A call for evidence on the role of gas in the electricity market

Department of Energy and Climate Change call for evidence submission

This is an *Engineering the Future* response to the DECC call for evidence on the role of gas in the electricity market.

This response has been developed by:

- **The Institution of Chemical Engineers**
- **The Institution of Engineering and Technology**

The response is supported by

- The Energy Institute
- The Institution of Civil Engineers
- The Institution of Mechanical Engineers
- The Royal Academy of Engineering

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Engineering the Future is a broad alliance of engineering institutions and bodies which represent the UK's 450,000 professional engineers.

We provide independent expert advice and promote understanding of the contribution that engineering makes to the economy, society and to the development and delivery of national policy.

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?

Strengths

- Cheap and quick to build; 1 year for large, open cycle peaking duty power plant and 2-3 years for a large combined cycle mid-merit and baseload plant.
- Gas-fired power stations have the potential to be upgraded to use CCS, as and when this is technically and economically viable on a large scale.
- High levels of operational flexibility are possible if the plant and the associated gas supply infrastructure are designed with this in mind; rapid ramp-up, shut-down and load following can be achieved without incurring undue reduction in efficiency or wear and tear issues.
- The carbon emissions for gas-fired combined cycle power plants are approximately half those of a coal-fired power station of a similar output.
- Lock-in issues are less than other forms of electricity generation as a gas-fired power station has a lifetime in the region of 25 years. However life extension is achievable as most components are replaceable, provided the plant remains commercially viable.
- Despite modern gas-fired power stations being able to achieve efficiencies of 60%, there is still significant waste heat which could be utilised e.g. by district heating systems. The longer term carbon lock-in issue can be partially mitigated if gas based CCGT CHP plants are equipped to support district heating systems, displacing gas for space and water heating.
- Plants have a small footprint so sites are easy to find (though carbon capture readiness will affect this and consideration of access to emerging CCS infrastructure might in future limit the ease of finding sites).
- Gas supply is available from a range of different sources and supplies could potentially be boosted by new sources of shale gas, though significant UK supplies may not be available for another 5-10 years and are subject to considerable uncertainty at present. This diversity of supply sources is leading to increasing variability of gas specification, which power plant owners need to allow for when purchasing or upgrading gas turbine-based power plant.
- Gas-fired-plants can be specified and built for dual fuel firing, with the flexibility of liquid fuel backup. This provides short term backup in the event of supply security issues. Front end design planning can accommodate the storage of liquid fuels on site. The amount of storage is depends on available space and safety, security risks capital costs and fuel deterioration need to be taken into account.

Weaknesses

- It creates a carbon lock-in over its 25 years life, reducing the incentive to move faster to a fully decarbonised electricity system.
- In comparison to coal-fired power plants, gas-fired plants are less able to increase their output at very short notice; for example, to arrest a fall in system frequency when a large generator fails unexpectedly elsewhere on the network. This is dependent on the actual generator performance characteristics and the way in which it is operated.
- Efficiency of a gas-fired plant drops dramatically under low-loading conditions, though this can be managed in the context of a large power system with many individual generating units.
- Currently there is no monitoring and assessment of true CCS-readiness for gas-fired power stations. To ensure progression to a low carbon system this assessment should

be rigorously carried out and locations need to be considered in relation to any emerging CCS infrastructure clusters

- There is currently no clear national strategy for short- or long-term gas storage, particularly to deal with seasonal demand variations.
- Although the indications are that there are sufficient gas reserves to address electricity demands to 2050 and beyond, the resources are finite. Global gas-generation build programmes will place more demand on gas resources and risks an exposure to higher gas prices. This may be compounded if global shale gas is not fully exploited.

When considering the different strengths and weaknesses of gas-fired power generation it is important that this be undertaken bearing in mind the performance of the energy system as a whole, and the actual and potential role of gas within it.

