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The Destruction of Scottish Power

Posted on January 6, 2016 by Euan Mearns

Summary

- The Scottish Government has set a target for renewable sources to generate the equivalent of 100 per cent of Scotland's gross annual electricity consumption by 2020.
- This target is set without reference to economic and environmental costs and sound engineering practice. Industry and academia have set out to try and deliver the goal, rarely stopping to ask if this strategy is wise or beneficial? Government funds are not available to challenge government policy.
- The intended consequence of this policy has been the closure of Cockenzie coal fired power station with Longannet to follow this year with a total loss of 3.6 GW dispatchable capacity. Can Scotland keep the lights on?

- The analysis presented here suggests that the Scottish electricity system, underpinned by nuclear and hydro, will most likely survive the closure of Longannet and supports the government position: *"there remains a low probability although credible risk that during periods of low wind and hydro output combined with low availability of the large thermal plant, the winter peak demand may not be met." [1]*
- In the early 2000s Scotland's electricity supply had near 100% redundancy and was absolutely secure. It has been converted into a fragile system, dependent on England, which is ironic for a government that seeks independence.
- The more important question is what happens to Scotland's electricity supply post-2023 when both of our nuclear power stations are scheduled to close. If these are to be replaced by new nuclear then action is required today. If they are not replaced by nuclear then what? It appears the only show in town is inter connectors with Iceland and Norway. The Scottish people need to have a debate as to whether they wish to become reliant upon expensive and intrinsically insecure electricity imports and see their energy jobs go overseas? Or do we wish to continue producing our own electricity using nuclear power. A self contained 100% renewable dream is unattainable.

Preamble

Scotland is a World leader in setting Green energy targets. The Scottish Government policy [2]:

46. The Scottish Government's targets are for renewable sources to generate the equivalent of 100 per cent of Scotland's gross annual electricity consumption by 2020. A target has also been set for renewable sources to provide the equivalent of 11 per cent of Scotland's heat

demand by 2020. Within the electricity generation target, a target has been set for “local and community ownership of 500 MW electricity by 2020”.

In November 2013 I wrote [3]:

Wind is currently killing the power generation system it requires for its own survival and the high electricity costs this brave new energy world has created is crippling the British economy and spreading energy poverty.

And in July 2014 [4]:

One casualty of the massive expansion of wind power will have to be Longannet coal fired power station which I imagine will close before 2020. The plan is, after all, to get rid of fossil fuel powered generation even although coal is likely to be the cheapest form of power production for many decades.

The energy chickens are now coming home to roost for Scotland, with utility Scottish Power announcing last year that the 2.4 GW Longannet coal fired power station will close in 2016. Will the lights and laptops stay on? This post charts the extraordinary rapid evolution of the Scottish electricity system and aims to answer this fundamental question.

Once Upon a Time in the Early Noughties

The configuration of Scotland’s electricity generating assets in the early 2000s are shown in Figure 1.

