of current demand. The circular economy trend to recycle "waste" will continue, consuming energy and creating more employment. It is in principle possible to provide many of these future hydrocarbon resources from Scottish biomass, although that depends on global price and security. Food supplies (energy for fuelling humans) could be met from more local supplies, but if consumers remain affluent, then choices to import will continue. Many models predict a decrease in meat production and consumption, due to the need to grow more food, and to decrease greenhouse emissions from agricultural livestock.

Import, and export, of electricity to and from England, as nearest neighbour will be inevitable to efficiently balance grid demand, and is desirable for this purpose across Europe. Modelling of this is continually unsatisfactory, as a "seller" of power is always assumed to exist within connected Europe. There is no good evidence for such master planning, hence this is a risk of supply shortage. Because Scotland and England have very different portfolios of generation, the embedded carbon in Scottish electricity is less than that from England. It is unclear if Scotland accounts this disbenefit of carbon when importing power from England, and unclear if England accounts the benefit of low carbon when importing electricity from Scotland. Or does all of the carbon mysteriously disappear at the Border - as sometimes occurs when electricity is moved between EU states.

Energy storage will increase, as the power system transitions from entirely centrally dominated, to include many disaggregated and embedded generators and suppliers. Those supplies can be optimised by the emergence of new aggregator businesses, with smart control supply to demand and supply to storage. This revolution has barely started, but when prices are correct will optimise the use of all renewable power output. How to achieve such large TWhr of storage, sufficient for several days of electricity, heat and transport consumption is not yet clear. Present prices for firm backup to wind power are around £10/MWhr, giving some confidence that this can be achieved. However those prices may rely on under-used legacy gas plant - that sets a price for future innovations to beat. The true long-run prices for firm power are uncertain, but there are good arguements that future renewables contracts would be better based on a firm power guarantee of delivery, where it is for the renewable generator to find and price-in reliable methods of supply.

5) What mix in the energy landscape: Renewable, offshore O&G, u/c U&G, nuclear, storage, other

This is not for Government to plan in detail, but to set standards or targets and enable markets which continually challenge and encourage progress. Overarching strategic requirements are: a) to deliver reliable resilient and continuous energy (not just electricity) b) priced that consumers industries and businesses can afford c) to achieve net-zero GHG (CO_2e) emissions across the entire economy. CCS is essential in all whole system models. Innovation in energy has been continually surprising, from the application of civil nuclear power, to discovery of oil, to tumbling prices of renewable electricity. However it is clear that constructing new large plant of hundreds MW or GW is currently an unreliable commercial risk. Even more so, large nuclear plant construction, which worldwide requires explicit state subsidy. For Scotland, the abundance of untapped local renewables makes full-life costs of new large nuclear very improbable, with no low-cost in-country waste disposal solution.

6) How to fulfil climate change obligation for Scotland, whilst meeting energy demand

Multiple actions are needed. It is essential that this is undertaken as a linked whole-system analysis across the whole economy, and is not segmented within different energy silos. The current system of 5 year reviews provides a continual ratchet. The role of the Committee on Climate Change is essential for unbiased external appraisal and advice of the whole-system.

Negative Emissions will also be required (Fig 1). Arithmetically, it is clear that attending to electricity alone is insufficient to deliver Scottish GHG targets. I calculate that attending to all-energy alone will also be insufficient. Consequently, negative emissions will be required in Scotland, and that unprecedented challenge will need several decades to solve. There are numerous immediate options which can offer multi-century carbon storage (Fig 1).

