PARSONS BRINCKERHOFF

EVIDENCE ON THE ROLE OF GAS IN THE ELECTRICITY MARKET- JUNE 2012

1 EXECUTIVE SUMMARY

Electricity supply should be discussed in Two Dimensions; Annual Electrical Energy TWh and Peak Demand GW. These are not the same and should not be confused. Capacity Energy Staircase diagrams are presented to illustrate how the combined UK Demand Target can be met, and the changing but critical role of gas in the electricity market.

'Market forces' are currently responding to an excess Plant Margin, resulting in some gas plant plant closures and mothballing.

In order to provide the low loss of load probability required to satisfy UK grid supply standards, a balanced mix of nuclear, CCGT, OCGT, biomass, coal with CCS, hydro and diverse marine generation plant is required, with wind, solar and other intermittent generation serving to reduce overall fuel consumption and carbon emissions

In the past there was a 'rule' for 24% installed 'firm' (Planning) Plant Margin. A similar 'firm' Plant Margin is still required to assure security of supply, allowing for planned and unplanned outages.

The target for 20% of required Annual Electrical Energy from wind by 2020 may be achieved with around 20-26GW Installed Nameplate Capacity of wind turbines, more than 5 times the present fleet.

Wind provides valuable low carbon Electrical Energy but cannot be relied upon to provide more than ~5% Installed Nameplate Capacity during winter peak demand periods

Some 10GW of net new gas stations are required by 2020 to satisfy Peak Demand. Not all gas stations need to be combined cycle, given that some will have limited annual running hours. If the 20% wind target is not achieved, the same gas stations will be required, but will use more fuel.

Delayed nuclear stations will deliver capacity later but new gas stations will be needed to fill the gap 2016-2021. Once new nuclear is commissioned, this and new wind will limit the running hours and investment returns of gas power stations, a factor which, unless mitigated by effective capacity payments, may discourage initial investment.

By 2025, a large installed fleet of gas stations is still required to meet Peak Demand. This remains true even if the target to build this amount of wind turbines is met or not. During 2025 low wind peak demand periods, nearly 60% of generation may be from gas plant. Despite this, the scenarios illustrate more than 50% reduction in the overall annual Carbon Footprint of UK electricity generation by 2025 if planned wind and nuclear projects are achieved.

Considering the very large continental scale of low wind meteorological conditions, any available interconnected renewable resources in other countries will largely be used locally and backup available for import to the UK will be from non-renewable sources and at a price closely reflecting the value of domestic backup plant plus the cost of the interconnectors.

2 INTRODUCTION

2.1 Parsons Brinckerhoff welcomes the opportunity to respond to the Department of Energy & Climate Change call in May 2012 for evidence on the role of gas in the electricity market.

2.2 Parsons Brinckerhoff, founded in 1885, is a leading international engineering consultancy group in infrastructure, transportation and power, employing over 14,000 employees in 150 offices worldwide. The firm offers skills and resources in management consulting, planning, engineering, programme/construction management and operations for all modes of infrastructure, including transportation, power and water. Parsons Brinckerhoff in the EUMENA region employs approximately 2,400 staff strategically situated across the United Kingdom, Europe, Middle East and Africa, offering a full range of design, engineering, project and programme management services for infrastructure and energy projects throughout the region.

3 AN ANALYSIS OF UK ELECTRICITY SUPPLY

3.1 For the year 2011, the **Annual Electrical Energy** supplied in the UK (324,000 GWh) was as follows[1]:

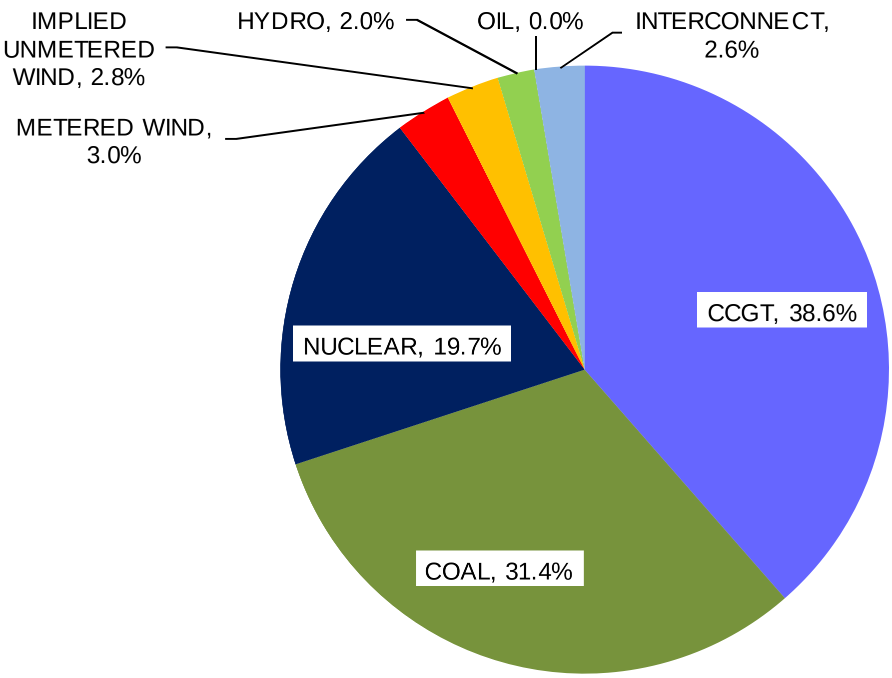


Figure 1

[1]http://www.bmreports.com/bsp/additional/saveoutput.php?element=generationbyfueltypegraphhistoric&output=CSV

3.2 The **Installed 'Nameplate'** capacity of plant which delivered this energy was 88.6 GW made up as follows:

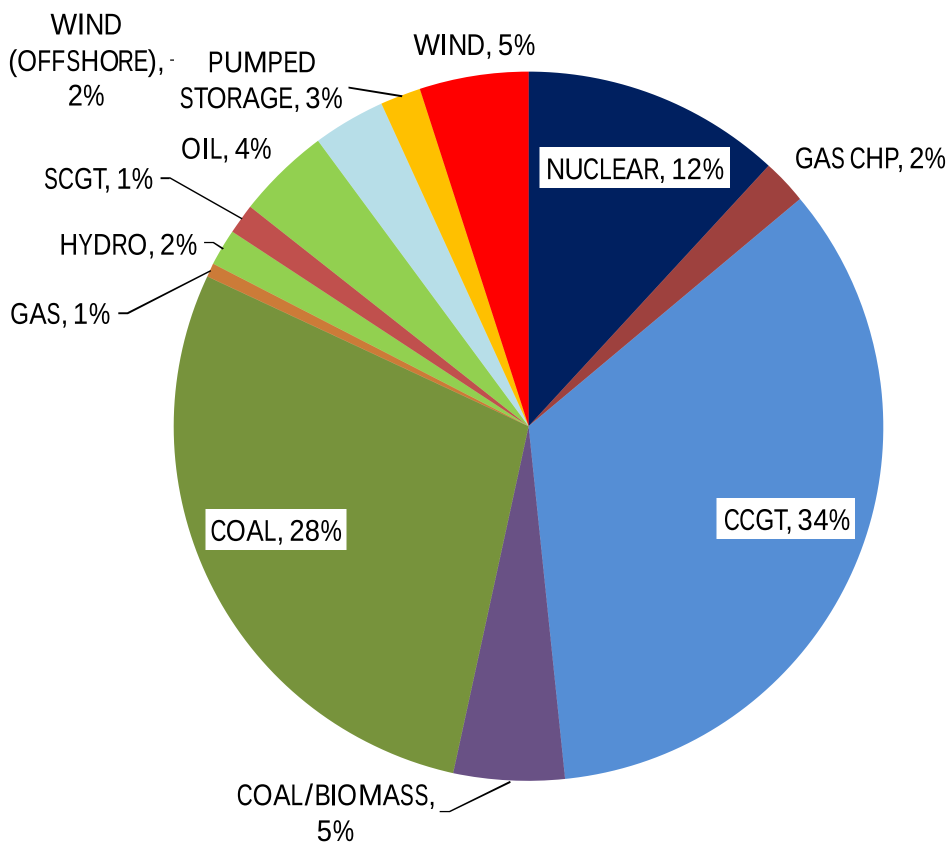


Figure 2

3.3 **Peak Demand** in 2011 was 58 GW[2]. The NGET Seven Year Statement shows GB Unrestricted Average Cold Spell (ACS) Peak Demand. The highest value is 60.0GW actual (60.7GW corrected to ACS) in 2007/08 but recent values have been slightly lower.

