Enstra Consulting response to DECC Request for Evidence

Future of Gas Generation

Below please find our answers to the questions posed in the call for evidence on the subject of the future of gas generation in the UK. We will be publishing this response on our web site www.enstra.com so everything contained within our response may be considered to be in the public domain.

Engagement & Questions

6.1 The Government is keen to generate an open discussion with interested parties about the role of gas in the UK's electricity sector.

Below we set out a list of questions for discussion on which the Government would like to engage with stakeholders.

Written responses should be sent to gasgeneration@decc.gsi.gov.uk or Gas Generation Call for Evidence, Area 4E, 3 Whitehall Place, London SW1A 2AW (telephone 030 0068 6796). The closing date for responses is 28 June 2012.

This document addresses each of the questions raised.

Peter Franklin
Director
Enstra Consulting

29th May 2012

enstra CONSULTING

a.What are the main strengths and weaknesses of gas generation in helping deliver a secure, affordable route to decarbonisation through to 2020 and then by 2050?

The strengths and weaknesses of Gas Generation

The strengths of Gas fired generation to provides a secure and affordable route to decarbonisation are:

- The gas transmission distribution infrastructure is already in place which obviates the need for significant new investment
- The LNG import infrastructure is also in place obviating the need of investment and accessing multiple source of international supply
- Gas generation capital costs are lower than nuclear or coal – as are full life cycle costs (on the basis of today's carbon price)
- The flexibility of gas fired generation enables it to fill in the troughs of wind generation
- Should unconventional gas be developed either internationally and/or in the UK (and given there are probably more unconventional gas reserves than conventional gas reserves) this form of hydrocarbon/energy will become extremely cost competitive
- Lower CO_2 emissions (without Carbon Capture and Storage (CCS)) than Coal

Where gas generation clearly suffers is in its Carbon content relative to both renewables and nuclear . Producing a significant proportion of the UK's electricity from centralised CCGTs (Combined Cycle Gas Turbines) would cause the country to fail to meet its 80% carbon reduction requirement.

The Stepping stone opportunity

However, by switching from centralised gas generation to community based or home/business based generation the Carbon penalty associated with gas generation can be significantly mitigated in the short term and removed in the long term to enable the UK to meet its 2050 80% greenhouse gas emissions reduction target.

This is because, 50-60% of the energy contained within the hydrocarbon is lost during the generation process and the subsequent transmission and distribution of the electricity to homes and businesses. This compares to 10-20% losses for community or premise based schemes where the heat is utilised. This implies that 30-50% of carbon emissions from centralised generation could be avoided if the UK moved to a more decentralised generation structure for gas fired generation. This would make a significant contribution to the UK's quest to meet its 2030 emissions reduction targets.

With regard to 2050, and the achievement of an 80% carbon reduction target, gas fired generation itself may become non-viable unless it is accompanied by Carbon Capture and Storage (CCS). However CCS may be both technically infeasible and uneconomic at the premise level – and only economic at centralised generation level.

We are on the horns of a dilemma.

On the one hand in the medium term (to 2030) we should decentralise gas fired generation to achieve maximum carbon savings.

On the other hand in the long term (to 2050) we should centralise them to be able to economically install CCS – but that would still lead to enormous energy wastage due to our inability to utilise the waste heat produced, and due to transmission and distribution losses incurred.

How can this dilemma be resolved?

A possible answer would be to envisage the distributed gas generation system as a stepping stone to a hydrogen based electricity production environment.

For this to occur the gas generation technology that would need to be deployed would have to be fuel cell based wherein natural gas is first reformed into hydrogen and CO_2 – and the hydrogen then combined with Oxygen (O_2) to form electricity and water (H_2O).

One could envisage a 2050 scenario where we have home and business based fuel cell units with a direct hydrogen feed from a community or regionally based source of hydrogen. This source could either be a regional natural gas reforming unit with CCS, a coal gasification plant with CCS producing hydrogen as a by-product, or a renewable or nuclear plant electrolysing water to create hydrogen (H_2) from a zero carbon source. All of these routes would provide the opportunity to meet the 80% carbon reduction targets.

It should also be noted that:

- all the above, with the exception of CCS, are proven technologies with decades of production history.
- large scale reforming units are currently being commissioned in China, and domestic gas reforming and fuel cell combinations are today being promoted by the South Korean government.

