Electricity Generation Cost Model - 2011 Update Revision 1

Department for Energy and Climate Change

August 2011

Prepared for

Department of Energy and Climate Change

Prepared by

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Revision History

Revision	Date of Issue	Pages Affected	Details of Change
Original	20/06/2011	N/A	N/A
Revision 1	05/08/2011	16, 17 & 24	Construction period for nuclear technology altered between NOAK and FOAK values. Resultant changes in levelised costs updated.

CONTENTS

EXECUTIVE SUMMARY

This report provides the supporting information to the update of cost assumptions and technical inputs for the DECC Levelised Electricity Cost Model.

The report begins by defining the scope of the work which PB undertook and the general limitations which were experienced. The methodology of the work, including the general approach and the data sources used, are then detailed. Also, any fundamental changes which had to be made to the model are explained.

The main focus of the report is an analysis of the methods and assumptions used to update the cost and technical inputs. The main parameters of key timings, technical data, capital costs and operation and maintenance (O&M) costs are discussed in full.

The report is concluded by giving an overview of each technology, in terms of the notable updates and key reasons behind these updates. The current state of the technology and any expected future changes are also discussed.

A summary of the updated cost assumptions and technical inputs have been included in the appendices of the report, along with the subsequent levelised cost results

1 INTRODUCTION

Parsons Brinckerhoff (PB) was engaged by the Department of Energy and Climate Change (DECC) on February 2nd 2011 to update the cost assumptions and technical inputs of the "Levelised Electricity Cost Model" which was originally created and updated by a third party[1].

This report summarises the work carried out by PB and aims to provide context for and an explanation of modifications made to the dataset that forms the model inputs.

1.1 Background

Details of the "Levelised Electricity Cost Model" can be found in the '*UK Electricity Generation Costs Update'* report by Mott Macdonald for DECC.

The inputs to the Model require updating periodically in order to reflect the varying costs of generation technologies, market forces and changing attitudes to the predicted costs of new technologies as knowledge and experience increases. The dataset provided as part of this work represents the current view of generation costs and performance and as such, the validity of the dataset shall decrease with time and require further updates in the future.

1.2 Report Structure

This report briefly describes the scope of work undertaken by PB in order to update the model inputs including the technologies covered, the input parameters investigated and the general limitations of the work. Following this, an overview of the methodology is detailed and covers the general philosophy and approach to obtaining robust values for the input parameters and major data sources. The report then provides a more detailed commentary on specific inputs, explaining any assumptions made for specific technologies. The report concludes by giving a brief overview of the results in a technology-by-technology format.

A summary of the updated cost assumptions and levelised cost results are included in the appendices.

[1] For further details, see: Mott Macdonald. *UK Electricity Generation Costs Update*. June 2010

2 SCOPE OF WORK

PB's scope only included the update of the cost assumptions to be inputted into the model, which was provided by DECC. PB was not responsible for the calculations or operation of the cost model.

2.1 Technologies

The technologies investigated and evaluated were as follows:

- Combined Cycle Gas Turbine (CCGT) plant
- CCGT plant with Carbon Capture and Storage (CCS)
- Advanced Supercritical (ASC) coal plant with Flue Gas Desulphurisation (FGD)
- ASC coal plant with FGD and CCS
- Integrated Gasification Combined Cycle (IGCC)
- IGCC with CCS
- Nuclear PWR plant (single unit)
- Nuclear PWR plant (multiple units)
- Pumped storage hydro-electric plant
- Open Cycle Gas Turbine (OCGT) plant
- 10 MW gas fired Combined Heat and Power (CHP) plant
- 50 MW gas fired CHP plant
- 500 MW gas fired CHP plant

2.2 Input Parameters

A range of cost and performance parameters were updated by PB and were classified within the model input sheets under the following areas:

- Timings – the development, construction, operational and decommissioning period
- Technical data – plant heat and power output, efficiency and forward profiles for availability, load factor and changes in efficiency due to degradation
- Capital costs – design and development, regulatory and licensing, construction, infrastructure and phasing of each technology across the appropriate time period
- Operational and maintenance costs – fixed and variable maintenance costs, use of system charges and insurance.

The model also contains input assumptions for the cost of CO_2 disposal, waste disposal, decommissioning, fuel price projections, exchange rates and CO_2 price projections; however these parameters were outside the scope of the work undertaken by PB and have values as set by DECC.

2.3 General Limitations

The key challenge in assembling the model input data was to prepare cost estimates under consistent assumptions for a wide range of technologies, some of which are well understood and have extensive market presence whilst others are at an earlier stage of development or application and are less well understood. Inevitably the methods by which estimates were prepared for each of these technologies varied, presenting challenges to ensure that unavoidable discrepancies between the methods were minimised. These potential discrepancies are explained for the purposes of transparency in Section 4.

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The work described in this report was generally limited by the availability of reliable and accurate data that was presented in a format suitable for transposition into the model. Further limitations were introduced by the format of parameters required for certain inputs, which could not be altered without significant intrusions into the mathematics and workings of the model. Specific issues arising from this and any assumptions that were required in order to overcome these limitations are described in the following sections.

3 METHODOLOGY

3.1 General Approach

Cost estimates were obtained using a staged approach, similar to that used in the Powering the Nation (PtN) report and subsequent updates published by PB. Initially, costs were sourced from a range of reference plants, although specific projects cannot be identified within the model or this report due to confidentiality constraints.

Where reference plants were unavailable, estimates were based on a combination of opinions from prominent studies and from the experience of technology experts within PB.

Any inputs for which an equivalent exists within PB's modelling used for the latest Powering the Nation Report Update were compared to those derived for the Update for validation purposes.

3.1.1 General Treatment of FOAK and NOAK

For all established technologies that are well understood such as CCGT, OCGT, coal ASC with FGD, IGCC, CHP and pumped storage, FOAK and NOAK values for all parameters were assumed to be equal. Variation between sites and general uncertainty was represented through the variation of values across the high, medium and low levels.

For new technologies or those with little commercial experience within the UK, inputs for FOAK and NOAK were differentiated where applicable. For CCS and nuclear technologies, FOAK was defined as the first plant within the UK, not including demonstration projects. This allowed for any experience gained from international projects to be accounted for. NOAK inputs were generally defined as the estimated level that would be achieved when the addition of one new plant within the UK would not in itself have any significant impact on the forward price of the technology beyond long term market trends.

The treatment of FOAK and NOAK became acute when considering the capital cost and forward price adjustments of new technologies. This issue is discussed further in Section 4.3.

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3.1.2 General Treatment of Input Levels

High, medium and low input levels were incorporated into the model for each parameter. For well understood technologies, these levels have been utilised to represent the variation in each parameter across specific example sites. For new technologies, the levels represent the range of uncertainty assessed for the forward estimates.

