ENGINEERING THE UK ELECTRICITY GAP

Institution of MECHANICAL ENGINEERS

UK energy policy has changed significantly over the course of the last few months. The UK Government has brought to an end a number of energy related initiatives, including subsides for wind and solar power generation, and tax relief on insulation products. In combination with this, it has also announced plans to end coal-fired power generation by 2025, and scrapped support for the Carbon Capture and Storage (CCS) demonstration project.

The Secretary of State for Energy and Climate Change has said that the Government's focus is "to create policy to ensure energy is affordable and secure and that in the past the balance had swung too far in favour of climate change policies".[1]

However it is far from clear that this market-led, consumer-based approach would lead to carbon reduction. With historically low oil prices and significant reserves of coal globally, there is potential for the cheapest fuel for power generation to be the one that is most polluting. Given there are now plans to phase out coal-fired power generation, it is easy to see how industry and consumers have increasing uncertainty on the security of energy supply.

Recommendations:

1. The UK Infrastructure Commission should assess the necessary incentives for industry and the public to reduce the demand on the electricity system through engineering efficiencies into processes and equipment, awareness raising and advocacy.
2. The UK Infrastructure Commission must urgently implement the changes necessary across the industry and supply chain to deliver security of electricity supply with no coal-fired generation. These include investment in research and development activities for renewables, energy storage, combined heat and power and innovation in power station design and build.
3. Collaboratively the UK Government and its delivery bodies, along with industry, should review the capacity in the supply chains to deliver the construction of the 'most likely' new power infrastructure. This includes identifying timeframes and milestones for conventional and unconventional power generation build (fossil fuel, nuclear, energy storage, combined heat and power and off-grid options) along with growth in skills and knowledge within the UK to meet the potential increase in demand.

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UK ENERGY POLICY

It is crucial that the UK Government develops a comprehensive long-term strategy for energy production that identifies the needs for research and innovation, as well as awareness raising and advocacy for demand reduction. The Institution of Mechanical Engineers published the Energy Hierarchy in 2009 which is one approach that could be used to provide direction to all sectors.

The recent changes in energy policy show that there is a worrying move away from the top priorities in the Energy Hierarchy. It remains crucial that we still look to energy demand reduction and energy efficiency as our main "tools" to address the challenges of UK energy supply. These are key areas where emission reductions can be made and UK competitiveness enhanced. The loss of renewable incentives and CCS support also show that Priorities 3 and 4 are not the current UK focus either. This leaves just Priority 5: the exploitation of conventional resources as the principal Government approach.

The development of any UK energy strategy must be connected to supporting UK skills and industry allowing these to develop and grow. With such huge developments unavoidable across the UK power sector, UK industry and citizens must be positioned to benefit from this. Without a strategy with clear milestones outside the political cycle, it is very likely that a significant amount of power infrastructure will struggle to be built because of a shortage of equipment and skills.

A clear energy strategy with defined milestones for expected power station development and construction would allow for the nuclear and gas sectors to grow their supply chain for human and capital resources. These types of milestones would enable apprentice and degree schemes to align with UK industry to ensure the construction of key components of power station and national grid connection.

SUSTAINABLE

Priority 1: Energy conservation
Changing wasteful behaviour to reduce demand.

Priority 2: Energy efficiency
Using technology to reduce demand and eliminate waste.

Priority 3: Utilisation of renewable, sustainable resources.

Priority 4: Utilisation of non-sustainable resources using low-carbon technologies.

Priority 5: Utilisation of conventional resources as we do now.

UNSUSTAINABLE

ENERGY IS NOT JUST ELECTRICITY

The UK power generation sector is under stress. There are moves towards more electric heating, more electric vehicles and the further electrification of railways. These, combined with increases in population, mean that the demand for electricity will continue to increase. It is far from clear that policy makers, industry and engineers are set up to manage this.

Electricity constitutes just 20% of UK energy use, with heat generation being twice this at around 40%, and transport fuels similarly being around 40%. This means that the UK Government's focus on electricity generation is a relatively small part of the challenge in decarbonising the UK energy sector.

In order to realise these plans for the UK power generation sector, first it is important to understand the nature of energy being used for power generation in the UK. On a typical day (using data for 08/12/2015) the inputs into the national grid need to meet a demand of 38.30GW[2]. That day, this was met by generation based on 22% coal, 27% gas, 23% nuclear and 13% wind with the final parts being made up from biomass and imports from France and the Netherlands. The loss of coal by 2025, along with growth in demand and the closure of the majority of our nuclear power stations will therefore be significant, leaving a potential supply gap of 40%–55%, depending on wind levels.

Often the issues of continued security of electricity, base-load supply and the role of renewables in generating electricity are conflated. Without significant energy storage options, renewables can only provide 'now time' input into the National Grid, but cannot provide support when demand is at a maximum. It is much easier to modify generation from gas, coal and even nuclear than the output from renewables.

The Government has made suggestions that greater use of interconnectors could be made increasing the levels of electricity brought in from other parts of Europe and Scandinavia, such as France, the Netherlands, Ireland, Iceland and Norway. While it may relieve the initial energy gap, this contribution is dependent on generation and supply costs set by those nations, sustainability of supply and ensuring that the UK is not cut off when electricity is in high demand. This model of relying on other nations for meeting the electricity gap could potentially be less secure than the current system and reduce affordability. The generation technologies used to produce this electricity may also be less sustainable and out of the control of the UK Government and citizens.