3.4 "In simple terms, the '**Plant Margin'**[3] is the amount by which the installed 'nameplate' capacity exceeds the peak demand. Thus a system with a peak demand of 100MW and 120MW of installed generation has a 20MW plant margin, which represents 20 per cent of the peak demand………..in the past, large integrated power system utilities (e.g. the Central Electricity Generating Board in England and Wales) sought to achieve a plant margin of some 24 per cent several years ahead of the event……….In the privatised electricity supply industry within England and Wales and Scotland, there is no set standard for the planning margin and the need for new plant is determined by market forces."[4]

[2] Figure 2.4 National Grid Seven Year Statement
[3] National Grid Seven Year Statement
[4] Seven Year Statement 2011 Appendix I

3.5 Parsons Brinckerhoff submits that these intended ‘market forces’ are currently counteracted both by the planning timescale and investment return uncertainty. ‘Market forces’ are currently responding to an excess Plant Margin, resulting in some gas plant closures and mothballing.

3.6 In the past there was a ‘rule’ for 24% installed ‘firm’ (Planning) Plant Margin allowing for planned and unplanned outages, which was conceived in the context of 2 x 660MW unit trips on a common busbar. This was also the origin of the maximum Infrequent Infeed Loss Risk criteria for grid connections which is 1320MW now and is to be increased for the new large nuclear units by 01 Apr 14 to 1800MW [5](which will be ~3% of Peak Demand, but could be 6.5% of minimum night demand). Occasional more severe incidents have occurred such as both French interconnectors tripping with a sudden loss of 2,000MW (e.g. at 23:30 on 25 April 1995). The system survived but breached the frequency standard with an excursion to 49.4Hz, but only for 10 seconds[6].

3.7 Hence, a ‘firm’ (Planning) Plant Margin of 24% can be assumed as a reasonable target, increasing to perhaps 26% margin when larger new nuclear units are connected. This is against the background of the Plant Margin being a relatively generous 38% in 2010/11 and perhaps 32% in 2012/13, but falling due to coal and nuclear closures and mothballing of non-viable and obsolete gas plant.

3.8 Future **Annual Electrical Energy** is assumed to remain approximately constant up to 2020, but it may rise to approximately double the current value by 2050 as the heat and transport sectors turn to electricity as they seek to reduce carbon emissions, provided this electricity is from low carbon sources.

3.9 **Peak Demand** is assumed to grow 1 GW to 59GW by 2025[7].

3.10 Electricity supply should be discussed in **Two Dimensions**; **Annual Electrical Energy** kWh/MWh/GWh and **Peak Demand** kW/MW/GW. These parameters are not the same and should not be confused.

3.11 In order to provide the low loss of load probability required to satisfy UK grid supply standards, a balanced mix of nuclear, CCGT, OCGT, biomass, coal with CCS, hydro and diverse marine generation plant is required, with wind, solar and other intermittent generation serving to reduce overall fuel consumption and carbon emissions.

3.12 **Nuclear** has base load characteristics and can offer generation providing steady energy and ~80% of its ‘Nameplate’ capacity during peak winter demand.

3.13 According to current timetables, only Sizewell B (Nameplate 1.2 GW) is expected to be still in operation beyond 2022. Up to 7.7 GW of existing nuclear generating Nameplate capacity is reaching the end of its operational life.

3.14 20 GW New Nuclear projects are planned with committed Grid Connection Agreements between 2017 and 2025, however a best scenario is assumed to deliver some 11.7 GW of New Nuclear by 2025.

3.15 In our analysis, Wind is assumed to reach 20% of **Annual Electrical Energy** by 2020. Biomass/Tidal/ Solar is assumed to reach 10% to support the legally-binding target to ensure

[5] NETS Security and Quality of Supply Standard Issue 2.2 - 05 March 2012, page 56
[6] NETS Security and Quality of Supply Standard Issue 2.2 - 05 March 2012, Page 69
[7] NGET SYS Figure 5.2 (extrapolated)

15%[8] of **Annual Electrical Energy** comes from renewable sources by 2020, with more than 30% of electricity generated from renewables including 20% of electrical energy from wind[9].

3.16 Wind provides valuable low carbon **Electrical Energy** but cannot be relied upon to provide more than ~5% Installed Nameplate Capacity during winter peak demand periods[10].

3.17 Based on scaling metered data[11] from May 2011 to May 2012 where wind provided some 3.5% of UK electrical energy from 4,686MW 'nameplate' installed, this 20% of required **Annual Electrical Energy** by 2020 may be achieved with around 20-26GW **Installed Nameplate** Capacity of wind turbines, more than 5 times the present fleet. But this fleet may only offer 1GW to the 58GW **Peak Demand**. Because of this, building more intermittent wind will not replace the one fifth of existing electricity generation capacity expected to close over the next decade.

3.18 Coal stations are expected to close in 2015 under LCPD with further closures by 2023 under IED. Existing coal stations may continue until carbon pricing and IED compliance costs burden their price advantage over gas.

3.19 Gas stations can offer flexible generation providing steady energy and ~90% of **Installed Nameplate** Capacity during peak winter demand.

3.20 In order to illustrate Scenarios to satisfy UK electricity demand for the years 2011, 2020 and 2025, **Capacity Energy Staircase** diagrams are included as Figures 3-5 and show the two dimensions of **Annual Electrical Energy** and **Peak Demand**. Low flat shapes represent more continuous generation with lower capacity. Tall narrow shapes represent high capacity but lower energy plants. Nameplate rating is reduced by typical availability during peak demand (Nuclear 80%, coal 85%, gas 90%, wind 5% etc.). 'Nameplate' capacity is also shown.

3.21 From 2011 to 2015, the retiring coal and oil plant will reduce both energy and capacity (and carbon) contributions. Peak demand is taken as 58GW and energy demand as 324 TWh (2011 actual, excluding interconnectors) and these define the two dimensional **Demand Target**.

3.22 By 2020, some nuclear plant is retired. Some 10GW of net new gas stations are required by 2020 to satisfy **Peak Demand**. Not all gas stations need to be combined cycle, given that some will have limited annual running hours. If the 20% wind target is not achieved, the same gas stations will be required, but will use more fuel.

3.23 If the 2025 scenario is achieved for nuclear and wind plant, the generation mix gives good 'fuel' diversity with more than half annual energy from low carbon sources. **A large installed fleet of gas stations is still required to meet Peak Demand**. During near zero wind conditions, the full UK demand must be satisfied by dispatchable plant and the system equipped with a suitable plant margin to cover for plant failures and demand variations. This remains true even if the target to build this amount of wind turbines is met or not. This suggests that during 2025 low wind peak demand periods, nearly 60% of generation may be from gas plant.

