Response to the RSE's Call for Evidence – Scotland's Energy Supply

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1. Preamble

I have concentrated on two risks that I see as being of high importance:-

- The risk to the sure, secure and affordable provision of the electricity component of energy as Scotland becomes more and more reliant on intermittent wind power
- The risk that in focussing on CO_2 emissions governments are ignoring a bigger climate change threat from the dissociation of Artic Clathrates – a threat for whjch, if realised, Scotland needs to be fully prepared and functional and not hampered by problems with the supply of electricity

2. Answer - Supply and Demand - Electricty

2.1 Qu 3 What are the biggest barriers faced to meeting the demand we will have for energy by 2030, 2040 and 2050?

I am greatly concerned about Scotland's electricity supply. My Argument is developed below:-

- Energy, including electricity supply, to Scotland (and the rest of the UK) should be secure, sure and affordable
- In addition the global warming threat must be addressed - so anthropogenic CO_2 emission reduction is a given. In Scotland, coal is out and gas and nuclear are tolerated by some. It is argued here that because of the intermittency of wind that gas and nuclear are essential for security, surety and affordability of supply
- Proof of wind power intermittency is evident from websites such as *www.gridwatch.templar.co.uk* . The months from April through September 2016 were, for example, bad months for wind power. Average outputs and "good days" are quoted by wind power industry. But the electricity supply needs to be continuous, so wind power in the UK is currently underpinned by nuclear, gas, coal, hydro and biomass. And imports from Europe. At the time of writing this, (10.00am 15th September 2016) the UK demand was 36GW, with 22% being supplied by nuclear, 47% by gas, 16% by coal, 3% by hydro, biomass 4% and 1% by wind. 7% was imported from Europe. Scotland was importing almost 1GW from England. This is despite there being widely distributed wind farms across Scotland and the UK – it has been argued in the past that sufficient wind would always be blowing somewhere to power generation. This has been shown to be incorrect. The results on the 16th September correlate with low wind speeds over the UK.
- The strategic mistake regarding electricity generation that Scotland has made is to build reliance on an intermittent future supply (wind power) without providing sufficient backup storage, and to accept the economic burdens imposed by the combination of provision of over-capacity in wind power installations and Constraint Payments are economically acceptable. The latter is based on the assumption that the wind would always be blowing somewhere, and when it was blowing everywhere, Constraint Payments would be made to compensate for over capacity.
- So the Scottish Government's policy – 100% electricity generation by renewables by 2020 (largely without storage) and ultimately nuclear free – addresses global warming, but given the now evident intermittency of wind, threatens security, surety and affordability of supply
- Even if the Scottish Government were to adjust this date, say to allow sufficient time for some storage to begin to be developed, Scotland's secure and sure electricity supply will

in any case diminish. Today we have the secure and sure capability of 4.6 GW. The demand in Scotland varies between 3GW and 6GW. So wind must supply at least 1.4 GW at peak demand, or Scotland imports electricity through the interconnector from England, provided it is available. The two interconnectors have a combined capacity of 5.3 GW.