THE FUTURE SUPPLY OF ELECTRICITY

There are currently 41 combined cycle gas turbine (CCGT) fired power stations operating in the UK[3] typically providing 23% of UK electricity, although the government reported figures for Q3 of 2015 show gas supplying a total of 35%. This is likely due to gas use in multi-fuel power stations.[4]

Separately, there are 16 civil nuclear reactors across nine sites providing typically 22% of UK electricity. Earlier this year it was announced that a new nuclear power plant would be built by 2025 at Hinkley Point C providing 7% of our base-load electricity requirements. It is however already too late for any others to be planned and built by the coal "shut-off" target of 2025.

From the evidence on policy and the current electricity generation above, we are therefore able to establish a number of different scenarios that might reflect how the UK electricity supply system could look in 2025. These scenarios all look at filling the coal gap in the context of the number of nuclear reactors scheduled for closure over the next 10 years. Combined with this is a significant shortfall in capacity which Government expects industry will plug primarily through the construction of CCGTs.

2050 PATHWAYS ENERGY CALCULATOR

The Department for Energy and Climate Change has an online "2050 Pathways" energy calculator[5] to be used to ensure that any of a range of different generation scenarios will still be sufficient to meet demand. The Institution of Mechanical Engineers attempted to put its own most likely scenarios into this Calculator only to find that the latest changes appear to take them out of the scope of the Government's predictions.

Using the "optimistic" case that there is no increase in demand, these four most likely scenarios are:

1. The coal-fired power stations have closed and only Hinkley C is built for new nuclear supply. To fill the demand gap of 22% a further 30 CCGT power stations will need to be built (most likely without combined heat and power networks and Carbon Capture and Storage (CCS)).
2. The coal-fired power stations are closed but four new large nuclear power stations or 20 small modular reactors are "fast-tracked" (most likely without any geological disposal facility for radioactive waste disposal).
3. The coal-fired power stations are closed but there has been a change in government and industry investment into more research and development of advanced solar, tidal and wind and CCS technologies combined with energy storage. Hinkley C is built with Combined Heat and Power (CHP) and hence just 10 new CCGT power stations (with CHP and CCS) are built.
4. "Business as Usual" with no added incentive for renewables and Hinkley C being only partially built and new CCGT power appearing at current rates (most likely without CHP and CCS). In this case, supply can only be secured by granting an extension to existing coal fired power stations.

While all of these scenarios find some way to "square the circle" of supply and demand, they have radically different impacts on our costs of production and as importantly on the carbon intensity of the electricity produced.

THE FUTURE FOR NATURAL GAS

In Q3 of 2015, 4993Mm^3 of gas was used for electricity generation, this was an increase of 8.2% on 2014.[6] UK gas production from the North and Irish seas is on the decline (below 40% total UK gas usage) with greater reliance on imports through pipelines and LNG tankers. Taking Scenario 1, it is possible to calculate that the UK will need to produce and import a further 4993Mm^3 of natural gas (3.6MT of LNG).

In 2013 6.8MT of LNG was imported into the UK[7] (seventh largest importer globally). This means that to meet the additional demand a minimum further 27 tankers a year would be required. This 50% increase will mean that the UK will be relying more and more on overseas imports, decreasing security and sustainability of supply.

A second option for UK-generated natural gas is its extraction through hydraulic fracturing of shale, or 'fracking'. In the UK very little gas is currently extracted from shale and to increase to the levels needed would require a step-change in the industry. On 18 December 2015 the House of Commons Energy and Climate Change Committee published the report of the Consultation on Priorities for Parliament, 2015–2020[9]. The section titled The Future of Gas identifies that over half the responses they had to the consultation in this theme were public opposition to shale gas projects. This type of opposition restricts the potential impact of shale gas in the wider energy landscape. When planning for 2025 this means that shale gas is unlikely to be ready in time to meet demand due to public opposition.

A further concern in the increased use of natural gas is the levels of emissions to atmosphere across the natural gas supply chain during the extraction, storage, transportation and supply. Methane has 21 times more global warming potential than CO_2 and currently the level of these emissions across the whole gas supply chain is largely unknown.[10]

THE LIKELY OUTCOME

This timeframe of 10 years to 2025 given by the Secretary of State for Energy and Climate Change to design, build and deliver new power to the grid makes the first three of our scenarios very unlikely due to the uncertainty surrounding UK energy policy, and the need to develop skills and a UK supply chain. To create and grow markets to support the supply chain with the necessary skills and materials as well as building connections to the grid are likely to be very expensive and time consuming. Adding in the role of planning committees and sourcing fuel means that current energy policy could be seen as a move away from energy security. Under our first three scenarios shale gas extracted in the UK will be key to avoid far greater imports. One final additional “nail in this coffin” is that currently electricity today is generated from 'paid for' power stations. These are power stations where the electricity generated has paid for the build costs and by 2025 in the first three scenarios given above, the cost of electricity will include depreciation on between 10–30 newly built power stations reducing affordability for consumers significantly.

Given electricity demand is also almost certainly set to increase, due to, among other things, population growth and the greater use of electric vehicles, the conclusion is that we have neither the time, resources, nor the sufficient number of skilled people to build enough CCGTs to plug this gap.

It is now time the review plans for a comprehensive and integrated electricity generation system in the UK. This means understanding fully the consequences of removing or adding specific technologies into the mix.

Finally, in considering the sustainability of the UK's energy system and its contribution to global warming, there are some associated factors that are often overlooked. It is critical that we reduce the pollution generated not only from electricity generation, but also from the four times as much energy we use in heat and transport. Continued focus is needed on supply, demand and emissions across the whole spectrum of energy use if we are to gain wider benefits in UK health and welfare.

RECOMMENDATIONS:

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