[8] Directive 2009/28/EC Annex 1
[9] DECC; The UK Renewable Energy Strategy 2009
[10] ENSG 'Our Electricity Transmission Network: A Vision For 2020' February 2012
[11] http://www.bmreports.com/bsp/bsp_home.htm

3.24 Delayed nuclear stations will deliver capacity later but new gas stations will be needed to fill the gap 2016-2021. Once new nuclear is commissioned, this and new wind will limit the running hours and investment returns of new gas stations, a factor which, unless mitigated by effective capacity payments, may discourage initial investment.

3.25 Very large Continental interconnectors are often suggested as a convenient backup for UK intermittent renewables. However, considering the very large continental scale of low wind meteorological conditions, any available renewable resources in other countries will largely be used locally and backup available for import to the UK will be from non-renewable sources and at a price closely reflecting the value of domestic backup plant plus the cost of the interconnectors.

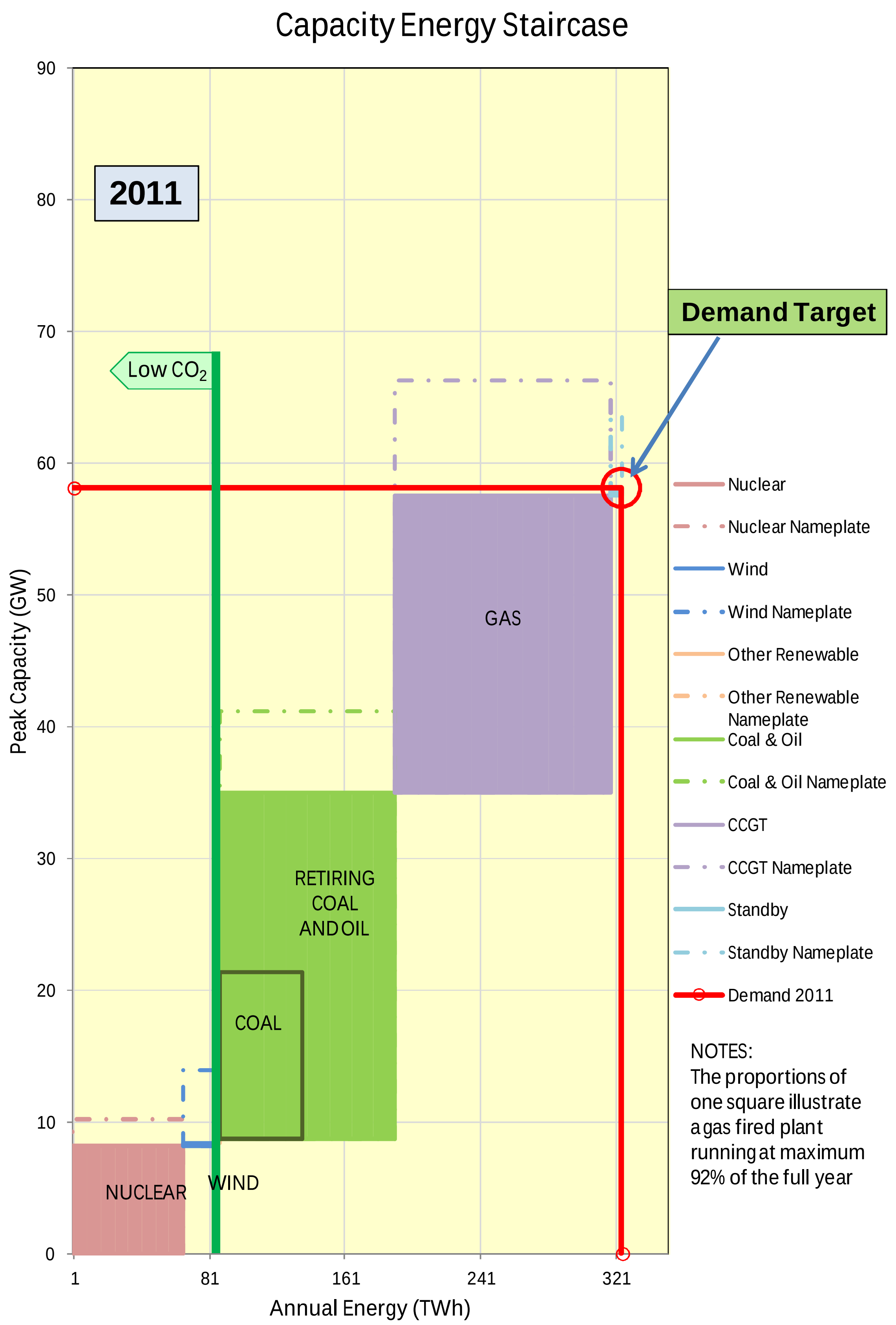
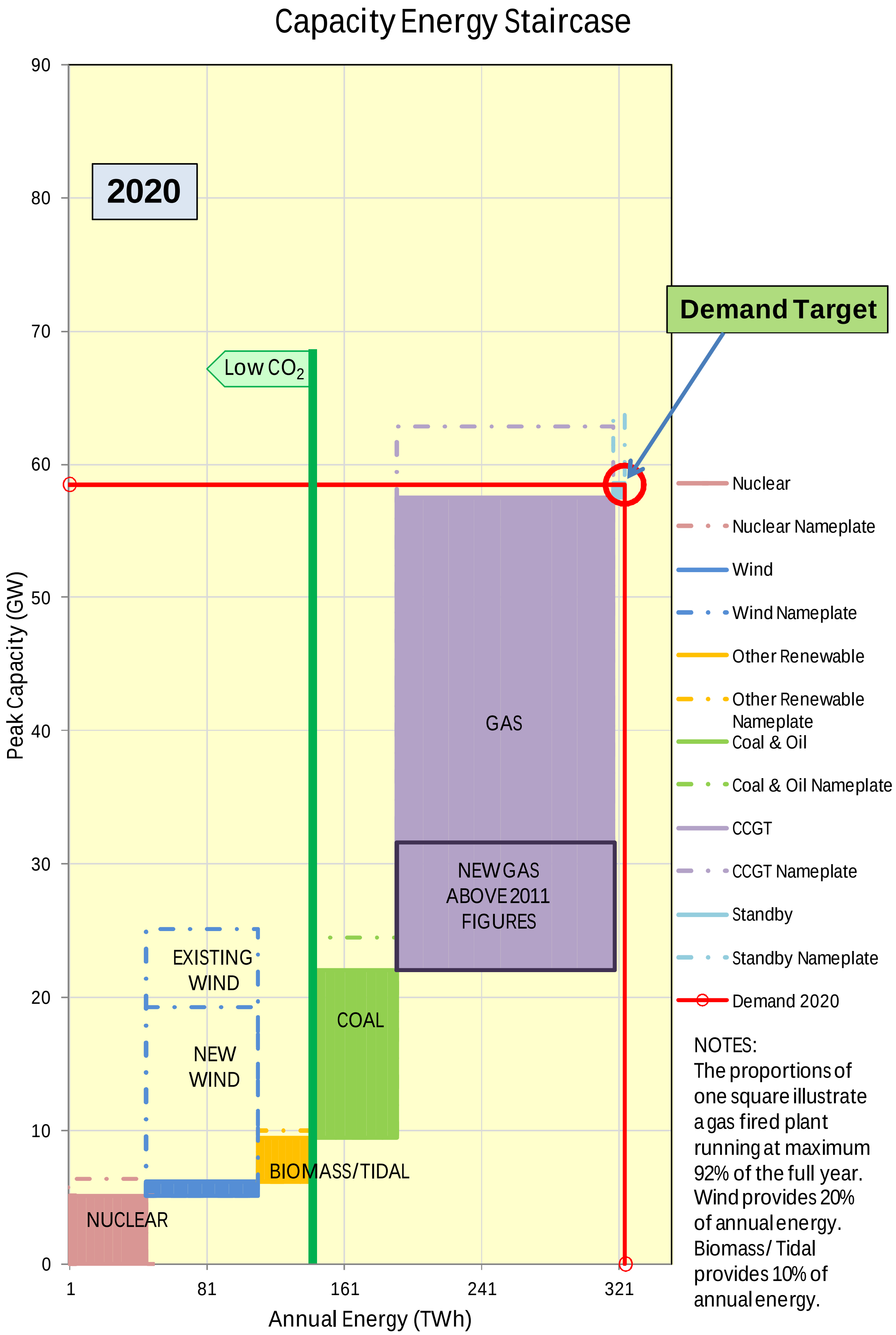