- But Torness will be decommissioned in 2023 and Hunterston in 2030, so Scotland's secure and sure electricity supply will reduce to 3.4 GW in 2023 and 2.4 GW in 2030. This puts additional demand on the interconnector when wind power is not performing
- We need to remain operational as a country for "normal" national imperatives - and prepare for the uncertainties – including changing weather patterns that might further influence the efficacy of wind power (too strong wind is as bad as none)
- Thus Scotland will now be frequently dependent on imports through the interconnectors with England, managed by the National Grid plc – (their connection charges shut Longannet). This assumes that England has sufficient capacity, either generated in England or imported from the continent. It is likely that much of this imported electricity will have been generated by coal, nuclear, gas and now diesel generator farms, detracting from Scotland's 100% renewable vision, and potentially putting a brake on independence.
- Solutions proposed to cover wind power intermittency
    - Reduce demand - more efficient homes, smart grid etc but this will take time. Also this is not a competent solution to wind's intermittency – there are times when wind power output is reduced to zero
    - Create adequate storage - distributed battery storage can contribute, but this will also take time (note production of Lithium has environmental issues, so batteries are not properly green) However, given the size of the outages possible, utility-scale storage is also required. Given available solutions such as heat, compressed air and hydrogen, these can be delivered within 10 years.
    - So gas will have to be used in the meantime, preferably Scottish shale gas if proven, preferably with CCS. CCGT stations can be cycled to compensate for wind's intermittency. Until 2030 Scotland will enjoy some nuclear supply toward the base load
- This raises the Fracking challenge – misinformation and emotion have superseded strategic need and science and engineering, creating a powerful anti-fracking political lobby in Scotland, England and Wales. The anti-frackers in Scotland have also chosen to ignore the two hundred years of experience of the much more intrusive surface and underground coalmining in Scotland, which did not ruin the environment. On the contrary, this industrial effort powered the industrial revolution, creating the foundation for the standard of living we all enjoy today. The local environmental legacy of coalmining has been managed. The British Government has taken the anti-fracking lobby on, and it is likely that fracking will proceed in England.
- It is argued that by 2030 and beyond Scotland will for periods will be dependent on imported energy when renewables are not delivering. The imports will be mainly gas and electricity. Gas carries the highest risk – certainly when sourced in Russia and the Middle East. Scottish shale gas, if proven, reduces the import risk. The UK (and hence Sotland) is moving toward more electrical interconnectivity with Europe and Iceland. The availability of trading capability with several partners is considered to improve security of supply and economics. But this has been initiated under the auspices of the EU. How will Brexit influence this?

2.2 Recommendations Regarding Scotland's Electricity Supply

We are moving into increasingly uncertain times – let's not add uncertainty of electricity supply to that.

Utility-scale storage also needs to be provided within the next ten years. There are several technologies worthy of consideration, as pointed out by learned societies.

I.e given performance data accrued over the last six years, the Energy Storage and Management Study published in 2010 needs to be re-examined. http://www.gov.scot/Publications/2010/10/28091356/9

Let's use shale gas (if proven) by tackling the anti-fracking lobby with strategy, logic and understanding of the fracking process based on science, engineering and experience gained in properly-managed operations.

And so proposed actions by Government and Universities with regard to Scotland's electricity supply:-

- Based on a transparent analysis of what might be called "the great wind power experiment", establish the degree of wind power intermittency. If this is significant, admit that 2020 vision is a challenge, and attend to
    - Storage (medium to long term solution)
    - CCS (medium to long term solution)
    - Take fracking on (quick solution),by attempting to convince the anti-frackers that it is safe, and needed for security, surety and affordability (it will also provide feedstock to the petrochemical industry, also important for the economy)
    - Address global warming impact on electricity generation and use, including the largely ignored potential kick from arctic CH_4 (see below)

3. Answer - Climate Change and Renewable Energy

3.1 Qu 7. What are the factors and risks which may impact Upon the Scottish Government meeting the targets it has proposed on sustainable and renewable energy?

Dissociation of Arctic Methane Clathrates

There is evidence that the release of methane from dissociating methane clathrates in the permafrost or under arctic seas is increasing as arctic temperatures rise. Some scientists are predicting an irreversible and large kick in global warming as extreme positive feedback takes place. The work is based on sound physical measurements and observations. A list of references is given a to h. Worryingly, only anthropogenic CO_2 is being addressed by governments and the IPCC – possibly because it is thought CO_2 production can be controlled, in contrast with a run-away Arctic, or they are in denial. The Paris Agreement COP21 doesn't even mention methane clathrates as far as I can see. Neither does the Scottish Centre for Climate Change appear to recognise them.