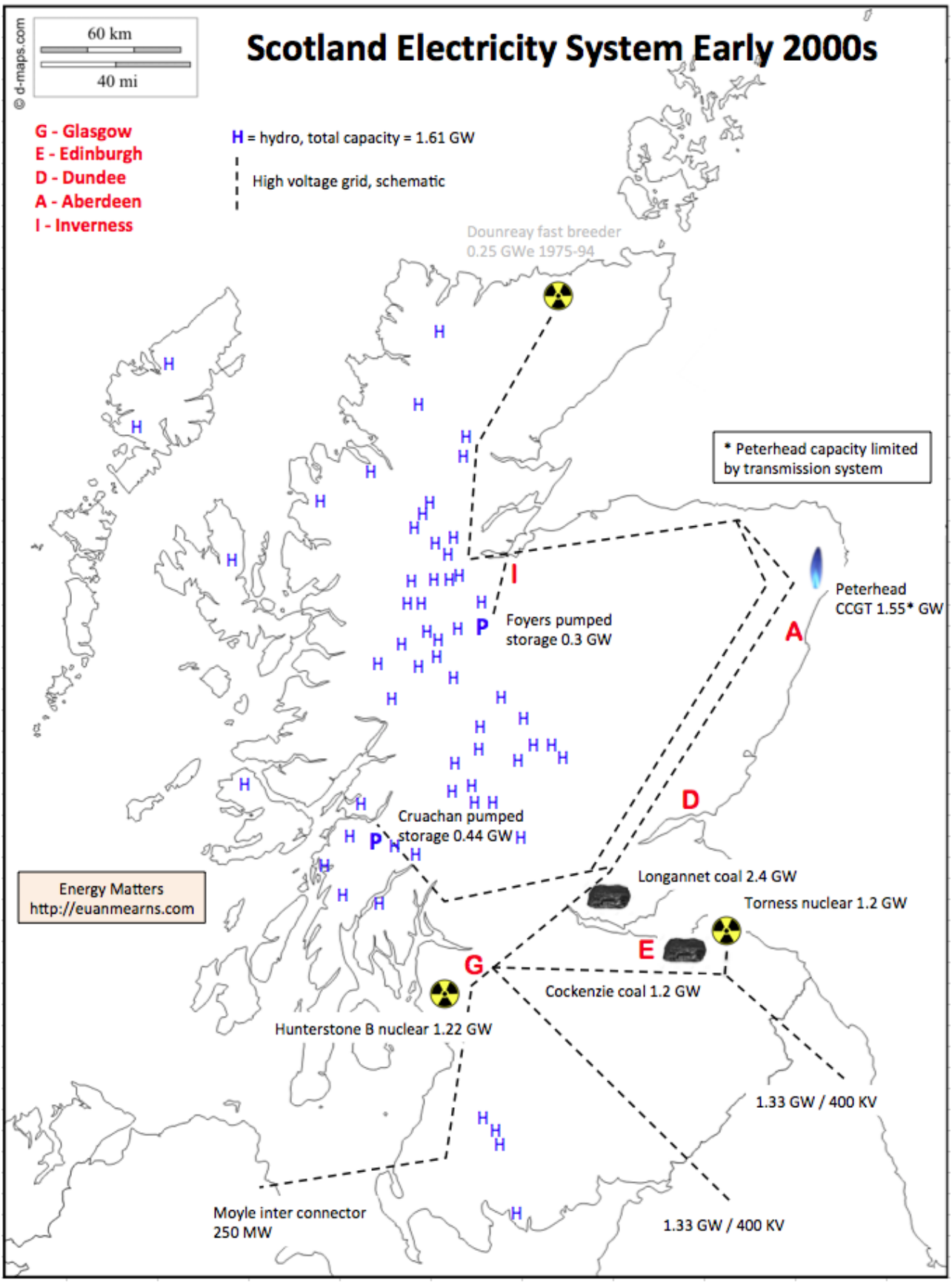

Figure 1 *The centralised power generation system of old, designed by engineers. [Base map source](#).*

The map shows the locations of the 5 main population centres and 5 large centralised power stations that are located close to the population centres. The population centres and cities are joined by the high voltage grid. In addition to the 5 big generators, there is a suite of hydro dams that are very small compared with other countries and two small pumped hydro schemes designed specifically to store surplus night time nuclear power and to feed this into the day time peak. This is how the engineers designed the grid to provide secure, low cost electricity, minimising transmission losses. Dounreay had ceased operation by the early 2000s but is shown to emphasise the fact that in the twentieth century Scotland was a word leader in twenty-first century generation technology.

The Grid

Scotland is joined to England by 2 * 400 KV power lines and to Northern Ireland by a 250 MW inter connector. As we shall see, Scotland had large surplus-generating capacity and these inter connectors were normally exporting power. Note, there is on-going confusion about the power transfer rating of inter connectors that I am reliably informed can only be used safely at about 60% of their power rating. When power ratings are quoted, it is never clear whether it is the gross nameplate capacity or net safe operational capacity that is given. A Scottish Parliamentary report says this:

Having undertaken a review on the Main Interconnected Transmission System, it was concluded that the existing transmission system can support a transfer in the winter months of approximately 2.65GW from England and Wales to Scotland [1].

Utility company National Grid operates the whole of the electricity grid in England and Wales but not in Scotland creating additional uncertainty in power transfers across the border. In Scotland there are two grid operators. In the North, Scottish and Southern Energy and in the South, Scottish Power that is a subsidiary of Spanish company Iberdrola.

The January 2006 model

Figure 2 shows how the generating assets shown in Figure 1 could easily meet Scottish demand.