Capacity Energy Staircase
2011
Demand Target
Low CO_2
Peak Capacity (GW)
Annual Energy (TWh)
90
80
70
60
50
40
30
20
10
0
1
81
161
241
321
GAS
RETIRING COAL AND OIL
COAL
NUCLEAR
WIND
Nuclear
Nuclear Nameplate
Wind
Wind Nameplate
Other Renewable
Other Renewable Nameplate
Coal & Oil
Coal & Oil Nameplate
CCGT
CCGT Nameplate
Standby
Standby Nameplate
Demand 2011
NOTES:
The proportions of one square illustrate a gas fired plant running at maximum 92% of the full year

Figure 3



Capacity Energy Staircase
2020
Demand Target
Low CO_2
GAS
NEW GAS ABOVE 2011 FIGURES
EXISTING WIND
NEW WIND
COAL
BIOMASS/TIDAL
NUCLEAR
Peak Capacity (GW)
Annual Energy (TWh)
90
80
70
60
50
40
30
20
10
0
1
81
161
241
321
Nuclear
Nuclear Nameplate
Wind
Wind Nameplate
Other Renewable
Other Renewable Nameplate
Coal & Oil
Coal & Oil Nameplate
CCGT
CCGT Nameplate
Standby
Standby Nameplate
Demand 2020
NOTES:
The proportions of one square illustrate a gas fired plant running at maximum 92% of the full year. Wind provides 20% of annual energy. Biomass/ Tidal provides 10% of annual energy.

Figure 4

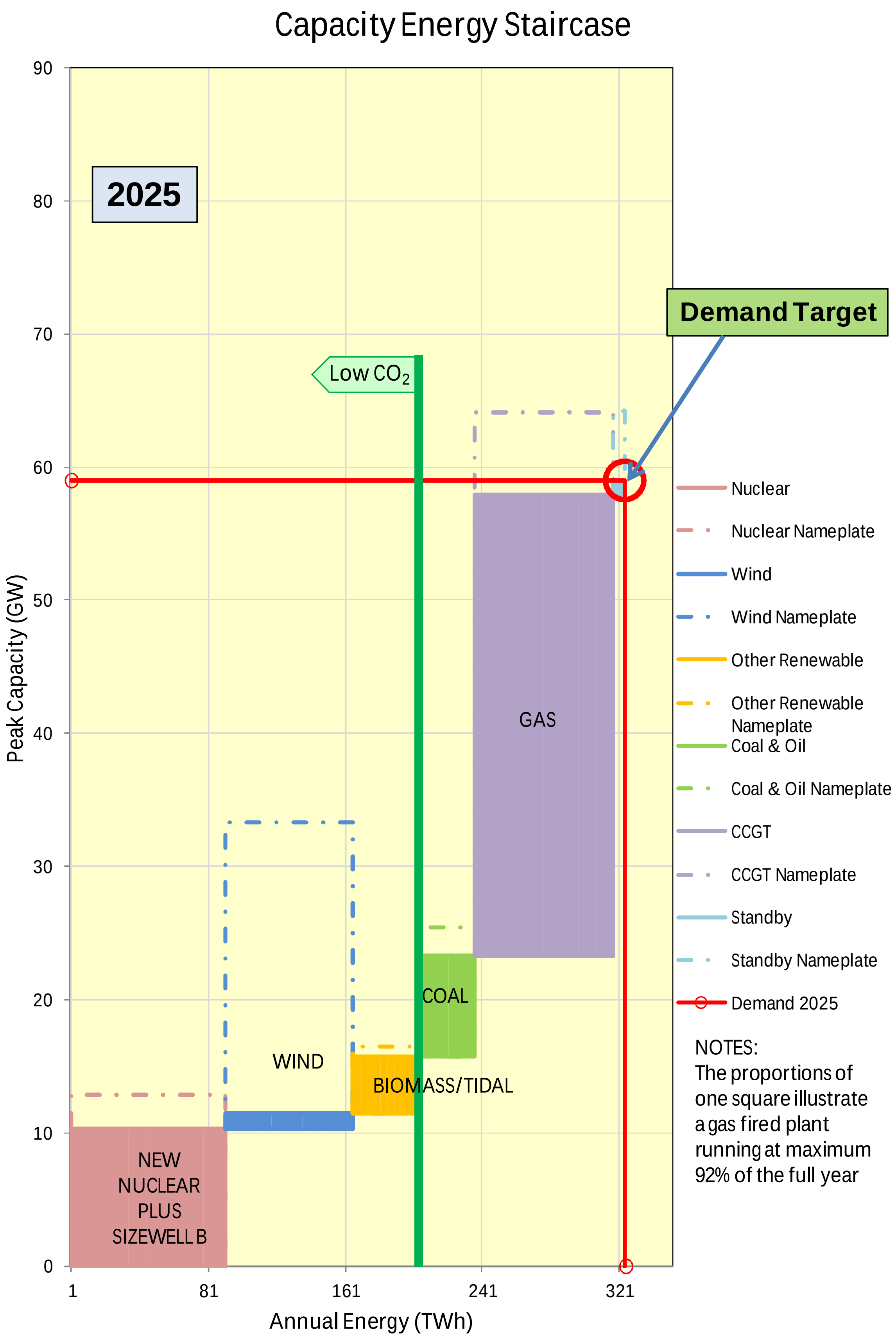
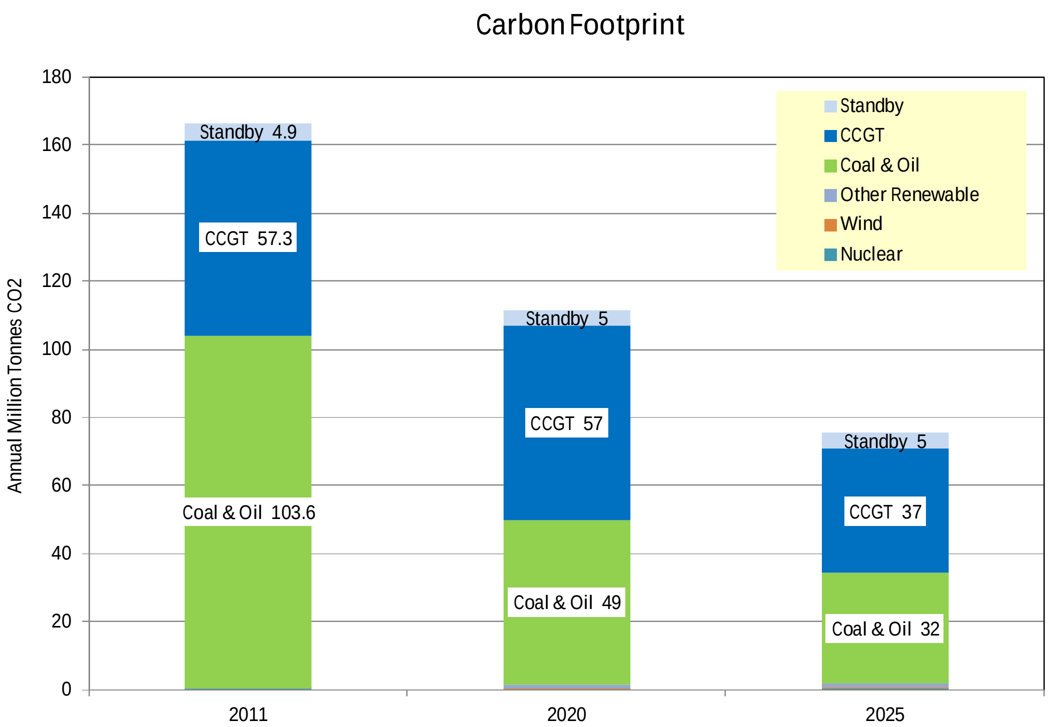