3.2 Data Sources

As described above, costs and technical parameters were taken from appropriate reference plants. However, other data sources include:

- Indexed historical cost – A historical cost value was adjusted for indices to give the price of raw materials, labour costs and other variables where appropriate.
- Reference UK projects – UK projects contracted in recent years were adjusted, where necessary, for timing and other differences to the reference concept to give relevant cost values.
- Reference International projects – International projects were adjusted for differences between local and UK costs and for currency (where not priced in US dollars or Euros) to give comparable cost values.
- Indicative costs for projects under development – In some cases, developers may publish indicative cost figures which were utilised as central cost estimates and an appropriate variation added to give high and low estimates.
- Cost databases and modelling software – In some cases it was necessary and appropriate to utilise cost data from the Thermoflow PEACE cost modelling software. This is industry

recognised software, which uses the user design inputs to accurately model the technical performance and relevant costs of different plant types. This method was particularly used to correct costs for plant of different configurations to the desired reference. The ratio of costs calculated by the cost modelling software for the priced configuration and the reference configuration was used to better correct the cost of the priced configuration to give a better estimate of the reference price. Performance estimates were also derived in this manner for CHP technologies.

- Studies and Literature search – Relevant published cost data for projects under development and for new technologies at an earlier stage of demonstration were analysed to prepare an assessment of the likely costs for such technologies when they become commercially available.
- PB experience – PB has drawn upon its own work in supporting the UK Carbon Capture & Storage (CCS) Demonstration Programme, and on other topics, to contribute further data to the literature search which underpinned estimates.
- PB estimates – In some cases it was difficult to obtain any robust value from which input assumptions could be extrapolated from accessible or published data. Where necessary PB used its own cost estimating facilities to estimate the appropriate adjustment to make when an input was scaled.

In the cases where specific data sources could be identified, such as published estimates and studies, these have been identified in Section 4.

A list of data sources used for the evaluation of the costs associated with CCS can be seen in Appendix E – CCS Data Sources. Confidential data sources are not included in this list.

3.3 Accuracy

In using the estimates prepared by PB the inevitable uncertainties need to be recognised. Costs should be considered in the light of the AACE International Recommended Practice 18R-97, Cost Estimate Classification System, which can be viewed in Appendix F – IRP 18R-97. This defines various levels of estimate accuracy according to the extent of engineering work completed on the project.

A Class 5 estimate is the accuracy likely to be achieved during a conceptual study which would at best be -20 % to +30 %, although for new technologies the accuracy is more likely to be -50 % to +100 %. The relevant levels of uncertainty for the different technologies (i.e. new or mature) were reflected by variations included within the high and low input levels as setup in the model.

3.4 Model Modifications

PB has not made any modifications to the workings or logic within the model itself. However, some of the technical data parameters have been modified for all technologies. The changes made are summarised in the following table.

Original parameter	Replaced with	Reason
Gross Power	Net Power	Most available capital cost quotes for each technology were given per unit of net power export. Therefore to avoid conversion errors, the power input for each technology was equal to the net power and auxiliary power was set to zero.
Gross Efficiency	Net Efficiency	Efficiency should be quoted as net to correspond with the net power. As the ratio of gross power to gross efficiency is equal to the ratio of net power to net efficiency, no further modification of the model inputs were required.

4 ANALYSIS OF COST INPUTS

This section of the report describes the working behind the more significant areas of the updated inputs. A comprehensive summary of each figure can be found in Appendix D – Technology-By-Technology Assumptions, and this should be referenced for technology specific explanations.

4.1 Timings

The timings for each technology were generally based on past reference projects and expected durations within the industry. For established technologies (for example CCGT and ASC coal) the figures were based on previous projects and the range of figures found was represented in the low and high values.

For new technologies (for example CCS and nuclear) the duration of periods were based on industry opinions and therefore are expected durations. These opinions were a result of learning from studies (both internal and external), conferences and communication with manufacturers. Therefore, the range of low and high figures represents the uncertainty of the figures, as discussed in Section 3.3.

4.2 Technical Data

4.2.1 Power and Heat Output

The quoted power output was selected to be representative of typical projects for the relevant technology type. These power outputs correlate with quoted costs and indicate the size of plant which the costs and performance inputs were based on. Although the actual value of power output is not represented in the levelised cost of a technology, it is significant due to the cost assumptions being based upon a plant of that size.

For the nuclear technologies the power outputs and other assumptions were selected to be representative for the number of reactors which are expected to be constructed on each site, in addition to the analysis for a plant with a single reactor per site.

Net power instead of gross power was entered into the model for each technology. This was because capital cost quotes for the majority of technology data is given or calculated on a per unit of net power basis. This approach avoided possible errors or additional calculations required to convert costs to a per unit of power gross basis, where higher auxiliary power levels are expected, such as for the CCS technologies.

4.2.2 Efficiency and Availability

The efficiency figures chosen represent, in the case of mature technologies such as CCGT, OCGT and coal ASC with FGD, the reasonable variation in efficiency from site to site. This variation is generally brought about by the economics of specific projects. For less mature technologies, the efficiency values represent the expected variation and uncertainty in this parameter.

For nuclear technologies, fuel prices are quoted per unit of electrical energy output and therefore the efficiency is not required to calculate the fuel consumed.

Availability includes estimates of the forced outage rate, outages due to a major overhaul and power degradation (where applicable). Although it is not usual to include power degradation within estimations of availability, it has been accounted for within the availability trend as there was no separate model input for power degradation (which is the decrease in total power output of a plant over time). Therefore for technologies that include power degradation (namely gas fired technologies) the availability may differ from the expected and more usual trends.

4.3 Capital Costs

4.3.1 Capital Costs

As mentioned previously in the report, the challenge relating to the evaluation of capital costs was to undertake the assessment on a consistent basis. The aim was to base the capital cost estimates on reference projects, but due to the nature and immaturity of some technologies this was not possible in all cases.

Wherever possible, reference project costs were used for the mature technologies. However, this approach was not possible for CCS technologies. When reference projects were utilised they were assessed and adjusted in terms of their relevance to the 'generic' technology type. This method has factored in criteria such as configuration and equipment constructed, location and build date. Taking these factors into consideration an indicative normalised cost was calculated.

For the CCS technologies a thorough study was completed to gather as many relevant data sources as possible, to assemble as comprehensive a set of current costs as possible. To do this many reports and studies were referenced, as shown in Appendix E – CCS Data Sources. Once this had been done PB took a view on the credibility of each study, and the related capital cost, and calculated an indicative 'incremental' capital cost for the addition of CCS to another technology. Therefore, for example, the total construction capital cost for IGCC with CCS was the capital cost of the IGCC technology plus the incremental capital cost for the CCS technology.

It should be noted that the CCS technologies were assessed individually for their addition to different technologies. Therefore the incremental cost for post combustion CCS for ASC coal is different to the incremental cost for pre combustion CCS for IGCC technology.

4.3.2 Changes in Capital Costs over Time

The capital cost adjustment curves allow for the assessment of expected change in capital costs as projects are modelled in future years. The curves account for underlying market trends and for immature technologies, any learning that would take place.