What should then be done with Gas Generation?

We should move to a distributed gas generation architecture as a stepping stone to a long term future with a significant hydrogen component in the energy mix.

This is because:

- 20-50% Carbon savings achievable in the short and medium term (up to 2035) vis a vis the centralised generation alternative
- 80%+ Carbon savings achievable in the long term (2050)
- Ability to leverage the existing gas transmission and distribution network as an extremely efficient (low losses vs electricity) energy distribution vector
- Future compatible pathway at the premise level – in the short/medium term gas reforming and hydrogen fuel cell at the premise level, in the long term drop out the reforming unit and feed hydrogen directly

b. What role can gas fired generation play in the future and what level of gas generation capacity is desirable?

Meeting heat and power demands

Heat and power demands are set to grow significantly over the coming decades as electric vehicles join the transport fleet, as the population grows and household numbers grow even faster as occupancy per dwelling declines with an ageing population. Heat demand growth will to some extent be offset by energy efficiency improvements – but demand for electricity will grow by anything from a factor of two to six between now and 2050.

From a sustainability perspective it would seem appropriate to minimise the use of finite energy energy resources e.g. gas, and to minimise the emissions of greenhouse gases whilst meeting the demands for heat and power.

Keeping the lights on

Whilst moving to a fully renewable plus nuclear (e.g. wind, solar, and nuclear) model of energy generation would meet carbon targets it would also bring with it an inability to meet peaks in demand. If the sun does not shine and the wind is still – on the coldest days of the year there would be no flexible capacity to bring on stream to meet the shortfall.

Gas is the obvious energy source to fill that gap since it provides a flexible generation option. However gas generation can be at the centralised CCGT level, at the community level, or at the individual premise level.

The question then becomes what mix of distributed and centralised gas generation is optimal?

Maximising electricity production from the satisfaction of heat demand in homes and businesses, then adding to this renewables production, and nuclear – and then providing the balance from CCGT's would appear to be the optimal solution.

This is because:

- The optimum solution will ensure that waste heat from gas generation is minimised. As much as possible heat is used for space heating and hot water for homes and businesses – not to heat up the local environment
- It will maximise the economic use of zero carbon technologies
- It will ensure that alternative flexible generation is available to complement wind power during production troughs which often coincide with periods of cold weather
- This will be true whether CCS is installed on gas generation or not. If it is not then Carbon reduction arguments would look to minimise production. If CCS is installed, economic arguments will argue for minimum production due to the energy wastage associated with centralised plants which cannot deploy their waste heat.

Where precisely does the optimum lie?

We do not know at this stage. What needs to be modelled is where the optimum balance between centralised and decentralised gas generation lies taking into account the economics of the alternatives, the emissions consequences of the alternatives, and the supply security consequences of the alternatives.

One thing is certain - it is not the centralised architecture we have today.

c. What are the key factors driving the economics of investing in new gas-fired power generation and how are these factors likely to change?

Key factors driving investment in new gas-fired generation

The economics of a centralised gas fired power station are determined by the capital cost of the plant, its operating costs, and crucially the value of its outputs (electricity) relative to the costs of its inputs (gas).

Currently the differential between the value of outputs and the cost of inputs (the spark spread) is too small to justify the capital expenditures involved given the plant may only be operating a few days per year to meet demand peaks. - hence, this request for evidence.

Furthermore, current economics are based on a carbon price hovering in the €10-15 per tonne range. If international accord comes about to tackle climate change this will inevitably rise significantly to reflect the costs of climate change remediation. This could value carbon an order of magnitude higher than today's prices e.g. €100-150 per tonne. This would make the economics of centralised CCGT's even poorer.

The Capacity Payment solution conundrum

The centralised gas generation industry sees the solution in terms of a capacity payment. A guaranteed income stream to make up for any potential deficiency in the spark spread.

However, if this is implemented in an uneven-handed manner it could well cause the "Law of Unintended Consequences" to kick-in to the detriment of the UK's achievement of its Carbon targets, and potentially its affordability aims.

This is because a capacity payment system which remunerates only centralised generation plant will halt the development of distributed generation – since it will skew the economics in favour of centralised plant. This in turn will remove the 30-50% carbon savings by 2035 which could be achieved by implementing a solution comprising the optimum mix of central and distributed generation.