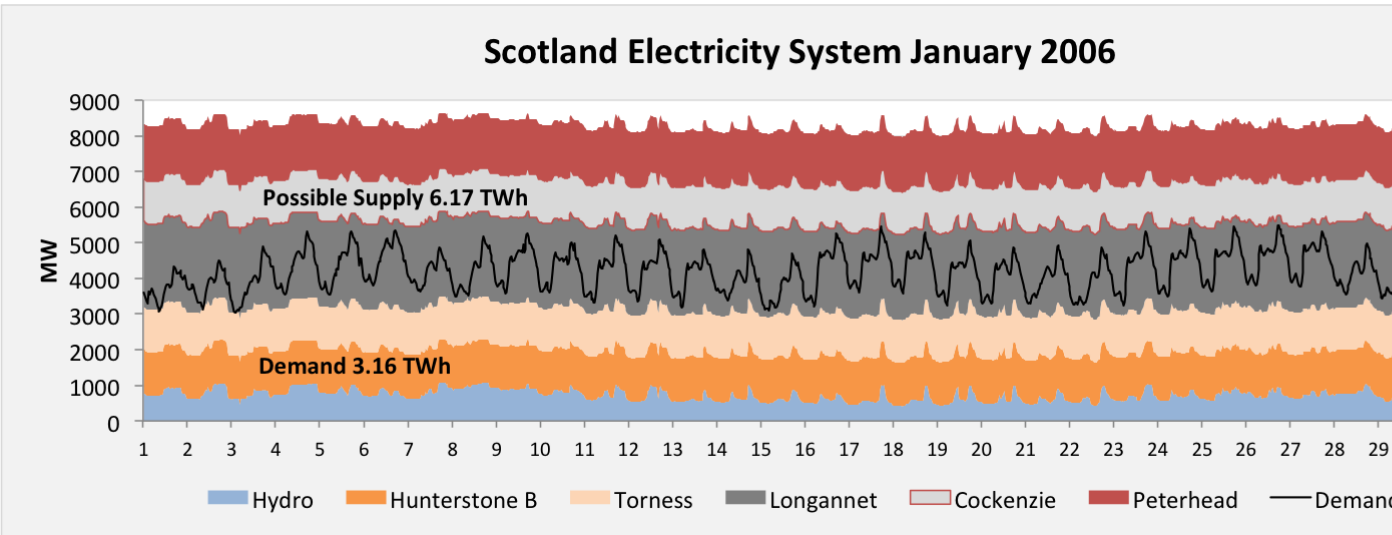

Figure 2 *Stacked chart of theoretical supply back in January 2006 where all assets are run continuously. The X-axis marks days of the month. The black line electricity demand / consumption.*

Demand data is from National Grid [5] where the total for England and Wales is deducted from "indo" to provide Scottish demand. I'm assuming this provides a profile for Scotland which in this case looks rather ragged but appears perfectly adequate for this purpose. Demand is discussed further in the Appendix.

Demand in the UK and Scotland is always highest at around 6 pm, on a weekday in winter (DJF). I don't have hydro production data for 2006 and data for January 2014 are used instead for illustrative purposes. Note while hydro has 1.6 GW nameplate it rarely gets above 1 GW [6]. It is run as base load in winter with minor load following adjustments. Nuclear, coal and gas all have capability to run continuously as shown. Doing so provides close to 100% surplus and all power stations would clearly not be run in this mode.

Figure 2 shows how total Scottish demand could be met from hydro, Hunterstone B, Torness and Longannet. Cockenzie and Peterhead were there as contingency. Nuclear power stations do require occasional refuelling and do occasionally trip and back up is required. Just 10 years ago, Scotland had belt and braces electricity security from diversified dispatchable sources. Let us now role the clock forward 12 years to 2017.