4.3.2.1 Market Trends

The underlying market trends for all technologies were derived based on analysis of the historical cost of CCGT plants built across the UK of above 500 MW since 2002. An average inflation figure of 2.84% was utilised to align the historical costs to 2009 and a linear cost curve was fitted to this data. However, due to the wide deviation in data, a strong linear correlation was not clear. It was therefore decided that for the medium level for each technology a flat market trend would be incorporated. The high and low levels were respectively equated to a positive and negative linear trend of approximately 1% change annually, as larger figures were considered unlikely to be consistent with the historical data. The high and low levels for each technology were then modified further with respect to the CCGT curves to reflect the level of uncertainty associated with each technology and therefore the potential for cost variation in the future.

The same underlying market trends were applied equally to the FOAK and NOAK scenarios.

4.3.2.2 Learning Curves

The forward capital cost adjustments for new technologies including CCS and nuclear also accounted for the cost reductions that could be brought about by learning. Potential learning rates have previously been researched and quantified as explained by the Rubin[2] report. The learning curves

[2] Rubin, E.S. Yeh, S. Antes, M. Berkenpas, M. and Davison, J., 2007. *Use of experience curves to estimate the future costs of power plant with CO2 capture.*

were based on an assumed build rate, learning rate and a "start of learning year" (see Appendix C – Assumed Start of Learning Dates), which indicated the year in which learning from either UK or international projects began to affect capital costs. In order to reflect the extent of learning across the initial stages of the project, learning for new complete capacity in each year was calculated and averaged over a number of years prior to initial operation. This period was set according to the current levels of learning that is taking place for certain technologies, even though a commercial project has not yet been completed.

The input assumptions for FOAK and NOAK differed due to the variation in learning rates and build rates from international projects and from UK projects.

4.3.2.3 FOAK and NOAK Validity

Many technologies in the report are currently considered to be at the FOAK stage, and are expected to remain at that stage until their "start of learning year" (see Appendix C – Assumed Start of Learning Dates). In order to provide an indicative value for the construction cost of a NOAK project commencing 2011 for technologies which in practice are still at FOAK stage, it was assumed that learning had begun to take place prior to 2009. This is an indicative exercise only and therefore NOAK prices quoted for technologies prior to their "start of learning year" are not strictly valid.

In years following the NOAK "start of learning year" the price adjustments reflect the cumulative learning from both international and UK projects that were assumed to occur between 2009 and the year being modelled. Results generated for these years are therefore fully valid.

FOAK price adjustments are valid for all years as the period before the FOAK "start of learning" year reflects market trends only with no learning.

4.4 Operational and Maintenance Costs

4.4.1 Fixed O&M Costs

Wherever possible the O&M cost assumptions were based on reference projects, although this method was more problematic than for capital costs. Due to the sensitivity of the material it was increasingly difficult to source up-to-date and definitive figures for the different O&M costs.

As a result of this, the source information used for PB's Powering the Nation study has been referenced for many of the technologies. Where this has been done the fixed O&M costs have been categorised into two amounts. The first amount is an allowance for the fixed maintenance of the machines (notably of the power train), for example the long-term service agreement (LTSA) fee for a gas turbine. Secondly, a figure for staff costs has been allowed for, which includes general administrative and operations staff. Both of these cost figures have been suitably adjusted for the technology involved and the size of the plant.

The CCS technologies have been evaluated using the same method as for the capital costs. Namely, a thorough study was completed to compile all possible cost data from different sources (Appendix E – CCS Data Sources), such as studies and reports. Once again PB's CCS experts took a view on the creditability of the source and calculated an indicative 'incremental' O&M cost for the CCS technology. This incremental cost was then added to original cost for the relevant technology.

4.4.2 Variable O&M Costs

For the purpose of the update of costs, the details of the variable O&M costs were simplified. It was assumed that all variable O&M costs were due to the cost of consumables, for example chemicals necessary for water treatment (applicable to steam turbine technology) and limestone consumed in the FGD process and other IGCC processes, etc. The cost of these consumables was based on relevant project data and appropriately adjusted for the size of plant and level of consumable usage, for each technology.

As mentioned in the previous section, the O&M costs for CCS technologies were calculated from various data sources. The incremental cost supplied was inclusive of both fixed and variable costs, based on an assumed number of fired hours. Therefore assumptions were made to divide this cost appropriately between fixed and variable costs. This was done using several calculations which accounted for the equivalent increase in CAPEX for the CCS technology, the equipment involved and the use of consumables in the CCS plant.

4.4.3 Fuel Costs

As mentioned previously, in Section 2.2, the update fuel costs and profiles did not fall within PB's scope.

The fuel costs for the pumped storage technology has been assumed to be zero and therefore there are no fuel costs allowed for in the fuel profile of the O&M costs.

5 TECHNOLOGY OVERVIEW

This section is intended to briefly highlight the key results, in a technology-by-technology format, and explain the main drivers behind the resultant levelised cost.

A summary of the updated cost assumptions can be viewed in Appendix B – Summary of Technology Input Assumptions and the calculated levelised cost results for a selection of technologies can be seen in Appendix A – Levelised Cost Results.

5.1 CCGT, OCGT & CHP

Generally, electricity generation from different gas turbine technologies are well established, well proven and well developed. Therefore, the costs for a generic gas plant tend to be less variable than for immature technologies. Differences in costs tend to arise from differences in design requirements and site features.

The output of the different gas fired technologies was updated to best reflect the normal size of a typical plant. For example, the net output for CCGT plant was increased to 850 MW as this is the typical size of plants being constructed at this time. Notably the net output of the large CHP plant was increased to 463 MW following discussions with DECC about the typical application for this size of plant.

As mentioned earlier this technology type is well established and therefore typically requires less capital investment, as shown by the levelised cost results. This was mainly because it was considered to be an off-the-shelf technology and therefore tended to have smaller development, regulatory and infrastructure costs as well as construction costs.

As mentioned in Section 4.3 of the report, the overall construction costs of CCGT, OCGT and CHP technologies were not expected to vary from the current overlying market trend, due to the maturity of the technology.

It is worth noting that the most substantial proportion of the levelised cost for these technologies is due to the carbon and fuel costs, which fall outside the scope of PB's update.

5.2 ASC and IGCC Coal

Similar to the gas fired technologies, coal fired technologies are well developed and therefore the capital costs involved are not expected to deviate greatly from the general market trend (as described in Section 4.3.2.1).

The net outputs which the cost updates were based on were unchanged as the previous figures used were representative of typical plants sizes for these technologies.

The drivers behind the higher capital cost (compared to those of gas fired technologies) are the fundamental differences in the nature of the thermal cycle and the additional systems required for fuel and ash handling and processing, as well as the flue gas treatment equipment, for example FGD.

Additional costs result from the use of higher temperatures within the boiler and steam cycles and the possible corrosive effects of coal impurities, requiring the use of high grade materials. As well as this, the equipment is generally of a larger scale, and therefore more expensive, due to the nature of the technology.

A coal power station requires many fuel handling systems. Compared to gas which can be piped directly to the point of delivery, coal requires bulk transportation to site (i.e. additional infrastructure) where it is handled and put into storage, from which it will be processed to the point of use. This amounts to many extra requirements, including extra plant space, delivery systems and handling systems.