The only fundamental Scottish research on clathrate dissociation I'm aware of is Prof Bahman Tohidi's work in the Institute of Petroleum Engineering at Heriot-Watt University, where they are investigated in an oil production context. (They can be a problem, forming in and blocking pipelines). The physics are the same for naturally-occurring clathrates however, and there is a growing network of foreign academics and research organisations working on these, primarily from a fuel resource of view. The Japanese are probably leaders in the field, and have

successfully prospected for and produced gas from hydrates.
http://www.mh21japan.gr.jp/english/

The USA's Department of Energy (DOE) also has a section devoted to hydrates http://energy.gov/fe/science-innovation/oil-gas-research/methane-hydrate According to the DOE, "Methane hydrates store huge volumes of methane formed by the bacterial decay of organic matter or leaked from underlying oil and natural gas deposits. The active formation of methane hydrates in the shallow crust prevents methane, a greenhouse gas, from entering the atmosphere. On the other hand, warming of arctic sediments or ocean waters has the potential to cause methane hydrate to dissociate, releasing methane into the deepwater sediments, the ocean or atmosphere. DOE is conducting research to understand the mechanisms and volumes involved in these little-studied processes"

I note the University of Strathclyde's work on the development of an instrument for atmospheric methane concentration measurement.

Some relevant public domain material addressing the threat of arctic methane to the climate is presented below.

- "Methane is an especially powerful greenhouse gas. There are large amounts of methane presently locked up, frozen, in high latitude tundra and, especially, in ocean sediments on continental shelves. We know from Earth's history that this frozen methane can be released suddenly by sufficient warming – thus this methane has the potential to greatly amplify humanmade global warming, if that warming reaches a level, a tipping point, such that large volumes of frozen methane begin to melt"

  James Hansen Club of Rome speech, Amsterdam, 2009

- I reproduce a section from Wikipedia:-

  a. Wikipedia - Methane clathrates and climate change

  Main article: Clathrate gun hypothesis

  Methane is a powerful greenhouse gas. Despite its short atmospheric half life of 12 years, methane has a global warming potential of 86 over 20 years and 34 over 100 years (IPCC, 2013). The sudden release of large amounts of natural gas from methane clathrate deposits has been hypothesized as a cause of past and possibly future climate changes. Events possibly linked in this way are the Permian-Triassic extinction event and the Paleocene-Eocene Thermal Maximum.

  Climate scientists like James E. Hansen predict that methane clathrates in the permafrost regions will be released because of global warming, unleashing powerful feedback forces which may cause runaway climate change that cannot be halted.

  Research carried out in 2008 in the Siberian Arctic found millions of tonnes of methane being released[36][37][38][39][40] with concentrations in some regions reaching up to 100 times above normal.[41]

  In their Correspondence in the September 2013 *Nature Geoscience* journal, Vonk and Gustafsson cautioned that the most probable mechanism

  to strengthen global warming is large-scale thawing of Arctic permafrost which will release methane clathrate into the atmosphere.[42] While performing research in July in plumes in the East Siberian Arctic Ocean, Gustafsson and Vonk were surprised by the high concentration of methane.[43]

  In 2014 based on their research on the northern United States Atlantic marine continental margins from Cape Hatteras to Georges Bank, a group of scientists from the US Geological Survey, the Department of Geosciences, Mississippi State University, Department of Geological Sciences, Brown University and Earth Resources Technology, claimed there was widespread leakage of methane.

b. Methane release from melting permafrost could trigger dangerous global warming | John Abraham | Environment | The Guardian

https://www.theguardian.com/environment/climate-consensus-97-per-cent/2015/oct/13/methane-release-from-melting-permafrost-could-trigger-dangerous-global-warming