The January 2017 model

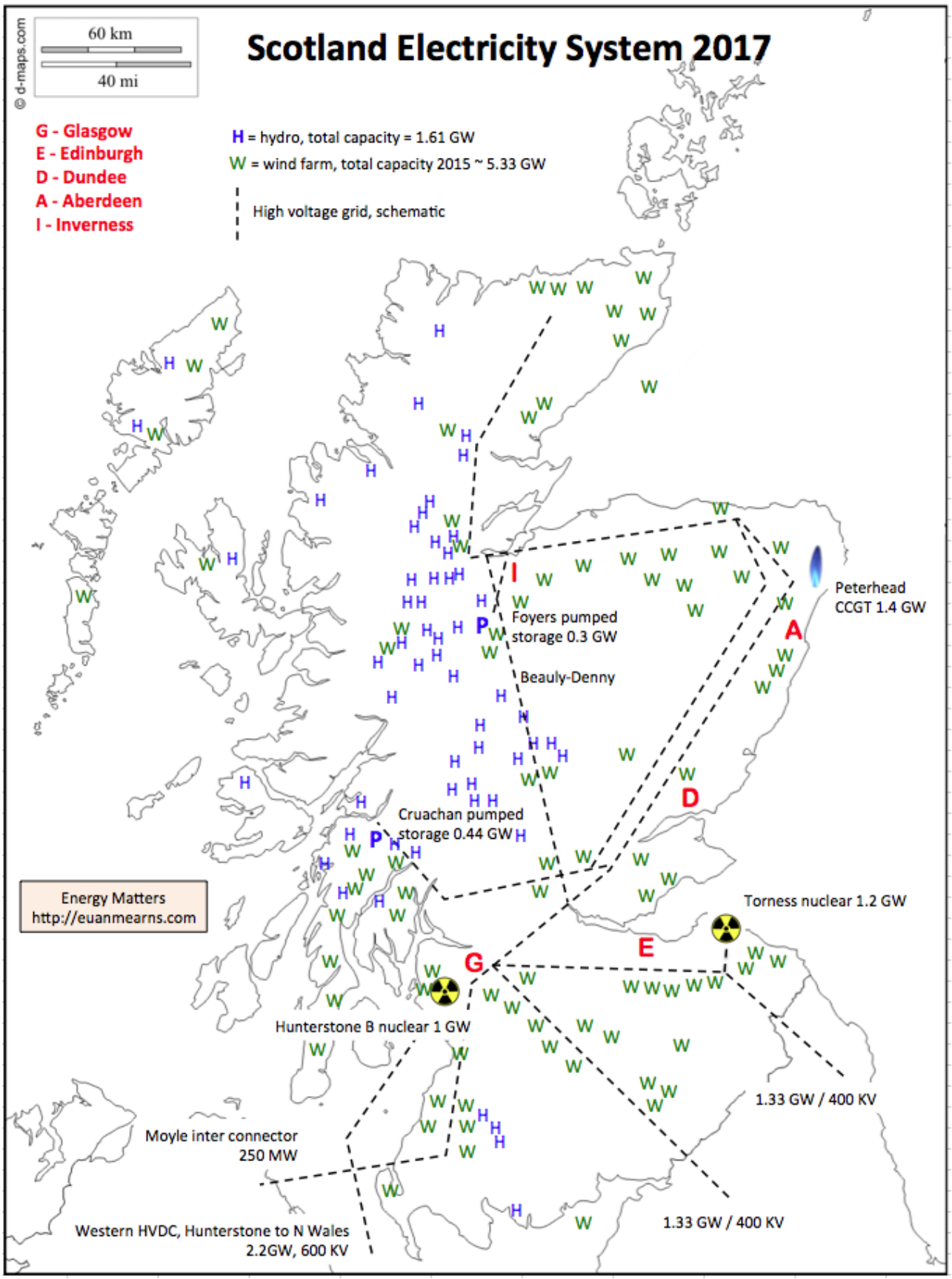

Figure 3 *The brave new world of distributed generation designed by politicians results in power stations and power lines everywhere. There seems to be a form of cognitive dissonance*

among those who believe that covering the countryside in infrastructure is somehow better than having a handful of centralised generators. The Green notion that distributed generation is somehow good, repeated over until it is accepted by many, as far as I am aware is not underpinned by any scientific or engineering evidence. It is simply dogma.

In 2017 the Dounreay fast breeder reactor has been decommissioned and replaced by several wind farms. Cockenzie coal has already closed and been demolished. And Longannet will close, barring government intervention, this year. That leaves Hunterstone B (de-rated to 1GW), Torness and Peterhead CCGT. The dispatchable capacity of Cockenzie and Longannet has been replaced by wind farms everywhere – well not quite. In drafting this map, which is schematic, it became obvious that the wind farms are located along the existing transmission network.

There are two significant changes to the grid. The first is the 400 KV Beauly-Denny Power line running S of Inverness. This power line is now operational and designed to transport wind and hydro power S and to relieve congestion on the lines that run S of Peterhead. The second is the Western submarine HVDC line running from Hunterstone to N Wales. Ostensibly built to export surplus green energy to England this has a dual purpose of keeping Scottish lights on when the wind does not blow. The western HVDC is under construction.

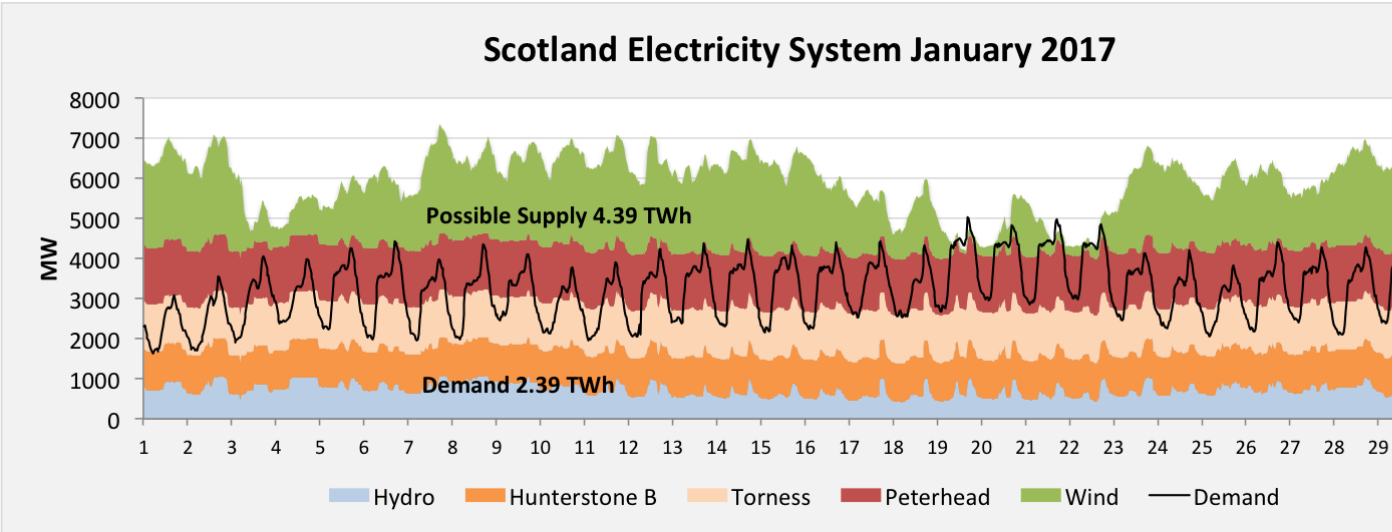

Figure 4

The model for January 2017 has the following elements:

- Hydro production based on actual UK production for January 2015
- Hunterstone B running continuously at 965 MW
- Torness running continuously at 1190 MW
- Peterhead running continuously at 1400 MW
- Wind based on UK metered wind production, January 2015, pro-rated at 41.1% Scotland based on installed capacities [7]. 2017 production may well be higher.
- Demand based on National Grid data "indo" minus England and Wales = Scotland for January 2015 [5]

A surprising outcome is the observation that for most of the month, demand could be met from hydro, nuclear and Peterhead CCGT. Only in the four day period 19 to 22 January when demand was high and wind fell close to zero is there a need for extra supply that could easily be met from pumped hydro and / or imports. ***Virtually all of the wind produced is surplus to requirements. And hydro + nuclear + some gas provides a system that is to large extent already decarbonised.***

But this of course is not how the grid is operated. Peterhead would normally be cycled to follow load and wind has priority in the merit order resulting in the new "real world" model shown in Figure 5.