The capital costs for IGCC are higher than for more conventional coal fired technologies as the technology and systems involved are generally more complex in terms of process and chemistry.

Also, there are many more ancillary systems which all require additional design and construction work.

Once again, it should be noted that the most substantial proportion of the levelised cost for these technologies is due to the carbon and fuel costs, which fall outside the scope of PB's update.

5.3 CCS

Currently CCS is a new, emerging and developing technology which is yet to be proven in the UK by means of a demonstration or commercial plant. Therefore the costs involved lack accuracy (as mentioned in Section 3.3) and are subject to much uncertainty. The net power outputs of CCS technologies have been chosen to match those of the primary technologies, but due to the large auxiliary power requirements of the CCS technology this requires an increase in the primary plant package. This is one of the reasons the CCS technology options are much more expensive than the primary technology options.

As detailed in Section 4.3.1, the costs for CCS technologies were sourced from a study of many reports and investigations. As it can be seen from the levelised cost results, the largest proportion of costs (excluding the costs which are outside of PB's scope) is the capital investment required. This is not only due to increased construction costs because of additional equipment and systems, but also because much more development and planning work would be required before the start of construction due to the infancy of the technology.

It is expected that there will be significant learning associated with CCS technologies (as detailed in Section 4.3.2.2), which will be linked to the increase in installed capacity. It is expected that learning shall reduce development, construction and infrastructure costs due to a better understanding of the technology in terms of construction and operation and due to the development of a more mature and economically efficient carbon transport and disposal market.

5.4 Nuclear

Previous versions of the model inputs sized the nuclear technologies for only one reactor per site. To this date PB are not aware of any developers planning to construct and operate single-reactor plants. Therefore it is more realistic to update the plant size (and its related costs) to the expected installed capacity, which is currently approximately 3300 MW.

Currently all new-build projects in the UK are in the planning process and as yet no developers have selected their preferred vendor and therefore no orders have been placed. There has been limited open tendering for nuclear power plant so comparable reference costs are restricted. Hence the estimates of the capital construction costs included here are subject to large variations, as shown by the range of figures.

PB's opinion is that the capital construction cost for nuclear power stations will be subject to affects from learning, as described previously in Section 4.3.2.2. Also, the costs estimates provided do not reflect any view on the impacts of the Fukushima nuclear plant crisis

It should be noted that PB deems it very unlikely that a single reactor nuclear plant will be constructed in the UK. Despite this, updates to the costs for single-reactor plant were provided. These were based on the figures for the related multi-reactor costs with suitable scaling. For example and most significantly, the construction cost for the single reactor site is approximately 5% more (per kW) than that for a multi-reactor site, due to the multi-reactor site achieving cost savings on shared infrastructure and related construction costs.

5.5 Pumped Storage

Pumped storage is a well developed technology which has been generating electricity in the UK for many years. Despite this the technology is subject to uncertainties and fluctuating costs. This is largely because the capital costs are highly influenced by varying civil work requirements due to the

location of the site. The high, medium and low capital cost levels for this technology therefore reflect this. The range of these figures also accounts for the uncertainty of site location and how this affects the technology utilised.

The success of a pumped storage project is dependent on the suitability of the site. Currently, many of the most suitable sites in the UK have been utilised, therefore leaving less suitable sites. As a result of this potential pumped storage projects will have to adapt and evolve from the simple dual reservoir design. These possible solutions are likely to incur additional development and construction costs, which are accounted for by large range of figures.

The capital cost trends for pumped storage reflect the increasing difficulties and civil works required, due to site location, as the installed capacity increases and more suitable and cheaper sites are used up.

APPENDICES

APPENDIX A – LEVELISED COST RESULTS

Appendix A presents the levelised costs for each of the major generation technologies in this report. Presented are two cases:

- Case 1 - projects starting in 2011, with technologies which have not been deployed in the UK in their current form considered FOAK, and those that have considered NOAK.
- Case 2 - projects starting in 2017, assuming that NOAK has been reached for all technologies due to prior deployment.

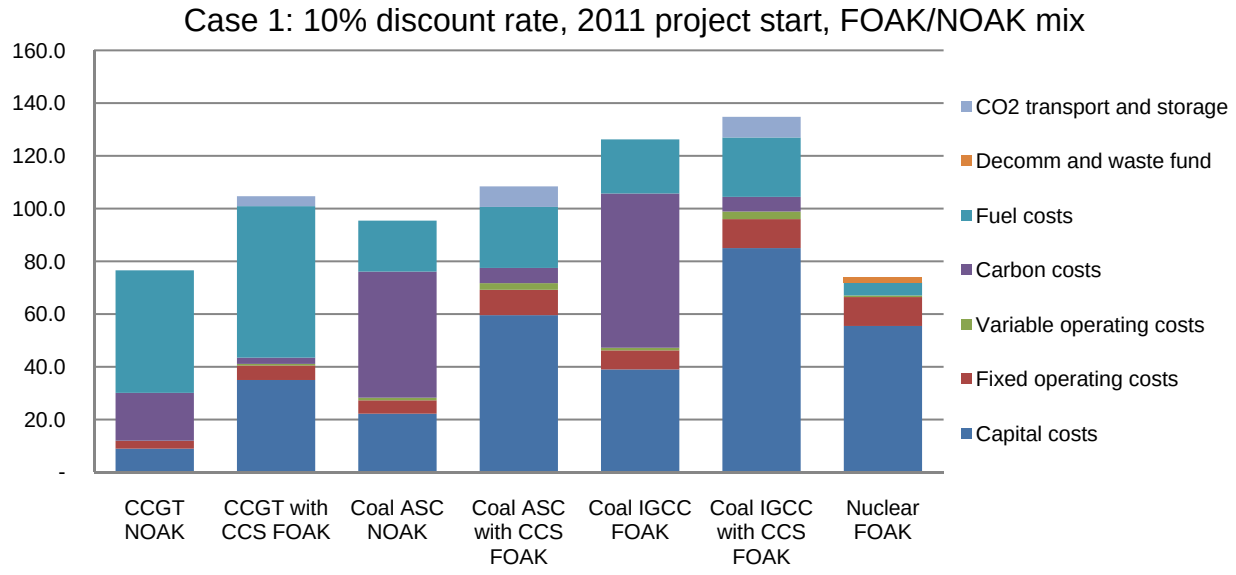
The levelised costs are based on a 10% discount rate, DECC's projected fuel prices and Carbon Price Support, and all central estimates of levelised cost data. However, for each case, presented is a graph demonstrating the sensitivity of levelised costs to high and low estimates of CAPEX, fuel and carbon price scenarios.