Capacity Energy Staircase
90
80
70
60
50
40
30
20
10
0
Peak Capacity (GW)
1
81
161
241
321
Annual Energy (TWh)
2025
Low CO_2
Demand Target
GAS
COAL
WIND
BIOMASS/TIDAL
NEW
NUCLEAR
PLUS
SIZEWELL B
Nuclear
Nuclear Nameplate
Wind
Wind Nameplate
Other Renewable
Other Renewable Nameplate
Coal & Oil
Coal & Oil Nameplate
CCGT
CCGT Nameplate
Standby
Standby Nameplate
Demand 2025
NOTES:
The proportions of one square illustrate a gas fired plant running at maximum 92% of the full year

Figure 5

4 CARBON FOOTPRINT

4.1 The carbon footprint for each scenario is illustrated as follows:



4.2 The overall Carbon Footprint reduces 2011 to 2025 from 166 to 76 million Tonnes CO_2

4.3 The main CAPEX cost of reducing carbon is 17 GW new wind, investment of £65bn.

4.4 Nearly 5 GW of other renewables is required, investment £9bn.

4.5 Around 10 GW new gas is required, additional investment £6.5bn.

4.6 Around 11 GW new nuclear assumed, investment £33bn.

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5 ENGAGEMENT & QUESTIONS

5.1 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?

5.1.1 Parsons Brinckerhoff believes that gas fired generation, particularly Combined Cycle Gas Turbine (CCGT) plant, already has, and will continue to have, an important role in providing both dispatchable capacity and efficient electrical energy to the UK as a vital complement to the large penetration of wind turbine energy which can deliver the low carbon objectives of the government.

5.1.2 Parsons Brinckerhoff recognise the value of wind turbines to provide low carbon energy by reducing fuel burn elsewhere, but with the limitation of providing almost no contribution to capacity during system peak demands.[12] Wind energy does reduce fossil fuel used, but does not provide dependable contribution to **Peak Demand**.

5.1.3 Gas generation provides reliable capacity and efficient energy with less than half the CO_2 emissions of unabated coal fired plant, at around 340kg/MWh compared with over 780kg/MWh for the best new coal-fired technology

5.1.4 CCGT plant in units of 430-600 MW can be built to deliver more than 58% Net LHV efficiency, depending on the cooling sink available at a particular site.

5.1.5 The CAPEX for CCGT plant is modest at around £600 -668/kW[13].

5.1.6 CCGT plant can be started to full load in less than one hour and can support part load operation down to 50% load.

5.1.7 If the 20% wind annual energy target is not achieved by 2020, the same gas stations will be required, but will use more fuel.

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

5.2.1 The main role of Gas Fired CCGT in the electricity market is to ensure that the **Peak Demand** is satisfied in all seasons.

5.2.2 Delayed nuclear stations will deliver capacity later but new gas stations will be needed to fill the gap 2016-2021. Once new nuclear is commissioned, this and new wind will limit the running hours and investment returns of new gas stations, a factor which may discourage initial investment.

5.2.3 New nuclear clearly provides a base load low carbon form of generation. However, in the event that the commissioning dates for new nuclear slip to 2023-2025, then additional gas fired CCGT can fill the interim gap but in doing so will defer further the need for new nuclear.

5.2.4 The desirable level of gas generation by 2025 is illustrated in Figure 5. The tall narrow shape represents high capacity but lower energy plants.

[12] e.g. 20 December 2010; 1700-1900; UK metered wind 61MW; UK peak demand 60,014MW.
[13] Electricity Generation Cost Model – 2011 Update; Revision 1; Department for Energy & Climate Change August 2001; Appendix B.

5.3 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?

5.3.1 An adequately positive clean spark spread over many years is required to assure investment decisions for CCGT. In the past, CCGT have been financed based on a forecast load factor which generates an acceptable Internal Rate of Return (IRR) over the project lifetime. If CCGT lifetime running hours are suppressed by subsidised low carbon generation, then alternative revenues will be needed to support the IRR for successful investment decisions.

5.3.2 Resolving investor uncertainty is a key to unlocking investment in new gas fired power generation. It is recognised that this is a key aim of the Energy Bill provisions.

5.4 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?

5.4.1 The current low clean spark spread has led to several CCGT plant closures or mothballing and a prospect of sustained higher clean spark spreads and /or a capacity payment mechanism are required to stimulate new build CCGT.

5.4.2 In the past, Section 36 Consent for a CCGT project could be obtained in around two years from selecting a suitable site. The present planning regime under National Infrastructure Planning (and the abolished former Infrastructure Planning Commission) has yet to show how long it takes for a Development Consent Order to be issued. Indications are that the process is significantly more complex and uncertain with estimated consent periods of 3-4 years.

5.4.3 Low load factors will present a barrier to investment in new CCGT. With a focus on supported renewables and nuclear, the load factors and running hours of CCGT will be reduced from those seen in the past. This effect can be seen in Spain where power generated by a large fleet of renewables takes precedence by law over other forms of generation in Spain's mix. However, this is forecast to lead to a 23% operating rate for CCGTs in 2012, according to estimates from gas grid operator Enagas[14].

5.4.4 Although several UK CCGT projects have been progressed through development, including granted consents and signed connection agreements, decisions to start the tendering process leading to an investment decision are unlikely to start until the form of the Energy Market Reform legislation and its mechanisms is clear.

5.4.5 Potential investors and funding organisations are also cautious in the light of recently financed CCGT plant, including examples in near European countries, which face low load factors and reduced returns.

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

5.5.1 Capacity auctions will need to assure capacity contracts to a project for enough years to assure investment decisions. Ten year capacity contracts for new plant may be too short, causing full investment costs to be allocated to the capacity price over ten

[14] European Power Daily; April 23, 2012

years.[15] This may be sub-optimal for the lowest electricity price. One year capacity contracts for existing stations may not prevent closure if stations are unsuccessful in the auction. Capacity auctions will need to assure capacity contracts for each year up to 12 to assure investment decisions.

5.5.2 As required by the Energy Act 2011, Ofgem will produce its first annual capacity assessment this September. It may be necessary to make some amendments to these statutory reporting requirements to ensure that reports in future years provide Ministers with the best possible information.