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

It is important to recognise that the consultation is only considering one aspect of a highly integrated energy system, which needs to be considered as a whole. Without clear strategy direction this question cannot be answered clearly. This is due to the wide spectrum of possible scenarios which include demand growth, the importance of electricity as an energy vector, and the roles of nuclear, renewable and other sources of electrical energy, as well as developments in demand management, super grids and smart grids. If the UK is to increase gas generation capacity, the impact on the UK's gas import dependency and its carbon target must be fully considered.

Since 2000 the UK dependency on fossil fuel imports has risen from -17% of total UK energy supply to +28%.[1] As UK gas and oil production decline, the UK is likely to become increasingly dependent on imports: in the case of gas this is likely to reach 60% by 2020[2]. This increases the UK's exposure to price volatility and energy security, though more recently the availability and price of global gas has mitigated this risk significantly.

In addition, in order to meet the UK's 2050 greenhouse gas targets, gas consumption without carbon sequestration has to be virtually eliminated. **Unabated** gas generation has a transitional role, filling the gaps that low carbon alternatives cannot in the short-medium-term. In this respect there is a tension between the need to decarbonise and the need to incentivise investors to build gas power plant in the short-term as recognised by the grandfathering provisions for the Emissions Performance Standard in the draft Energy Bill.

There are a number of reasons why gas-generation will remain important over the next 20-30 years:

- **Flexibility:** The power generation system is becoming less flexible as coal and oil-fired generation exit the market due to EU legislation. The inflexible nature of nuclear power and variability of wind generation, coupled with the lack of progress in developing and deploying storage, leaves gas-fired plants currently flexible enough to meet most of the system's growing need for responsive plant. However, greater international interconnection, demand management and additional pumped storage may assist in the longer term. The use of gas-fired generation in the short term can support the transition period while new technologies, such as smart grid and storage, are

[1] Digest of UK Energy Statistics 2011

[2] National Grid Future Scenarios indicate that for both the Gone Green and Slow Progression scenarios gas imports exceed 66.5% import dependency by 2020. http://www.nationalgrid.com/NR/rdonlyres/86C815F5-0EAD-46B5-A580-A0A516562B3E/50819/10312_1_NG_Futureenergyscenarios_WEB1.pdf

developed to better manage demand and supply, and systems integration. Gas-fired generation is also likely to be required in the longer term to handle long periods of low wind generation.

- **Time to market:** The delays in the new nuclear programme and its considerable time to market is causing increasing concern over tightening capacity margins caused by the exit of coal and oil from the market. There is a chance of short-term derogations for coal-fired plants in the event of nuclear life extension proving impractical but gas is the only realistic option to fill this gap without contravening EU environmental legislation.
- **Attractive investment:** Nuclear and large-scale offshore wind requires significant investment with heavy up-front capital requirements and perceived high risk. Conversely, gas-fired plant is proven and the scales of investment and return are reasonable. If the EMR delivers a favourable market framework, then investment in gas generation will be attractive.

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

In the short-term, high gas prices and low carbon prices are making the short run costs of gas generation higher than coal, particularly given the current (if temporary) surplus of generation capacity arising from depressed demand levels.

However, the cost of developing, constructing and operating a gas-fired plant is well known and the technical performance and capabilities are understood. The risks and economic uncertainty relates to the interrelationships between:

- Expected load factor and duty cycle
- Gas unit price and the extent to which long term supply contracts can be obtained
- Electricity unit price and the extent to which long term contracts are available
- How further revenues may be derived from the proposed capacity mechanism

At present it is uncertain how accessible load factors, duty cycles and electricity prices are likely to evolve because potential investors do not know how much plant will get built (nuclear, renewables) subject to other incentives. The market space available to gas will be very much shaped by these technologies. Thus an investor in a new gas-fired plant will struggle to understand whether the asset will enjoy an extended life in base-load service or whether it will fairly rapidly move to a duty where it essentially acts as a backup for wind generation.

Currently there is a lack of clear data to predict the future evolution of electricity demand. Greater use of electric vehicles and some anticipated increase in the use of electricity for space heating would increase demand, potentially very substantially, but this market is growing only slowly at the current time. There is a need for clarity and intermediate targets, to effectively plan for future electricity provision and the associated capacity requirement. As things stand currently developers will not invest in plant that might not be used if demand does not increase, and consumers would also not wish to pay for unnecessary capacity through a capacity mechanism.