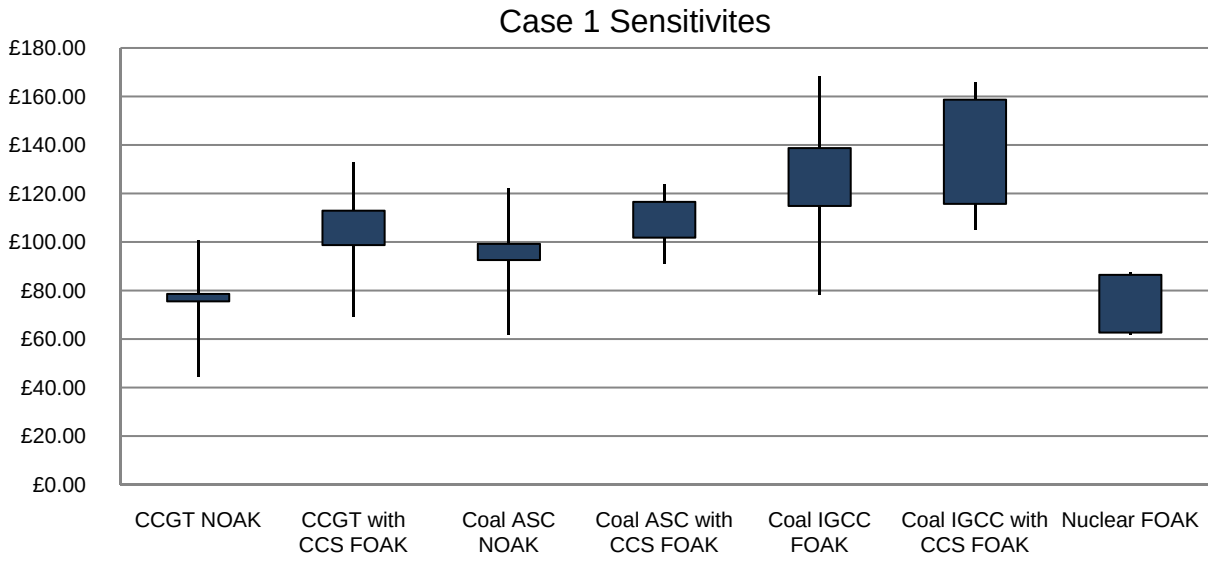
These results have been generated by DECC using the input assumptions supplied in this update by PB.

Nuclear costs given reflect the cost estimates for a multiple (two units) reactor plant.

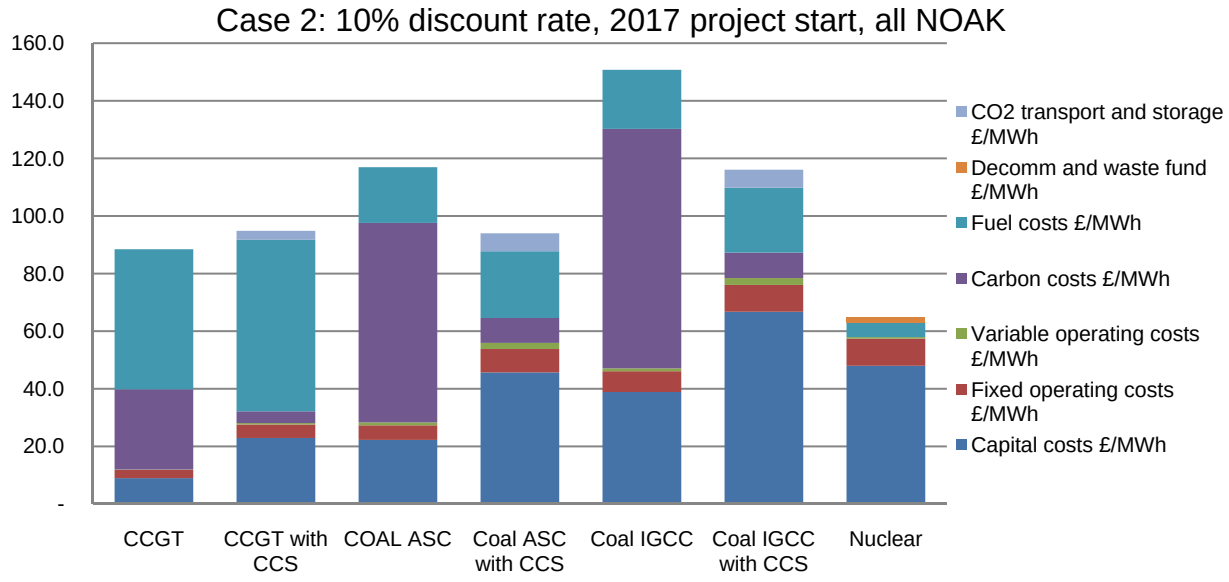
For the graphs showing the cost sensitivities, the solid bars represent the high and low CAPEX figures and the thin extending lines show the sensitivity to combined high/low CAPEX, fuel and carbon projections

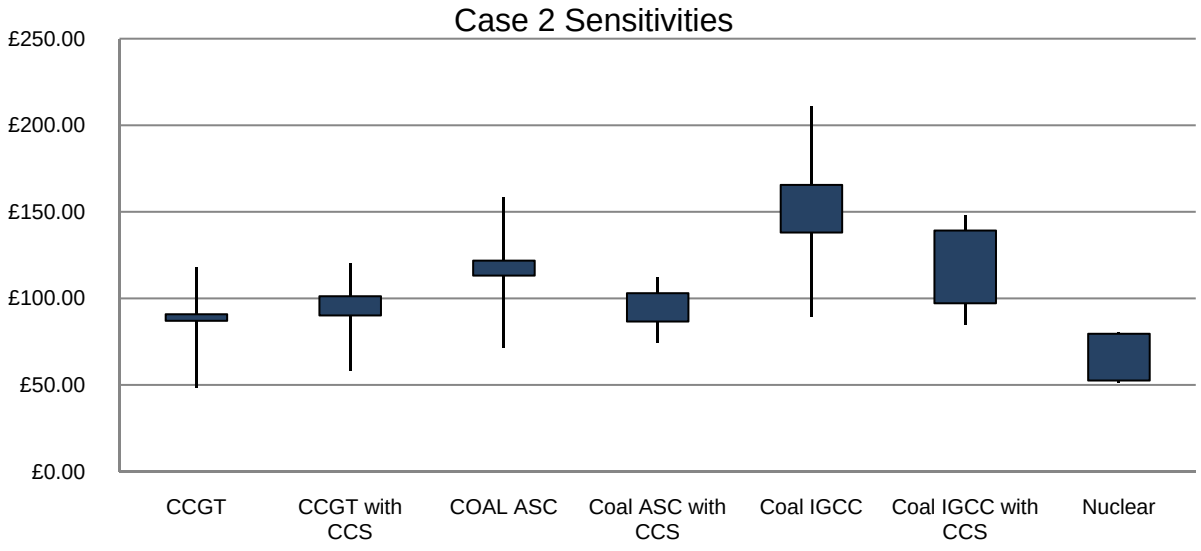
Case 1: 10% discount rate, 2011 project start at projected EPC prices, FOAK/NOAK mix								
LEVELISED COSTS		CCGT NOAK	CCGT with CCS FOAK	Coal ASC NOAK	Coal ASC with CCS FOAK	Coal IGCC FOAK	Coal IGCC with CCS FOAK	Nuclear FOAK
Capital costs	£/MWh	9.0	35.0	22.2	59.6	39.0	85.0	55.5
Fixed operating costs	£/MWh	2.9	5.5	5.1	9.6	7.2	11.0	11.0
Variable operating costs	£/MWh	0.1	0.6	1.0	2.5	1.0	2.9	0.6
Carbon costs	£/MWh	18.1	2.4	47.8	5.7	58.5	5.6	-
Fuel costs	£/MWh	46.5	57.5	19.3	23.1	20.5	22.5	5.0
Decomm and waste fund	£/MWh	-	-	-	-	-	-	2.0
CO2 transport and storage	£/MWh	-	3.8	-	7.8	-	7.8	-
Total	**£/MWh**	**76.6**	**104.8**	**95.4**	**108.3**	**126.2**	**134.8**	**74.1**