5.5.3 Nuclear will only be able to bid in a capacity auction four years before commissioned. This could be significantly after the required final investment decision.

5.5.4 It will be important to ensure that existing planning and grid connection consents do not lapse where construction of new gas plant has not begun.

5.5.5 Fast-tracking new projects which already have consent and grid connections could be facilitated by a fast-track mechanism.

5.5.6 Such a mechanism could be an early capacity auction. Auction specifications require careful consideration if they are not to offer various gaming possibilities for the bidders. We have reviewed this and outline the following scheme which we believe goes some way to avoiding some of the worst pitfalls:

5.5.7 The capacity auction would request the following data:

- Baseline existing CCGT capacity of the bidder by year, for the next 15 years
- Proposed additional capacity to be constructed
- Offered annual capacity cost for new capacity £/kW to be paid for the 15 year term of the agreement

5.5.8 The Scheme would offer to pay the annual capacity charge for new capacity, for capacity in excess of the baseline. The total CCGT capacity would be tested or demonstrated each year by actual running of the capacity. Payment would be calculated on the difference between the total tested CCGT capacity and the contracted Baseline CCGT capacity.

5.5.9 Refinements on this scheme might include escalation of the annual capacity charge with a suitable cost index to adjust for fixed O&M cost variation e.g. staff salary cost, spares and maintenance costs. But such escalation would be minor. The 15 year term could be extended, but a shorter term would be less attractive as it would be more costly while guaranteeing capacity for a shorter period.

5.5.10 The intent of this process is to avoid bidders offering new capacity on one hand and then retiring less efficient/ higher cost/ lower duty capacity on the other.

5.5.11 We would propose that the total capacity cost arising from the auction be allocated back to the licensed electricity suppliers in proportion with their annual peak power delivery. The counter party to the capacity payments might be NGC under Ofgem supervision or it could be one of the other entities that are involved in managing payments for ROCs, LECs etc. at that level.

[15] 5340-impact-assessment-on-the-emr-capacity-market 9.23; Contract length: 1 year contracts for existing plant and ten year contracts for new plant.

5.6 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?

5.6.1 Strategic Gas Storage is required to meet peaks in local, regional or national demand and to maintain supply in the event of loss of supply from a system entry point.

5.6.2 Under the regulated gas business, the gas Shippers buy storage space. Shippers buy gas volume during the summer period when demand and market price is low then sell to the market in winter when demand and market price is high.

5.6.3 For gas fired sites without available capacity in the gas network, the long time scale for any gas network reinforcement and cost implications under ARCA can be prohibitive.

5.6.4 Parsons Brinckerhoff view is that OFGEM should pay for strategic storage rather than allow it to be market led because the market incentives are diminished but the security of supply imperatives remain.

APPENDIX A - PARSONS BRINCKERHOFF ANALYSIS OF UK CAPACITY

Parsons Brinckerhoff have analysed the existing and planned UK generation fleet over the years 2011 to 2025, considering:

1. existing and continuing plant; plant with reduced Transmission Entry Capacity (TEC) from April 2013; forecast plant closures under LCPD opted out regime; (Figure 6)
2. new plant under construction or commissioning, (Figure 7)
3. projects with NGET Consents approved (Figure 8)
4. projects with NGET awaiting Consents (Figure 9)
5. current IPC applications, (Figure 10) and
6. projects under NGET 'scoping' (Figure 11)

This results in six charts as each additional category is included (Figures 6-11). A growing Maximum Demand is shown based on 57GW in 2011 growing to 59GW by 2025. A parallel line is shown for the Maximum Demand plus 24% Plant Margin. The Firm Margin erodes from a 2011 high level of 38%. Wind is shown hatched to represent its lack of contribution to Capacity.

Figure 10 shows a plausible balanced solution, but many of the planned projects considered for this are awaiting construction and connection consents, planning permissions and may not be viable to proceed to financial investment decision.

Figure 11 shows the case in which every project in the visible planning system is built and only under this case does the plant margin become excessive.