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

The major barriers to investors relate to confidence in the revenues that can be earned in the electricity market. Recent and ongoing reforms in the UK energy landscape have effectively ring-fenced large parts of the market, reducing the space in which gas operates and making the environment far more uncertain.

The size and shape of the future markets is difficult to predict given the considerable and on-going uncertainty over the planned development and implementation timeline for nuclear power and renewable generation.

During this transitional phase there is the chance of reduced capacity margins as prospective investors in gas generation delay investment due to uncertainty with the market reforms. It is therefore essential that rapid progress is made to minimise the extent of these delays. While talk of “the lights going out” may be overly dramatic, the early retirement of opted-out coal plant combined with a recovery in the economy could increase the risks of supply interruptions. There is also a potential concern that derogations might be sought for old coal plant should capacity margins erode seriously which would add to uncertainty. Any decisions to seek derogations would in any case need to be taken by 2014 to allow effective planning for the resumption of maintenance at plants previously scheduled for closure from 2016.

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 capacity mechanism and EPS are important to investors in gas-fired plants, but confidence is also linked to the pace of nuclear plant development and the deployment of renewables.

The long timeline for the EMR output and implementation, with some elements not planned to come into effect until 2019 is currently limiting confidence in the direction of UK energy strategy.

The complexity of the proposed EMR is also a concern due to modelling of potential market behaviour, pricing and plant load factors being fraught with uncertainty. At the current time a solution is not clear although there are various options.

Technological issues must be addressed from the initial stage in the strategy to ensure that plants are designed to deliver the correct capacity at the right level of responsiveness, fuel flexibility and efficiency for their role in the energy system. Thus, energy policy should include the development and communication of strategy designed to future-proof the electricity system overall. Under EMR, this is the role of the System Operator, which needs to follow a consultation process rather than top down changes. If implemented effectively this would lead to a system that is dynamic in response to flexible demand, achieving required ramp up and ramp down rates, suitable response times and to provide effective back-up.

Correctly specified, gas-fired generation can provide the flexibility to accommodate more intermittent forms of generation as well as demand variability. Plants and turbines need to be designed to deal with the additional strains entailed by ramping up and down. Different sectors and plants within the electricity generation network need to work together cooperatively to be effective, with guidance and interaction with National Grid. The scenario thus envisaged will be very different from the uncontrolled “dash for gas” in the 1990s.

The current plethora of different strategy and policy development strands (gas, heat, system balancing) in addition to EMR need to be addressed more holistically. Longer-term future policy aspirations also need to be better developed, e.g. demand side response, smart grids, super grids, storage, energy efficiency, etc.

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

The UK currently has significant energy storage in the form of coal stocks at power stations. However, as unabated coal is taken out of the generation mix and North Sea gas production decreases, the need for gas storage and long term contracts for gas increases.

Different types of storage must be provided to cope with regular everyday variations as well as the large seasonal shifts in demand such as the longer term storage to provide the additional supply needed in the winter. The lack of certainty over future gas prices, future sources, competition for supply between heat and electricity generation, and demand from other countries all make the provision of gas storage more important. Currently, there are no financial incentives, only market incentives for investment in strategic gas storage. The lack of clear incentives is of concern and may need to be considered to ensure security of supply and more stable pricing. The requirement for additional gas storage will have to be considered in the light of other forms of energy storage which mitigate the intermittency of renewables generation.

A number of issues related to the infrastructure need to be addressed; covering design and location of power plants and storage but also considering the regional variations in the calorific value of gas. The Gas Safety (Management) Regulations 1996 (GSMR) and tolerance within turbine specification is currently sufficient to deal with different gas supply but increasing the tolerance of turbine specification increases cost. A greater challenge may arise if gas imports originate from areas where the GSMR is not standard. It is not unusual for power plants to be designed with this in mind, to cope with current supply and future sources but this is a long term consideration. Appropriate plant specification can also allow plants to run on synthesis gas as well as natural gas.