Case 2: 10% discount rate, 2017 project start at projected EPC prices, all NOAK								
LEVELISED COSTS		CCGT NOAK	CCGT with CCS NOAK	Coal ASC NOAK	Coal ASC with CCS NOAK	Coal IGCC NOAK	Coal IGCC with CCS NOAK	Nuclear NOAK
Capital costs	£/MWh	9.0	22.9	22.2	45.7	38.9	66.7	48.0
Fixed operating costs	£/MWh	2.9	4.7	5.1	8.2	7.2	9.3	9.4
Variable operating costs	£/MWh	0.1	0.5	1.0	2.1	1.0	2.4	0.5
Carbon costs	£/MWh	27.8	4.1	69.3	8.6	83.2	8.8	-
Fuel costs	£/MWh	48.6	59.5	19.3	23.2	20.5	22.5	5.0
Decomm and waste fund	£/MWh	-	-	-	-	-	-	2.0
CO2 transport and storage	£/MWh	-	3.1	-	6.3	-	6.3	-
Total	**£/MWh**	**88.4**	**94.8**	**116.9**	**94.1**	**150.8**	**116.0**	**64.9**





APPENDIX B – SUMMARY OF TECHNOLOGY INPUT ASSUMPTIONS

This section summarises the cost inputs which have been updated in this issue of the generation costs, displayed in a table for the different technologies.

It should be noted that not every cost that has been updated is shown in these tables, as they are summary tables. Also, these tables contain figures which are calculated from PB's updated figures, using calculations which are set up within the DECC model and therefore outside of the control of PB. Also to note, is that the net efficiency displayed in these tables refers to the lower heating value (LHV) net efficiency for each technology.

PB notes that some of the calculated figures, notably the average degradation and average availability, are not representative of expected performance during the expected operational life of the plant. For example, the average availability figure does not account for the actual operational life of the plant which is being modelled. Therefore the calculated figure can become skewed towards figures estimated for the plant after the expected operational life.

CCGT

Gas Plant - CCGT		1st OF A KIND			Nth OF A KIND		
		Low	Medium	High	Low	Medium	High
Key Timings							
Total Pre-development Period (including pre-licensing, licensing & public enquiry)	years	2.0	2.3	5.0	2.0	2.3	5.0
Construction Period	years	1.8	2.0	2.5	1.8	2.0	2.5
Plant Operating Period	years	20.0	30.0	35.0	20.0	30.0	35.0
Technical data							
Net Power Output	MW	850	850	850	850	850	850
Net Efficiency	%	57.0%	58.0%	60.0%	57.0%	58.0%	60.0%
Average Degradation	%	2.2%	2.2%	2.2%	2.2%	2.2%	2.2%
Average Availability	%	91.8%	92.7%	93.6%	91.8%	92.7%	93.7%
Average Load Factor	%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
CO2 Removal	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Capital costs							
Pre-licencing costs, Technical and design	£/kW	11.0	12.0	13.0	11.0	12.0	13.0
	£m	9.4	10.2	11.1	9.4	10.2	11.1
Regulatory + licencing + public enquiry	£/kW	0.4	0.4	2.9	0.4	0.4	2.9
	£m	0.3	0.4	2.5	0.3	0.4	2.5
EPC cost	£/kW	576.0	640.0	768.0	576.0	640.0	768.0
	£m	489.6	544.0	652.8	489.6	544.0	652.8
Infrastructure cost	£/kW	13.2	16.5	20.6	13.2	16.5	20.6
	£m	11.2	14.0	17.5	11.2	14.0	17.5
Owners' predevelopment costs as % of EPC price		2.0%	1.9%	2.1%	2.0%	1.9%	2.1%
Total Capital Cost (excl. IDC)	**£/kW**	**600.5**	**668.9**	**804.5**	**600.5**	**668.9**	**804.5**
Operating costs							
O&M fixed fee	£/MW/yr	19,091	23,182	27,273	19,091	23,182	27,273
	£m/yr	16.2	19.7	23.2	16.2	19.7	23.2
O&M variable fee	£/MWh	-	0.1	0.2	-	0.1	0.2
	£m/yr	-	0.7	1.4	-	0.7	1.4
Total O&M costs	**£m/yr**	**16.2**	**20.4**	**24.6**	**16.2**	**20.4**	**24.6**
		3.3%	3.6%	3.6%	3.3%	3.6%	3.6%
Insurance	£/MW/yr	1,818	2,727	4,091	1,818	2,727	4,091
	£m/yr	1.5	2.3	3.5	1.5	2.3	3.5
Connection and UoS charges	£/MW/yr	-6,259	1,484	8,947	-6,259	1,484	8,947
	£m/yr	-5.3	1.3	7.6	-5.3	1.3	7.6
CO2 transport and storage costs	£/MWh	-	-	-	-	-	-
	£m/yr	-	-	-	-	-	-
Total fixed costs: £/MW/yr		*14,650*	*27,393*	*40,311*	*14,650*	*27,393*	*40,311*
Total Operating Costs	**£m/yr**	**12.5**	**24.0**	**35.7**	**12.5**	**24.0**	**35.7**
Ratio of fixed O&M to EPC price: %		3.3%	3.6%	3.6%	3.3%	3.6%	3.6%