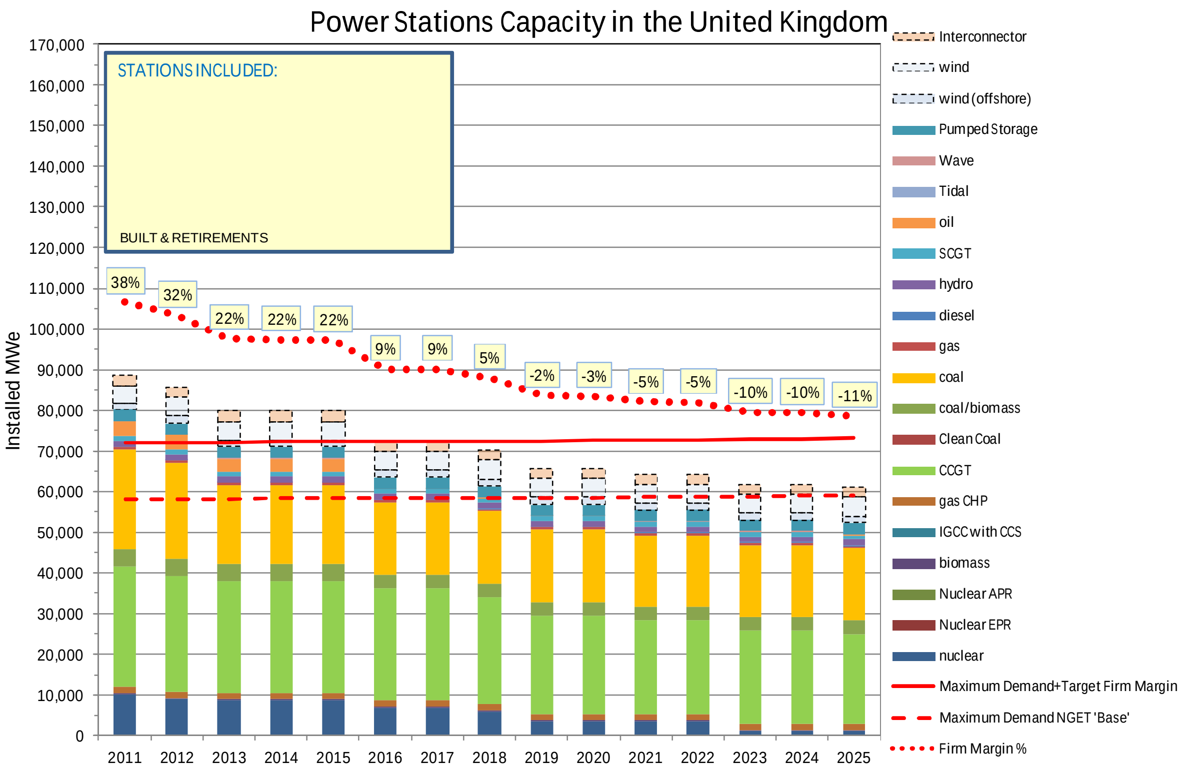

Figure 6

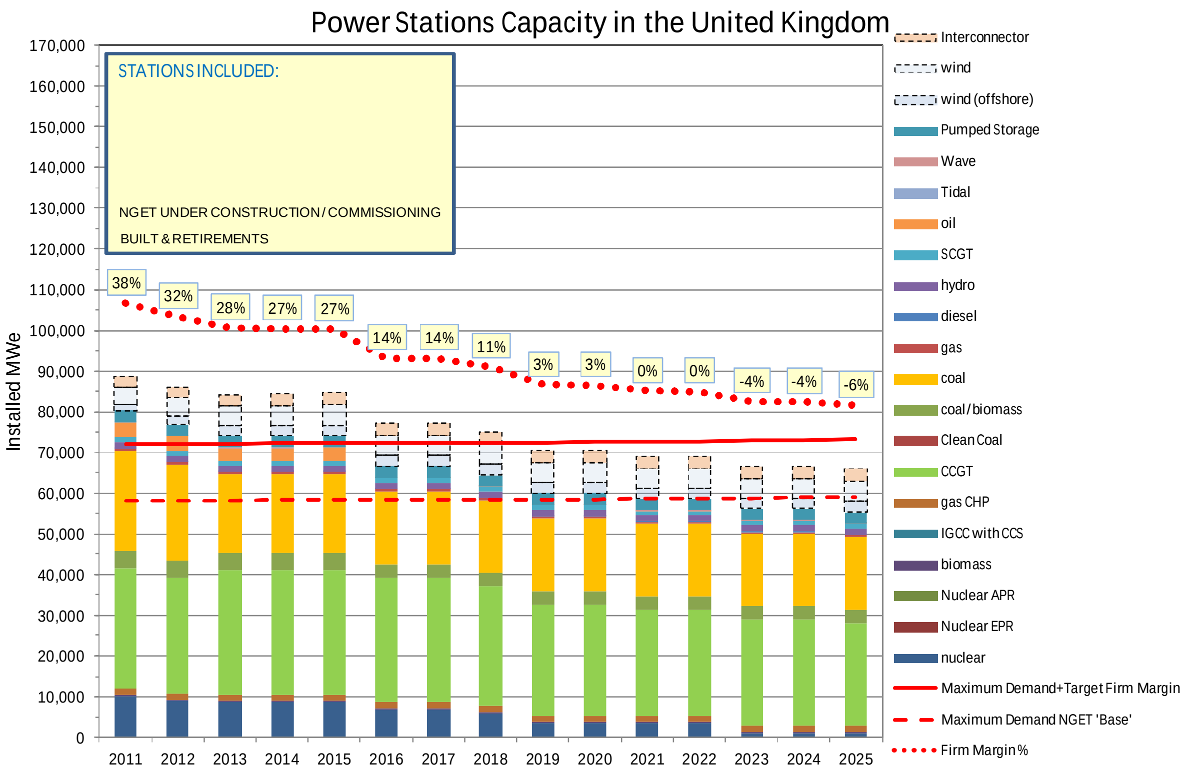

Figure 7

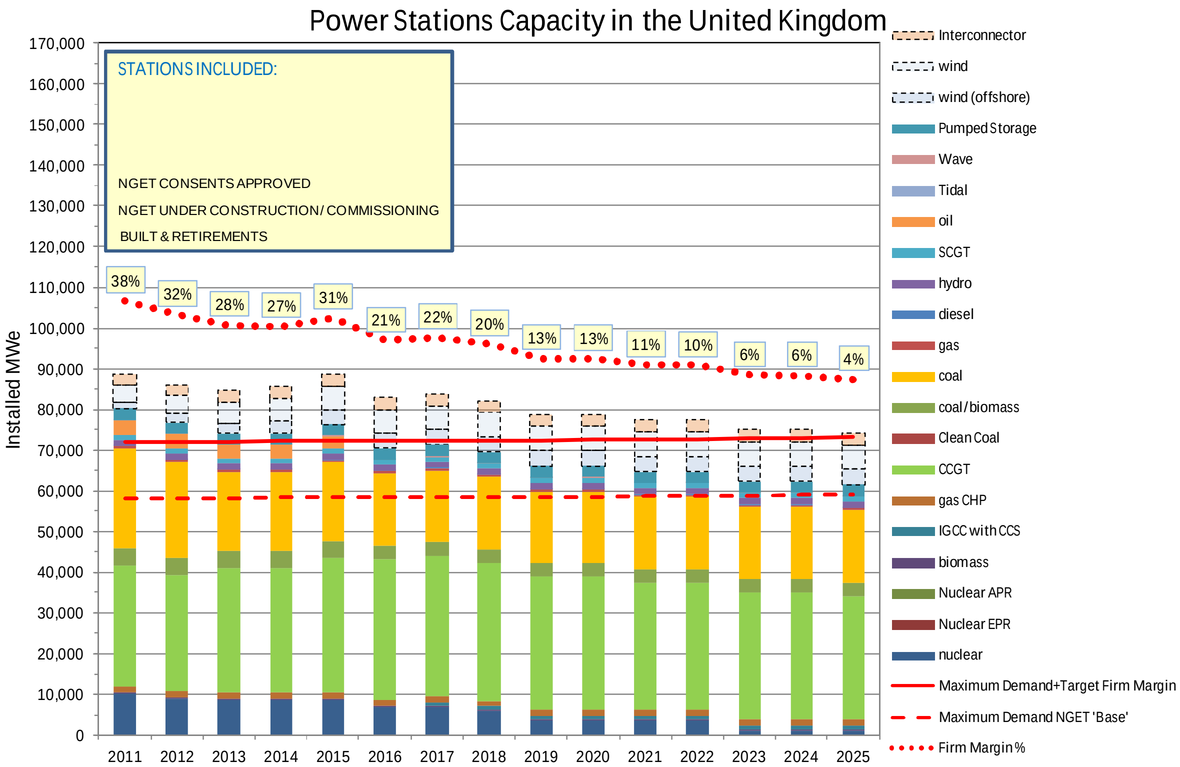

Figure 8

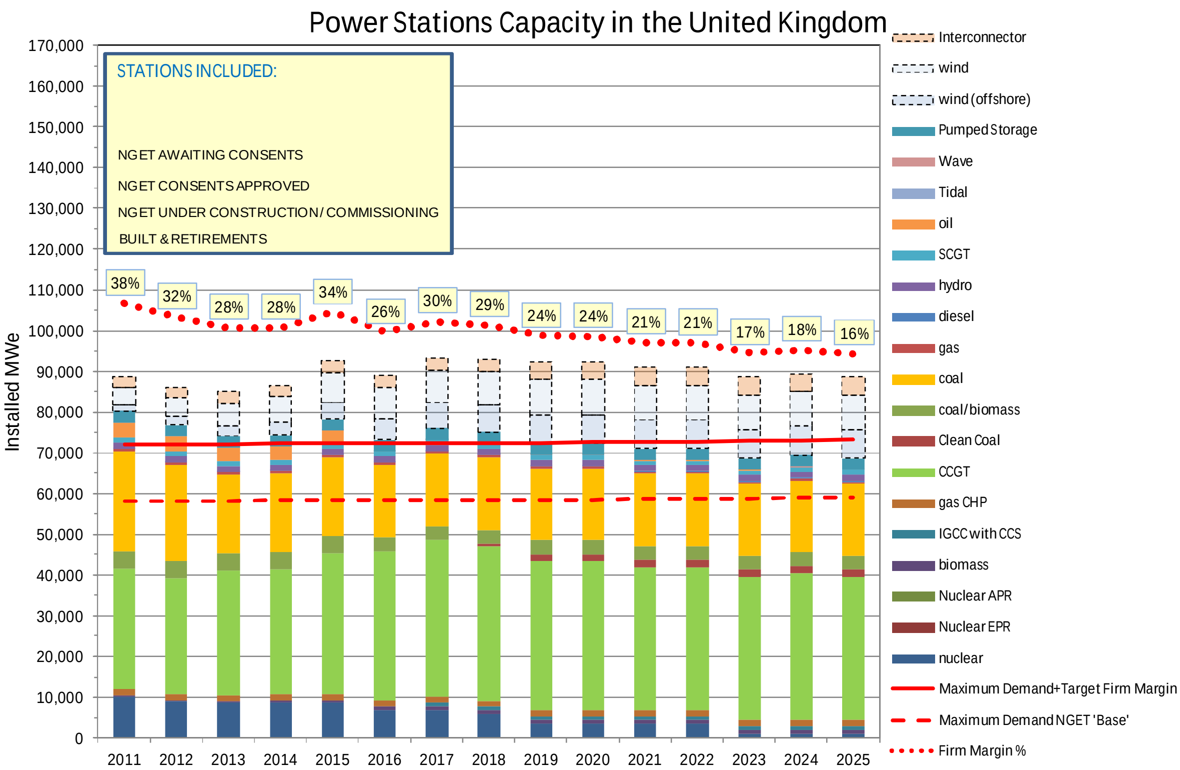

Figure 9

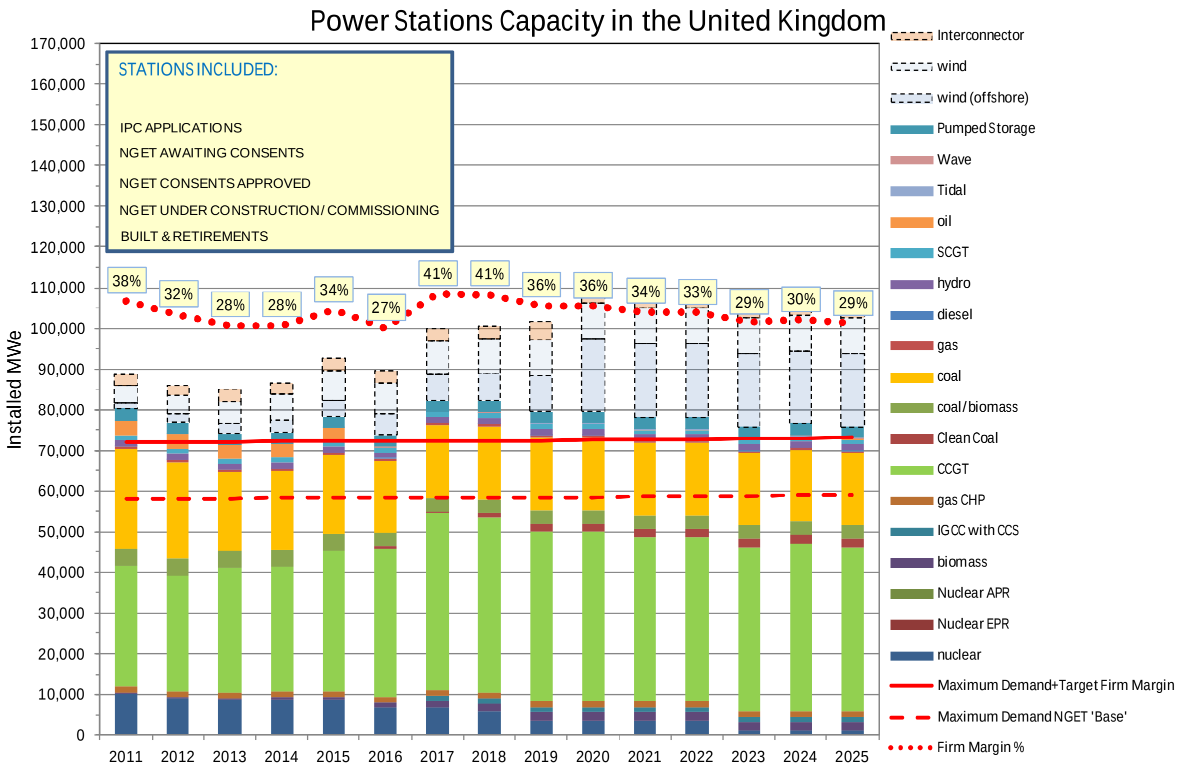

Figure 10

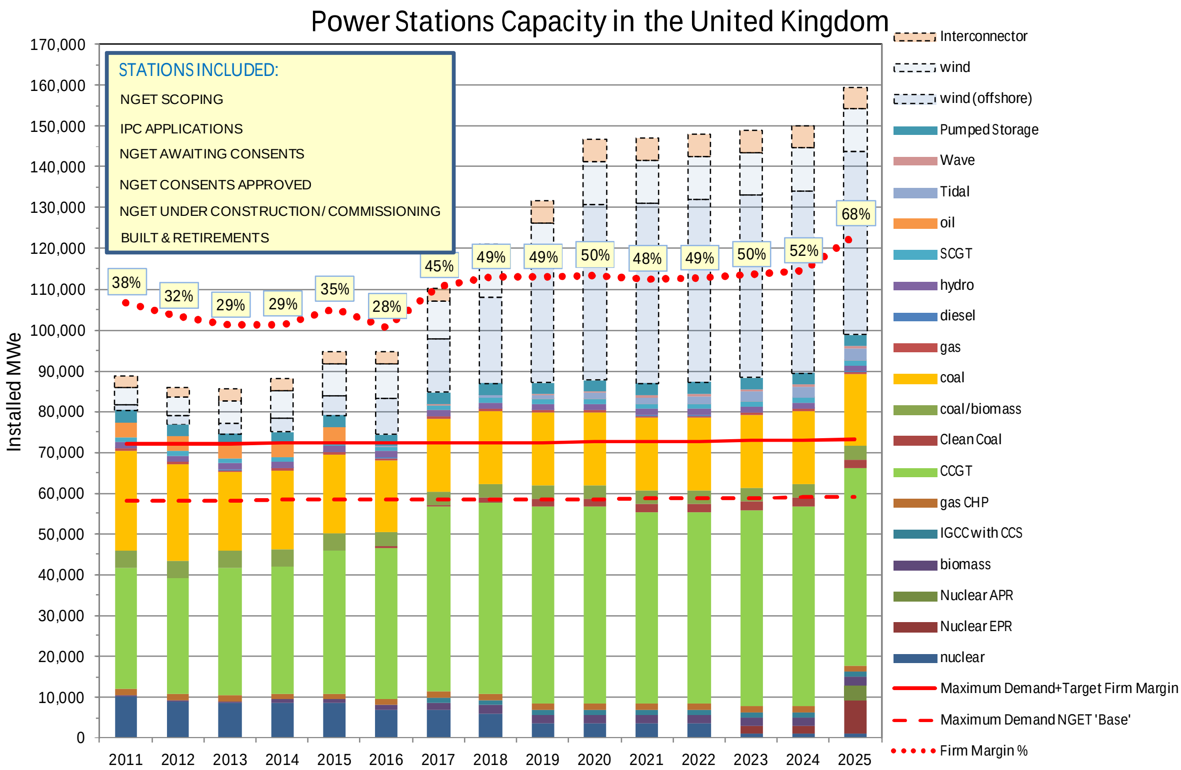

Figure 11

APPENDIX B - PROJECTS CONSENTED UNDER SECTION 36

Several projects, including gas fired CCGT power stations already have Section 36 Consent to Construct. Parsons Brinckerhoff has worked with Clients to develop several of these. Due to a combination of later connection dates, influenced by precautionary early connections for new nuclear projects, recent low clean spark spreads and market reform uncertainty, none of these projects has been progressed to start construction. The Section 36 Consent grant date and 3 or 5 year validity for all known projects is shown in the following chart to illustrate the problem of expiring consents.