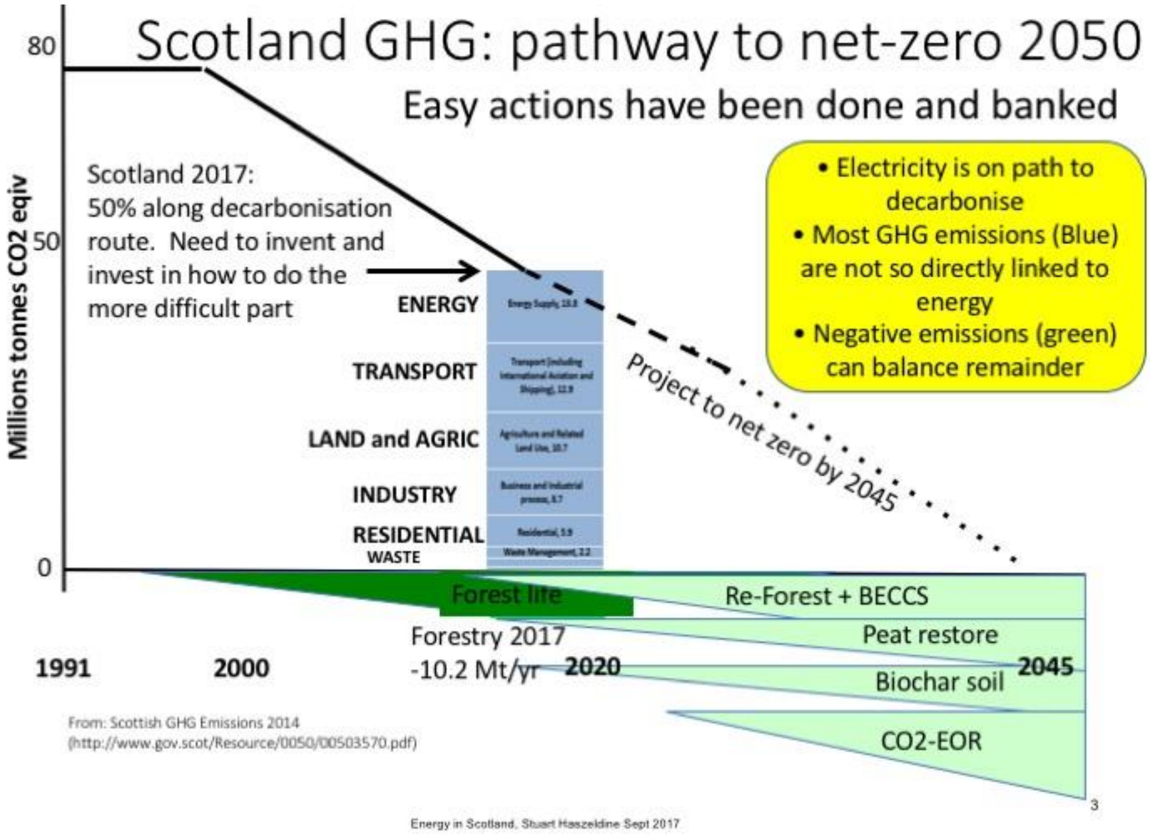

FIG 1 Past emissions of greenhouse gas inventory in Scotland, with present inventory, and illustrative projected path to achieve net-zero GHG by mid-century. It is noticeable that most of present-day electricity has decarbonised or is on a pathway to do so. Future supply-side electricity will need to replace nuclear generation, plus managed generation to balance demand from electric vehicles, and maybe heat. Remaining GHG emissions will need actions in addition to electricity decarbonisation. A noticeable feature is the opportunity for Scotland to use large quantities of negative emissions to balance hard to capture sources. Examples of negative emissions could include capture of CO2 from brewing or distilling; doubling or trebling forest areas to provide local sustainable forest biomass combustion with CCS; recarbonisation of soil with biochar, enhanced mineral weathering, or injecting large tonnages of CO2 to greatly extend the life and improve the efficiency of oil production.

It will be necessary to offset continuing emissions from some parts of the Scottish economy (eg agriculture, industry, aviation), by achieving extra GHG removal to storage from other parts of the Scottish economy. To store CO2 from BECCS or air capture, CCS is needed.

7) What risks to Scott Gov meeting its sustainable and renewables energy targets

The difficulties in 2017 are to sustain innovation and investment in cost reduction for established renewables (onshore and offshore wind), whilst also providing incentives to develop and provide pilots of tidal stream, wave power and CCS. A very important unknown aspect remains the ability to store energy to provide guaranteed supply from variable renewables. This will be a huge task, and the levers and powers do not all reside with Scottish government, but with UK pricing of electricity networks and heat.

8) Environmental impacts and wastes from a future energy mix
Many of these issues are at least partly understood, even if not acted upon. Some are measurable, manageable and understandable at local scale-for example siting of small renewables projects. Some are understood, but difficult to mitigate at Scottish scale due to lack of finance and economic power, for example carbon emissions with CCS. some are partly understood but financially prohibitive to mitigate at Scottish scale, for example disposal of radioactive wastes.

9) Environmental impacts on others in world, of Scottish energy supply chain
Whilst Scotland continues to produce and to import fossil hydrocarbons, it can be argued that carbon emissions have a long-term continuing negative impact on all global citizens

10) How can energy be accessible to all at acceptable cost and understandable tariff
At present, electricity costs more to poor and low users, and less to high consumption domestic users and industries. Adjusting these tariffs, to provide lower cost "basic" electricity and heat could be enacted, paid for by increased tariff for large users.

11) Challenges advantages and lessons from community energy : rural, urban
Community energy has provided world-leading innovation in many parts of Scotland. However it is not inevitably clear that district heating, for example, provides GHG benefit and is very costly to retrofit. If combined with power, or combined with new sources of efficient generation (such as fuel cells), then the benefits may be more clear.

12) How can Scottish Govt co-operate:, with generators, network operators, and retailers
Continued dialogue, as now, with short chains of access to government

13) How to debate with evidence: business, society, government
important to combine quantitative calculations, including employment, across the whole energy system, two combined with ethical political and locked in system pressures.

14) How to retain and develop skilled energy professionals in Scotland
Continue construction and maintenance of projects. Innovation makes expert businesses

15) Innovation for the future and how to link with Industrial Strategy
Efficiency of energy use, decarbonisation of power and heat will help, but negative mission balancing (Fig 1) will be required to reduce prohibitive costs, unaffordable by established industries. Scotland should aim to be a low carbon industry innovation centre, competing with Tees to attract startups internationally to locate into the diverse industrial ecology.