CCGT with CCS

Gas Plant - CCGT with CCS

		1st OF A KIND			Nth OF A KIND		
		Low	Medium	High	Low	Medium	High
Key Timings							
Total Pre-development Period (including pre-licensing, licensing & public enquiry)	years	4.0	5.0	6.0	3.0	4.0	5.0
Construction Period	years	4.5	5.0	7.0	3.0	4.0	6.0
Plant Operating Period	years	10.0	12.0	15.0	20.0	25.0	30.0
Technical data							
Net Power Output	MW	850	850	850	850	850	850
Net Efficiency	%	47.5%	48.3%	50.0%	47.5%	48.3%	50.0%
Average Degradation	%	2.2%	2.2%	2.2%	2.2%	2.2%	2.2%
Average Availability	%	91.8%	92.7%	93.6%	91.8%	92.7%	93.7%
Average Load Factor	%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
CO2 Removal	%	90.0%	90.0%	90.0%	90.0%	90.0%	90.0%
Capital costs							
Pre-licencing costs, Technical and design	£/kW	25.0	30.0	40.0	20.0	25.0	40.0
	£m	21.3	25.5	34.0	17.0	21.3	34.0
Regulatory + licencing + public enquiry	£/kW	2.8	2.9	2.9	2.8	2.9	2.9
	£m	2.4	2.5	2.5	2.4	2.5	2.5
EPC cost	£/kW	1,413.0	1,575.0	1,813.0	1,130.0	1,260.0	1,450.0
	£m	1,201.1	1,338.8	1,541.1	960.5	1,071.0	1,232.5
Infrastructure cost	£/kW	20.7	25.9	32.4	20.7	25.9	32.4
	£m	17.6	22.0	27.5	17.6	22.0	27.5
Owners' predevelopment costs as % of EPC price		2.0%	2.1%	2.4%	2.0%	2.2%	3.0%
Total Capital Cost (excl. IDC)	**£/kW**	**1,461.5**	**1,633.8**	**1,888.3**	**1,173.5**	**1,313.8**	**1,525.3**
Operating costs							
O&M fixed fee	£/MW/yr	30,000	39,600	51,600	25,000	33,000	43,000
	£m/yr	25.5	33.7	43.9	21.3	28.1	36.6
O&M variable fee	£/MWh	0.5	0.6	0.8	0.4	0.5	0.6
	£m/yr	3.3	4.2	5.3	2.7	3.5	4.4
Total O&M costs	**£m/yr**	**28.8**	**37.9**	**49.1**	**24.0**	**31.6**	**40.9**
		2.1%	2.5%	2.8%	2.2%	2.6%	3.0%
Insurance	£/MW/yr	2,680	4,400	7,200	2,680	4,000	6,000
	£m/yr	2.3	3.7	6.1	2.3	3.4	5.1
Connection and UoS charges	£/MW/yr	-6,259	1,484	8,947	-6,259	1,484	8,947
	£m/yr	-5.3	1.3	7.6	-5.3	1.3	7.6
CO2 transport and storage costs	£/MWh	3.0	3.8	4.5	2.5	3.1	3.8
	£m/yr	20.5	25.9	31.4	17.1	21.6	26.2
Total fixed costs: £/MW/yr		*26,421*	*45,484*	*67,747*	*21,421*	*38,484*	*57,947*
Total Operating Costs	**£m/yr**	**46.2**	**68.8**	**94.2**	**38.0**	**57.8**	**79.8**
Ratio of fixed O&M to EPC price: %		2.1%	2.5%	2.8%	2.2%	2.6%	3.0%

Coal ASC with FGD

Coal Plant - Pulversied fuel, ASC with FGD

		1st OF A KIND			Nth OF A KIND		
		Low	Medium	High	Low	Medium	High
Key Timings							
Total Pre-development Period (including pre-licensing, licensing & public enquiry)	years	2.0	3.5	5.0	2.0	3.5	5.0
Construction Period	years	2.8	3.0	4.0	2.8	3.0	4.0
Plant Operating Period	years	25.0	35.0	45.0	25.0	35.0	45.0
Technical data							
Net Power Output	MW	1,600	1,600	1,600	1,600	1,600	1,600
Net Efficiency	%	43.0%	44.0%	45.0%	43.0%	44.0%	45.0%
Average Degradation	%	5.5%	5.5%	5.5%	5.5%	5.5%	5.5%
Average Availability	%	93.7%	94.9%	95.9%	93.7%	94.9%	95.9%
Average Load Factor	%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
CO2 Removal	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Capital costs							
Pre-licencing costs, Technical and design	£/kW	20.0	25.0	35.0	16.0	20.0	30.0
	£m	32.0	40.0	56.0	25.6	32.0	48.0
Regulatory + licencing + public enquiry	£/kW	0.2	0.2	1.6	0.2	0.2	1.6
	£m	0.3	0.4	2.5	0.3	0.4	2.5
EPC cost	£/kW	1,450.0	1,600.0	1,800.0	1,450.0	1,600.0	1,800.0
	£m	2,320.0	2,560.0	2,880.0	2,320.0	2,560.0	2,880.0
Infrastructure cost	£/kW	18.0	22.5	28.1	18.0	22.5	28.1
	£m	28.8	36.0	45.0	28.8	36.0	45.0
Owners' predevelopment costs as % of EPC price		1.4%	1.6%	2.0%	1.1%	1.3%	1.8%
Total Capital Cost (excl. IDC)	**£/kW**	**1,488.2**	**1,647.7**	**1,864.7**	**1,484.2**	**1,642.7**	**1,859.7**
Operating costs							
O&M fixed fee	£/MW/yr	20,000	35,000	50,000	20,000	35,000	50,000
	£m/yr	32.0	56.0	80.0	32.0	56.0	80.0
O&M variable fee	£/MWh	0.8	1.0	1.2	0.8	1.0	1.2
	£m/yr	10.9	13.3	15.7	10.9	13.3	15.7
Total O&M costs	**£m/yr**	**42.9**	**69.3**	**95.7**	**42.9**	**69.3**	**95.7**
		1.4%	2.2%	2.8%	1.4%	2.2%	2.8%
Insurance	£/MW/yr	1,675	2,500	3,750	1,675	2,500	3,750
	£m/yr	2.7	4.0	6.0	2.7	4.0	6.0
Connection and UoS charges	£/MW/yr	- 6,259	5,050	12,640	- 6,259	5,050	12,640
	£m/yr	- 10.0	8.1	20.2	- 10.0	8.1	20.2
CO2 transport and storage costs	£/MWh	-	-	-	-	-	-
	£m/yr	-	-	-	-	-	-
Total fixed costs: £/MW/yr		*15,416*	*42,550*	*66,390*	*15,416*	*42,550*	*66,390*
Total Operating Costs	**£m/yr**	**35.6**	**81.4**	**121.9**	**35.6**	**81.4**	**121.9**
Ratio of fixed O&M to EPC price: %		1.4%	2.2%	2.8%	1.4%	2.2%	2.8%