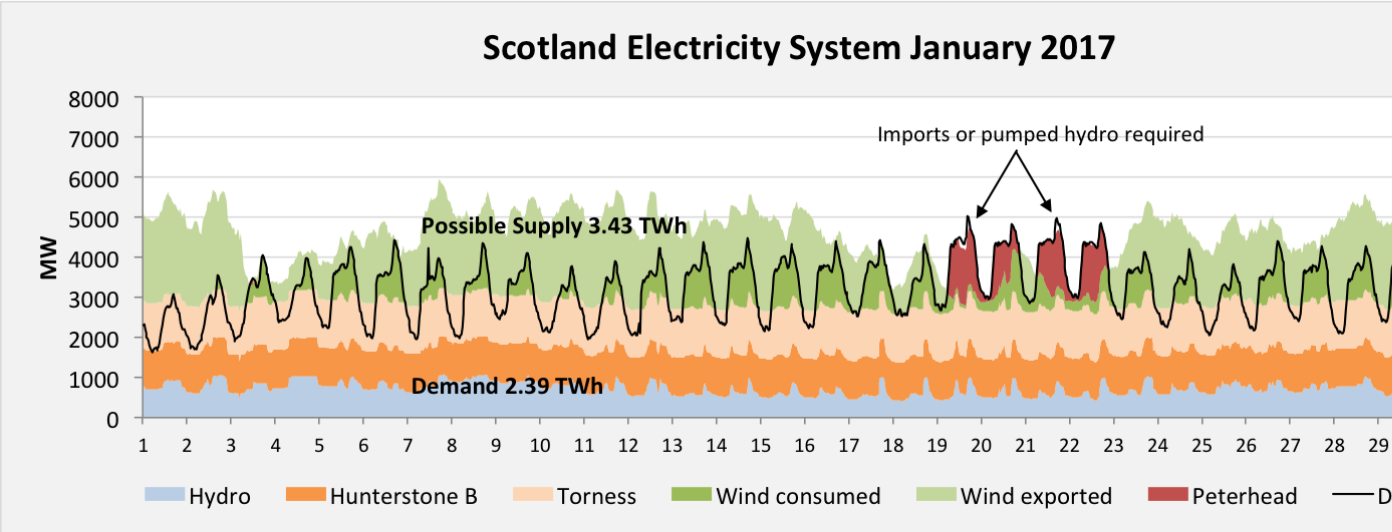

Figure 5

Figure 5 is the same as Figure 4 apart from wind and Peterhead CCGT are switched in the merit order and Peterhead follows load when there is a supply deficit. There remains a tiny deficit in the period 19 to 22 January owing to high demand and low wind output that is easily met from pumped storage or imports.

Two features of this outcome: 1) 0.294 TWh of wind are consumed in Scotland (24%) and 0.919 TWh are exported or curtailed (76%). 2) Peterhead is only needed for four days producing 0.072 TWh out of a maximum possible 1.042 TWh. That represents 7% capacity factor. This is for a cold winter month and demand in Summer is likely to be even less. I don't see how the power station can possibly be profitable at that level of utilisation and it may well join Longannet on the FF scrap heap thereby destroying the life support for the renewable system that killed it.

A nuclear trip model

Finally I want to examine the outcome of nuclear base load tripping. Our nuclear reactors under the stewardship of EDF have become much more reliable than before, they do however occasionally trip. The 6 EDF sites that include Hunterstone and Torness each have two reactors and one day in November I noticed that 5 of these 12 reactors were down. It would be interesting to know why.

Figure 6 shows the impact of a reactor trip at Hunterstone B from 16 to 22nd January and a trip at Torness from 19 to 25th January. These trips overlap during the period of high demand 19 to 23 January. Peterhead is ramped to maximum capacity to compensate but this still leaves a yawning gap that cannot be met by indigenous supply or from storage.