To make matters worse, should medium term (by 2035) international agreement lead to the establishment of a Carbon price which truly reflected the economic costs of climate change remediation, as per the Stern report, the UK would find itself financially disadvantaged having invested in a gas generation architecture which structurally produces far more carbon, with an associated high cost of Carbon than necessary, by having more centralised generation in the mix than decentralised.

What should be done to make sure the UK does not suffer from these unintended consequences?

Any capacity payment scheme needs to be even-handed and sized to need

This could be achieved by:

- Providing the same level of capacity payments should also be available to community and premise based plant – down to the domestic fuel cell which often has the option to produce hot water to step up electricity production at a time of peak electricity demand. This ensures the market does not become skewed toward centralised generation. Administration of any scheme needs to be structured such that individual homes and businesses can participate easily.

- Limiting the capacity payments for CCGTs to the capacity needed once the distributed electricity production, sized to heat demand, has been netted off the total requirement. Potential providers of centralised gas fired generation should bid for this net requirement which will be significantly below today's envisaged requirement (because abundant distributed generation lies outside DECC's current scenario possibilities).

d. What barriers do investors face in building new gas generation plants in the UK? What are the key regulatory uncertainties that may prevent debt and equity investors making a final investment decision in gas generation and supply infrastructure?

The uncertainties facing investors are myriad

What level of Carbon prices will governments deliver over the coming decades? To date these have been very low. Should they start to match the economic costs of climate change remediation the economics of centralised generation vs distributed will shift dramatically in favour of the distributed solution due to the inherent inefficiencies of the centralised solution

What will happen to the spark spread? It looks pretty certain that electricity prices must rise due to the costs of decarbonising electricity production. However, where gas prices will be is uncertain. If the UK is reliant on LNG imports from politically unstable sources prices could be high and spark spreads low. On the other hand if significant quantities of unconventional gas come on-stream gas prices could dive, as they did in the US when its shale gas came on stream, and spark spreads could widen dramatically

What level of capacity payments will be made available – might these be withdrawn without notice like renewable subsidies?

Might energy storage technologies become economic such that balancing gas fired capacity is no longer needed? This could come through a breakthrough in battery technology or the creation of hydrogen production facilities attached to wind farms and/or nuclear power station. (In the US research has proven that thermal slurries can be used to store and release hydrogen within a plant thus obviating the need to transport it as an interstitial hydride within expensive materials such as palladium)

The Gas generation opportunity

Energy companies (the big 6) have generation as a hedge against the impact of volatile wholesale prices on their retail businesses (although you might well argue that EDF have a retail business as a hedge to their nuclear generation business).

However when looking at investments in gas generation capacity energy suppliers have a choice of investing in centralised CCGT's or in Distributed generation.

Whilst we recognise that it is extremely presumptuous of us to second guess the strategies of the big 6, it would not seem unreasonable to put forward a view that seeking the minimum risk generation investment strategy would be a sound and prudent strategy to follow.

We would argue that this is to follow the strategy outlined in this document – to invest in community and premise based generation until customer heat demand is met and then to balance off with centralised generation (where economies of scale should mean for the same level of waste heat/carbon a central solution is cheaper).

That said we recognise that this is not the case today as both the government and industry paradigms are focused on the electrification of transport and heat – with the electricity to be supplied from centralised sources.

e. Are there any other policy issues that need to be addressed beyond the Government's proposals for the capacity mechanism and the EPS?

The policy issue that needs to become the focus of the energy debate is what mix of distributed and centralised gas generation does the UK need?

We would argue strongly for a review of the various alternatives for the architecture of gas generation in the UK in the context of the "Trilemma" of issues to be balanced. These are Climate Change, Security of Supply, and Affordability.

This is because:

- On the "Climate Change" dimension the picture is absolutely clear. The distributed solution is far superior to the centralised solution given the 30-50% lower CO_2 emissions.

- On the "Security of supply" dimension the picture is also clear. The distributed solution is far superior to the centralised solution given the 30-50% reduction in gas demand, and hence imports requirements. In addition the consequence of plant failure are much more limited in the distributed architecture than in the centralised given the significantly higher proportion of demand catered for by units in the centralised architecture compared to the distributed alternative. Losing a CCGT is a major UK event, losing a micro-chp unit in a single home is not.