Traditionally, location of plants has not been an issue but in the move towards a lower carbon economy plants need to be located near future CCS networks; typically coastal regions of industry clusters. To utilise combined heat and storage, district heating systems provide a solution, however this would require power plants to be located reasonably near to urban areas.

Having established the need for gas storage there are number of essential processes and risks to be managed in the development phase before moving to financial investment decisions. Some examples include agreement on the type of storage required, financial modelling, initial equity investment, site selection, feasibility engineering and submission of planning consent, permits and regulatory approvals. Project risks include not gaining planning consent; gas market conditions not supporting the project models, lack of equity finance, and in the case of underground storage, results of exploratory wells which may deem the salt strata or reservoir as being unsuitable for gas storage.

The overall project time frame from inception of project to beneficial operation differs from project to project and can be up to six years, or even in excess of ten years.

Key elements of the physical infrastructure differ if the project is on or offshore and if it is based on caverns in salt strata or depleted reservoirs. A typical onshore project in salt strata uses brine and water systems to enable leaching of the caverns with the brine being disposed of into the sea or used by local chemical/salt production companies. Leaching is often done in phases which can take up to 18 months for two or three caverns.

In tandem with the leaching, the engineering, procurement, and construction of the gas processing area, interconnecting gas pipelines, and national transmission system connection may take some three years to complete. Completion of each cavern for acceptance of gas will then proceed.

It would be desirable for the gas system and the forthcoming gas strategy to be developed as an integrated whole recognising its role in the total energy system and also as a feedstock supply (e.g. a system where surplus gas (including gas liquids) can be switched from electricity generation to petrochemical industry feedstock according to demand).

The impact of unconventional gas

An imminent report by the Royal Society and Royal Academy of Engineering considers the scientific and engineering evidence relating to the technical aspects of the risks associated with hydraulic fracturing. It concludes that the health, safety and environmental risks associated with hydraulic fracturing as a means to extract shale gas, can be managed effectively in the UK as long as operational best practices are implemented and enforced through regulation.[3]

It is likely to be up to a decade before there is a substantial supply of indigenous shale gas (because of a shortage of exploration rigs; legal and planning hurdles to exploration and production; and the better prospects in Poland and elsewhere in Eastern Europe). Nevertheless there may be an earlier increase in gas supplies from shale gas in Eastern Europe, although Stevens[4] notes that the geology in Europe is less favourable than in the USA. The impact of European shale gas on price and availability in the UK depends on transportation routes and capacity in the European market.

Resource estimates for unconventional gas in the UK are confused at this moment. Estimates by Cuadrilla suggest that the Bowland Shale in Lancashire could have 200 trillion cubic feet (tcf) of gas-in-place compared to the British Geological Survey estimate of 4.7 tcf (current UK demand is around 5 tcf per year). However, only a fraction of this will be economically recoverable. The precise proportion will only be known through actual production wells but it could be as low as 10%. There are claimed to be a further 10 potential shale gas sites of similar nature in the UK. We should not forget the possible plays in Poland, China, et al which would have an indirect beneficial effect on the UK if proven and exploited, by reducing demand on conventional sources.

As long as there is potentially increasing exploitation of unconventional gas sources in the UK and Europe, there is a strong case for accelerating the development of CCS for use with gas-fired power plants. Aligned with this, there should be consideration of shortening the timescale for a tightening of the Emissions Performance Standard (EPS).

The recent IEA report entitled “The Golden Rules for a Golden Age of Gas” is relatively positive in terms of the size of the global resource but does highlight the environmental and social risks which must be addressed to ensure public acceptance.[5]

[3] Shale Gas Extraction in the UK: A review of hydraulic fracturing. http://www.raeng.org.uk/shale. *Publication due 29 June 2012*.
[4] Paper by Paul Stevens entitled “The 'Shale Gas Revolution': Hype and Reality” delivered to Chatham House in September 2010. http://www.chathamhouse.org/publications/papers/view/178865.
[5] IEA Report: http://www.worldenergyoutlook.org/media/weowebsite/2012/goldenrules/WEO2012_GoldenRulesReport.pdf