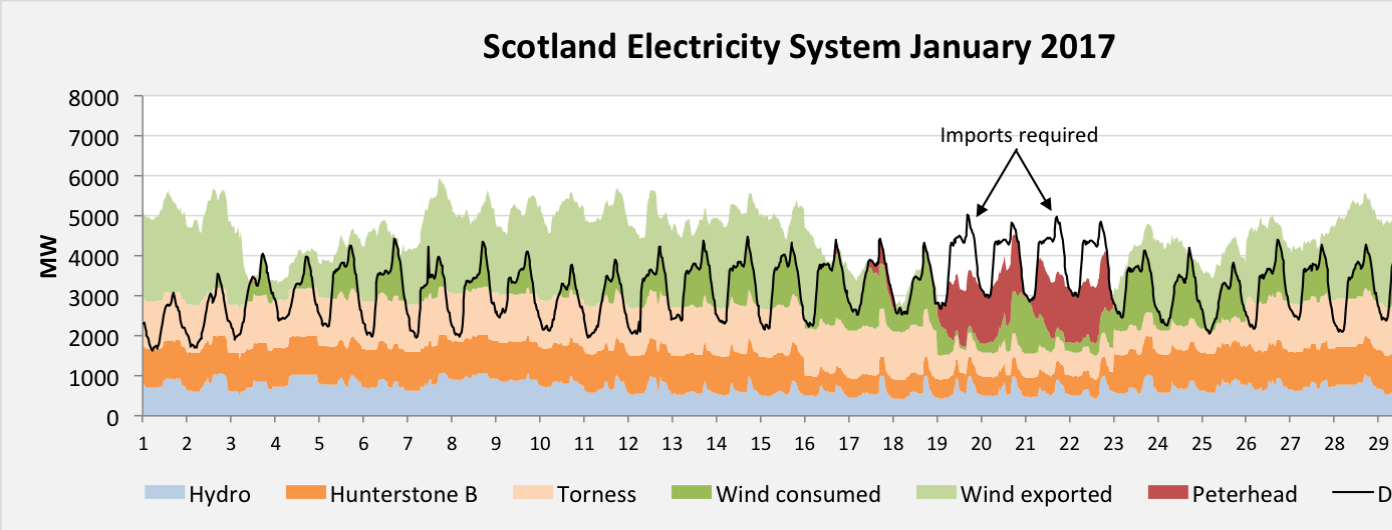

Figure 6

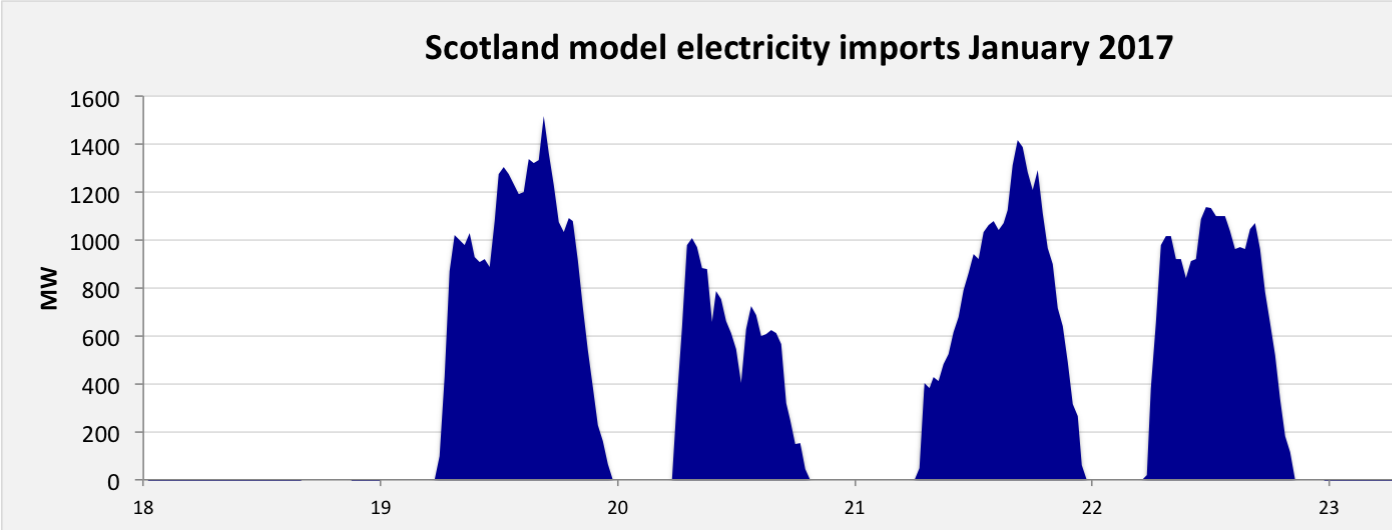

Figure 7 *The electricity import requirement created by hydro + nuclear + wind + Peterhead gas not managing to meet demand when 50% of Hunterstone B and Torness are both tripped (see Figure 6).*

The 2017 nuclear trip model scenario creates a maximum import requirement of 1517 MW on the 19th (Figure 7). Current interconnection capacity with England is more than adequate to meet that eventuality (Figures 1 and 3). But that is not the real issue. The real issue is whether England will have the reserve capacity, equivalent to two CCGTs, to switch on to satisfy Scotland's needs? This scenario takes place when it is cold and calm and past experience shows that during pan-European wind lulls wind generation can fall close to zero everywhere [8]. England may be contemplating blackouts at this time and may quite simply not have spare capacity to send north.

A broader question here is why English consumers should pay to keep dispatchable capacity at the ready in order to meet shortfalls in Scottish production? Scotland will be helping the UK meet renewable targets, but there are already signs that George Osborne is growing weary of throwing money at this policy. Scotland's electricity supply will quite likely become a political football.