- The situation from an "Affordability" perspective the picture is by no means as clear. Without a doubt centralised generation has an economy of scale advantage over distributed generation – however whether this is enough to outweigh the factors which would tip the economics in favour of a distributed solution is not as yet proven.

And how should the analysis be structured?

The factors which need to be taken into account when assessing the economics of the alternatives are as follows:

- The marginal capital cost of the centralised versus the distributed solution. For the premise based solution this is the difference in cost between a condensing gas boiler and a gas fired heat and power unit, for a centralised gas fired power station it is the total cost of construction
- The operating costs of the two solutions. In the distributed case the maintenance and production teams are there already due to the need to manage the gas heating system. The marginal cost of operating the generating component is practically zero. In the centralised case the full cost of operating and maintenance personnel needs to be factored in
- The gas cost dimension. The distributed solution is 30-50% more efficient and so gas costs will be 30-50% less than the centralised solution
- The gas price dimension. In a global system characterised by more distributed generation demand for gas will be significantly reduced which in turn will reduce the price of the base hydrocarbon vis a vis a world characterised by a centralised gas generation architecture. There is therefore a good argument for using a higher gas price (lower spark spread) when considering the economics of centralised options and a lower gas price (higher spark spread) when considering distributed options
- It may well be the case that even when taking into account the costing and pricing dimensions above that a centralised solution is the lower cost option. In turn this means it is the most affordable – and leads to lower levels of fuel poverty unless some income redistribution measures are put in place to protect the fuel poor. However, when we look at our logic when assessing generation as a whole – we have chosen the less affordable solutions provided they are better on the "Climate Change" and "Security of Supply"

dimensions. This applies to Wind, Nuclear and Solar generation. If we are prepared to subsidise these zero carbon solutions should we not also consider incentivising a distributed gas generation solution which is also advantageous on the “Climate Change” and “Security of Supply” dimensions – potentially to the same extent if the end game becomes distributed gas reforming with CCS, and H_2 supply to homes and businesses.

f. Given a continuing role for gas and the potential for increased volatility in gas demand, to what extent is gas supply and related infrastructure a barrier to investment in gas fired generation? What impact will unconventional gas have on the case for investing in gas generation and the supporting infrastructure?

Gas supply and related infrastructure constraints

In a world characterised by increased centralised gas generation capacity (as coal stations close, and the nuclear build cycle gathers pace) we need to look at whether the line pack mechanism can cope with the peaks associated with the coldest winter day.

On this day wind generation could fall to close to zero, and demand for heating and electric power go to maximum. Since gas would be used to satisfy both heating demand directly and to fuel electric power stations we would see location specific peaks develop which are far greater than those experienced to date.

There will be a physical limit to the speed at which gas molecules can be moved through the system to the centralised power stations. Whether line pack can meet this scenario is an unknown.

It is worth noting that the pressure points will be the centralised gas fired power stations. Gas will need to flow to these units, in vast quantities – very quickly - potentially across many miles of pipeline. The more centralised the architecture the worse the problem becomes since distributed demand sources could be more easily services through line pack (an increased level of flow needed throughout the entire system rather than a massively increased flow needed at a few points in it).

Unconventional Gas

Without a doubt the emergence of significant unconventional gas production in the UK would widen the spark spread and make investment in gas generation more attractive. This would be true for both centralised and distributed generation.

Signals today are however mixed regarding the UK's wish to embrace or reject the shale gas opportunity within its own territory.

What does this mean for the design of the gas generation architecture in terms of the balance between centralised and distributed?

Both factors only go to reinforce the logic of promoting a distributed gas generation infrastructure complemented by limited centralised gas generation.

This is because:

- Limiting the scope of centralised generation minimises the risk that line pack cannot cope with meeting CCGT demand peaks
- In the absence of unconventional gas, hydrocarbon prices will be high and an architecture that minimises hydrocarbon waste (i.e the distributed architecture) will be more economically attractive (lower energy losses)
- In a world of abundant unconventional gas the best of all possible worlds is possible. Emissions can be minimised in the short term by moving to decentralised generation and in the long term through a move to a CCS and H_2 solution. Security of supply can be enhanced through the availability of UK supplies, and affordability boosted through lower energy costs.