"A policy briefing from the Woods Hole Research Center concludes that the IPCC doesn't adequately account for a methane warming feedback"

c. Arctic Methane Alert from GeoengineeringWatch.org

This article presents scientists opinions and observations regarding the severity of the Arctic hydrate problem

www.geoengineeringwatch.org/documents/**arctic-methane**-alert.pdf

d. Arctic Methane Emergency Group

This is an organisation that has been attempting to raise the seriousness with which arctic methane release is treated

http://ameg.me/

e. United Nations Framework Convention on Climate Change

An article from 2014 reporting "vast methane plumes" being released from the Arctic ocean and a crater in the Yaml peninsula probably caused by methane release from thawing permafrost

http://newsroom.unfccc.int/nature-s-role/new-methane-signs-underline-urgency-to-reverse-emissions/

f. The case for and approaches to Geoengineering

This is presented by Nathan Currier in the Huffingtonpost

http://www.huffingtonpost.com/nathan-currier/arctic-climate-change_b_1911550.html**Geoengineering**

g. Oxford have a Geoengineering Programme, and collaborate with other English universities. Little attention is paid to the subsurface.

http://www.geoengineering.ox.ac.uk/

h. Stephen Salter has been working on cloud brightening

http://rsta.royalsocietypublishing.org/content/370/1974/4217

3.2 Recommendations Regarding Arctic Clathrates

If the predictions of those who have studied methane release from the Arctic are correct, then there is little time left to prevent an acceleration of global warming. The fact that the release of Arctic methane is apparently largely ignored by governments presents a challenge.

The key measures included in the COP21 agreement make no allowance for the climate change kick predicted by arctic methane scientists, neither with regard to the source of the greenhouse gas, nor the predicted timescale, viz:-

- To peak greenhouse gas emissions as soon as possible and achieve a balance between sources and sinks of greenhouse gases in the second half of this century
- To keep global temperature increase "well below" 2C (3.6F) and to pursue efforts to limit it to 1.5C
- To review progress every five years

These suddenly look rather inadequate. See http://arctic-news.blogspot.co.uk/p/how-much-time-is-there-left-to-act.html

Notwithstanding this, geoengineering is beginning to attract effort, and Salter's continued innovative contributions to climate control are to be lauded. However, in my opinion it is worthwhile examining the feasibility of capturing Arctic methane at or near source and liquefying it for transport to market, displacing conventional hydrocarbon production from elsewhere in the world. This would convert at least some Arctic methane into products or CO_2, reducing the methane effect.

Japan has made capture of subsea hydrates work, but techniques for capturing methane from the melting Tundra need to be developed. Given Scotland's universities subsurface and subsea strengths, and Scotland's petroleum-related engineering and project management skills, this is a worthwhile – indeed critically important - topic for collaboration.

This is a potential project with a big concept and very substantial multi-disciplinary content. It would challenge the environmentalists who, if the methane predictions are correct, would need to choose between managed industrial scale access to the Arctic and accelerated global warming. It makes the anti-fracking conundrum look small in comparison. The project would begin by assembling the data, analysis and opinions already available, enabling a position to be taken. If that position is that the predicted risks are credible, the complex project scope can be outlined, at least to the point where serious discussions with the various likely protagonists can begin.

4. General Conclusions/Recommendations

The UK and Scotland's electricity and energy provision – necessarily sure, secure and affordable - has become highly politicised given the linkage between its provision and climate change. Scotland has chosen to move progressively toward renewables, with a major reliance on wind power, which is now proven to be intermittent. To overcome this, utility-scale storage should be developed. This is possible within a ten-year timescale. If shale gas production could be made to work in Scotland – geological and political challenges - this would help provide an appropriately sure and secure energy/electricity generation mix. Along with the proposed interconnector directly between Iceland and Scotland, which could provide necessary backup derived from geothermal.

And while it may seem like a doomsday-type prediction at hits time, the developing Arctic clathrate dissociation should be raised as a topic of international importance and be thoroughly examined.

Finally, affordability/cost of supply is not a trivial matter. As well as influencing business and the economy, we should acknowledge that even now people die in their homes from hypothermia in Scotland.