In 2006, Scotland's electricity system was amazingly robust. We had about 100% redundancy and ability to stand alone through almost any scenario – nuclear trips, drought, coal or gas shortages. Come next year Scottish Government policy has created a fragile system and one where we may be dependent on others to keep the lights on. The probability of pan-European cold and calm weather occurring in any winter is high, I'd guess close to 1. I do not have the data to estimate probability of nuclear trips, that is perhaps a question to be answered in comments. But the Scottish Government are aware of the risks their energy policy has created [1]:

However, there remains a low probability although credible risk that during periods of low wind and hydro output combined with low availability of the large thermal plant, the winter peak demand may not be met.

It is astonishing that the Scottish Government is taking risks with the well being of the Scottish people and economy in pursuit of renewable energy dogma.

No Nuclear Future

Scotland's ageing reactors are both due to be decommissioned in 2023. History tells us that these advanced gas cooled reactors outlast their design life and gain license extensions. But if they are to be replaced, a change in nuclear power policy is required soon and the process for procuring replacements begun. The Scottish government also has a 'no new nuclear' policy.

It is not clear to me what the plan is beyond 2023. The government surely cannot believe in a 100% dispatchable renewable system built around failed wave, theoretical tide and fantasy hydrogen and pumped storage schemes [9].

I am left to speculate that the no-nuclear fall back position is the Ice Link inter connector to Iceland and the Scotland – Norway inter connector:

Ice Link

The interconnector will be over 1000km long, 800 – 1200MWHVDC transmission link connecting Iceland to GB, and offering bi-directional flows

And:

IceLink is a project in a feasibility stage, designed to deliver renewable, flexible generation to Great Britain from 2024 [10]

NorthConnect

NorthConnect is a commercial Joint Venture (JV) established to develop, build, own and operate a 1400 megawatt (MW) High Voltage Direct Current (HVDC) 'interconnector'. The interconnector will provide an electricity transmission link between Scotland and Norway. The interconnector will allow electricity to be transmitted in either direction across the North Sea.

And:

The aim of the NorthConnect project is to install the HVDC cable connection between Norway and Scotland by 2022 [11]

I will not at this point argue against the construction of either of these inter connectors, paid for by foreign capital and designed to provide energy jobs in Iceland and Norway. But I will most certainly make a case against replacing Hunterstone B and Torness, indigenous primary energy supply providing jobs in Scotland, with expensive and intrinsically insecure electricity imports.

The Scottish people need to debate our energy life beyond 2023 since decisions that will settle that future need to be taken today. With Scottish parliamentary elections to take place on 5th May 2016, what better time to begin that debate?

Appendix – A note on demand

I am unsure that the National Grid demand data I'm using is correct. But at face value, Scottish electricity demand has dropped significantly between January 2006 and January 2015. There are a number of reasons why this may be true:

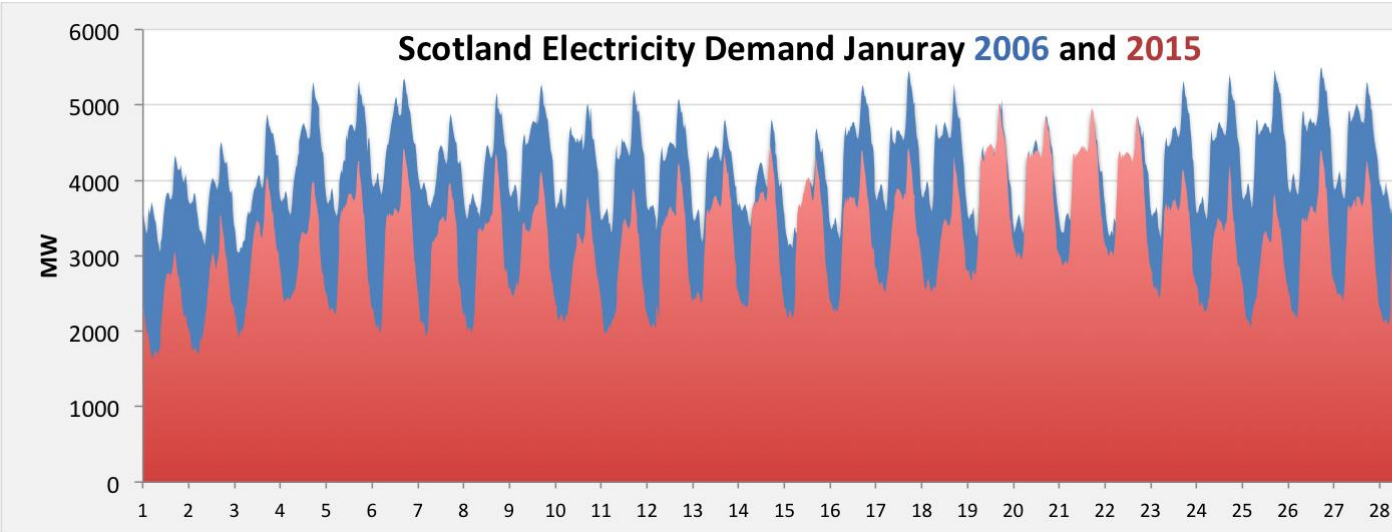

Figure 8 *Demand for 2006 and 20015 compared.*

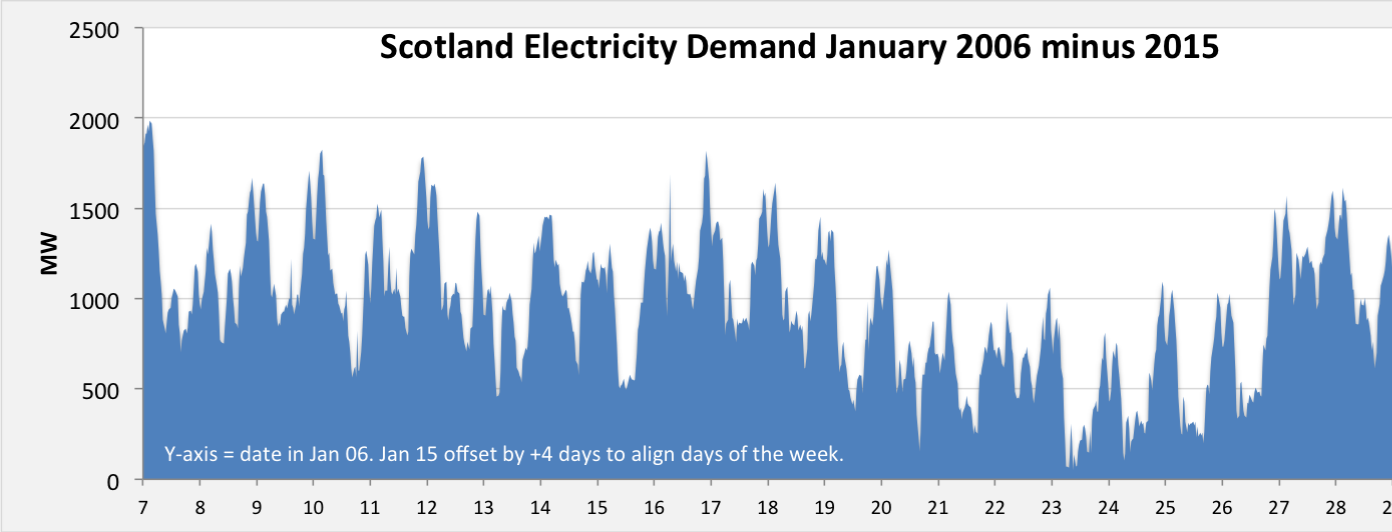

Figure 9 *The difference between 2006 and 2015 shows that night time demand has fallen the most. This may reflect policy change.*

Electricity demand follows daily, weekly and annual cycles. Daytime always higher than night time. Weekdays normally higher than weekends. Winter always higher than summer. Peak demand in any given year, when blackout risk is highest, will always be on a weekday in winter around 6 pm. Because of this, comparing January 2006 and 2015 is not straight forward. 2015 has been offset by +4 days to align the days of the week between these two years in Figure 9. Another two days have been chopped off the chart to remove New Year demand effects. The residual shows how demand in 2006 was much higher than in 2015, especially at night. Some possible reasons are detailed below.

1. Local unmetered wind farms and solar PV do not appear in production data but are embedded in demand data showing up as negative demand giving the impression of demand reduction.
2. Measures have been taken to reduce electricity demand such as energy efficient devices and improving home insulation.
3. Energy prices have sky rocketed during this period with a natural effect of spreading energy poverty and reducing demand.
4. The financial crash has wounded economies, reducing demand.
5. The weather, in particular temperature, affects demand. I've not investigated whether January 2006 was colder or not.

[Note added 8th January: I received this via email from an engineer today:

I read you blog about *The Destruction of Scottish Power*. As usual you do some very interesting calculations but I was surprised that you came to the conclusion:
' The analysis presented here suggests that the Scottish electricity system, underpinned by nuclear and hydro, will most likely survive the closure of Longannet and supports the government position: *"there remains a low probability although credible risk that during periods of low wind and hydro output combined with low availability of the large thermal plant, the winter peak demand may not be met." [1]'*

I think that 'will most likely survive the closure of Longannet' is much too optimistic. Later in the blog you write 'Come next year Scottish Government policy has created a fragile system and one where we may be dependent on others to keep the lights on' That is much better. It is worth noting that advice from power system engineers is not to rely on imports at peak demand. You note the risk of capacity not being available from England and Wales when urgently needed in Scotland. The risk of such a situation has, as far as we know, not been quantified. And then there are the operational probems that have not yet been adequately modelled – and the black start situation that could be a horrendous problem for Scotland in the absence of Longannet. We need to call for the system to be properly engineered.]

[1] Security of Electricity Supply in Scotland
[2] 7th Report, 2012 (Session 4): Report on the achievability of the Scottish Government's renewable energy targets
[3] Energy Matters: Parasitic Wind Killing Its Host
[4] Energy Matters: Scotch on the Rocs
[5] National Grid Data Explorer
[6] Energy Matters: UK Grid Graphed
[7] Renewable Energy Foundation: Energy Data
[8] Energy Matters: The Wind in Spain Blows….
[9] Energy Matters: The Coire Glas pumped storage scheme – a massive but puny beast
[10] Ice Link
[11] NorthConnect