Coal ASC with FGD & CCS

Coal Plant - Pulversied fuel, ASC with FGD and CCS

		1st OF A KIND			Nth OF A KIND		
		Low	Medium	High	Low	Medium	High
Key Timings							
Total Pre-development Period (including pre-licensing, licensing & public enquiry)	years	4.0	5.0	7.0	3.0	5.0	7.0
Construction Period	years	4.0	5.0	6.0	3.0	4.0	5.0
Plant Operating Period	years	15.0	20.0	25.0	20.0	25.0	30.0
Technical data							
Net Power Output	MW	1,600	1,600	1,600	1,600	1,600	1,600
Net Efficiency	%	35.8%	36.7%	37.5%	35.8%	36.7%	37.5%
Average Degradation	%	5.5%	5.5%	5.5%	5.5%	5.5%	5.5%
Average Availability	%	93.7%	94.9%	95.9%	93.7%	94.9%	95.9%
Average Load Factor	%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
CO2 Removal	%	90.0%	90.0%	90.0%	90.0%	90.0%	90.0%
Capital costs							
Pre-licencing costs, Technical and design	£/kW	20.0	25.0	40.0	18.0	23.0	30.0
	£m	32.0	40.0	64.0	28.8	36.8	48.0
Regulatory + licencing + public enquiry	£/kW	1.5	1.5	1.6	1.5	1.5	1.6
	£m	2.4	2.5	2.5	2.4	2.5	2.5
EPC cost	£/kW	3,343.0	3,530.0	3,780.0	2,674.0	2,824.0	3,024.0
	£m	5,348.8	5,648.0	6,048.0	4,278.4	4,518.4	4,838.4
Infrastructure cost	£/kW	22.0	27.5	34.4	22.0	27.5	34.4
	£m	35.2	44.0	55.0	35.2	44.0	55.0
Owners' predevelopment costs as % of EPC price		0.6%	0.8%	1.1%	0.7%	0.9%	1.0%
Total Capital Cost (excl. IDC)	**£/kW**	**3,386.5**	**3,584.0**	**3,855.9**	**2,715.5**	**2,876.0**	**3,089.9**
Operating costs							
O&M fixed fee	£/MW/yr	42,912	71,520	100,128	35,760	59,600	83,440
	£m/yr	68.7	114.4	160.2	57.2	95.4	133.5
O&M variable fee	£/MWh	2.3	2.5	2.7	2.0	2.1	2.3
	£m/yr	30.7	33.8	36.9	25.6	28.2	30.8
Total O&M costs	**£m/yr**	**99.4**	**148.3**	**197.1**	**82.8**	**123.6**	**164.3**
		1.3%	2.0%	2.6%	1.3%	2.1%	2.8%
Insurance	£/MW/yr	2,680	4,400	7,200	2,680	4,000	6,000
	£m/yr	4.3	7.0	11.5	4.3	6.4	9.6
Connection and UoS charges	£/MW/yr	- 6,259	5,050	12,640	- 6,259	5,050	12,640
	£m/yr	- 10.0	8.1	20.2	- 10.0	8.1	20.2
CO2 transport and storage costs	£/MWh	7.0	7.8	8.6	5.6	6.3	6.9
	£m/yr	92.4	103.9	115.5	73.9	83.1	92.4
Total fixed costs: £/MW/yr		*39,333*	*80,970*	*119,968*	*32,181*	*68,650*	*102,080*
Total Operating Costs	**£m/yr**	**186.1**	**267.3**	**344.3**	**151.0**	**221.1**	**286.5**
Ratio of fixed O&M to EPC price: %		1.3%	2.0%	2.6%	1.3%	2.1%	2.8%

IGCC

Coal Plant - IGCC

		1st OF A KIND			Nth OF A KIND		
		Low	Medium	High	Low	Medium	High
Key Timings							
Total Pre-development Period (including pre-licensing, licensing & public enquiry)	years	4.0	5.0	7.0	4.0	5.0	7.0
Construction Period	years	4.0	5.0	6.0	4.0	5.0	6.0
Plant Operating Period	years	20.0	30.0	40.0	20.0	30.0	40.0
Technical data							
Net Power Output	MW	870	870	870	870	870	870
Net Efficiency	%	38.0%	41.0%	43.0%	38.0%	41.0%	43.0%
Average Degradation	%	2.2%	2.2%	2.2%	2.2%	2.2%	2.2%
Average Availability	%	91.8%	92.7%	93.6%	91.8%	92.7%	93.6%
Average Load Factor	%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
CO2 Removal	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Capital costs							
Pre-licencing costs, Technical and design	£/kW	25.0	30.0	60.0	20.0	25.0	40.0
	£m	21.8	26.1	52.2	17.4	21.8	34.8
Regulatory + licencing + public enquiry	£/kW	0.4	0.4	2.9	0.4	0.4	2.9
	£m	0.3	0.4	2.5	0.3	0.4	2.5
EPC cost	£/kW	1,700.0	2,300.0	2,900.0	1,700.0	2,300.0	2,900.0
	£m	1,479.0	2,001.0	2,523.0	1,479.0	2,001.0	2,523.0
Infrastructure cost	£/kW	33.1	41.4	51.7	33.1	41.4	51.7
	£m	28.8	36.0	45.0	28.8	36.0	45.0
Owners' predevelopment costs as % of EPC price		1.5%	1.3%	2.2%	1.2%	1.1%	1.5%
Total Capital Cost (excl. IDC)	**£/kW**	**1,758.5**	**2,371.8**	**3,014.6**	**1,753.5**	**2,366.8**	**2,994.6**
Operating costs							
O&M fixed fee	£/MW/yr	39,000	51,750	68,000	39,000	51,750	68,000
	£m/yr	33.9	45.0	59.2	33.9	45.0	59.2
O&M variable fee	£/MWh	0.8	1.0	1.2	0.8	1.0	1.2
	£m/yr	5.8	7.1	8.3	5.8	7.1	8.3
Total O&M costs	**£m/yr**	**39.7**	**52.1**	**67.5**	**39.7**	**52.1**	**67.5**
		2.3%	2.3%	2.3%	2.3%	2.3%	2.3%
Insurance	£/MW/yr	2,010	3,000	4,500	2,010	3,000	4,500
	£m/yr	1.7	2.6	3.9	1.7	2.6	3.9
Connection and UoS charges	£/MW/yr	- 6,259	5,050	12,640	- 6,259	5,050	12,640
	£m/yr	- 5.4	4.4	11.0	- 5.4	4.4	11.0
CO2 transport and storage costs	£/MWh	-	-	-	-	-	-
	£m/yr	-	-	-	-	-	-
Total fixed costs: £/MW/yr		*34,751*	*59,800*	*85,140*	*34,751*	*59,800*	*85,140*
Total Operating Costs	**£m/yr**	**36.0**	**59.1**	**82.4**	**36.0**	**59.1**	**82.4**
Ratio of fixed O&M to EPC price: %		2.3%	2.3%	2.3%	2.3%	2.3%	2.3%

IGCC with CCS

Coal Plant - IGCC with CCS

		1st OF A KIND			Nth OF A KIND		
		Low	Medium	High	Low	Medium	High
Key Timings							
Total Pre-development Period (including pre-licensing, licensing & public enquiry)	years	4.0	5.0	7.0	3.0	5.0	7.0
Construction Period	years	4.0	5.0	6.0	4.0	5.0	6.0
Plant Operating Period	years	15.0	20.0	25.0	20.0	25.0	30.0
Technical data							
Net Power Output	MW	870	870	870	870	870	870
Net Efficiency	%	34.5%	37.3%	39.1%	34.5%	37.3%	39.1%
Average Degradation	%	2.4%	2.4%	2.4%	2.4%	2.4%	2.4%
Average Availability	%	91.8%	92.7%	93.6%	91.8%	92.7%	93.6%
Average Load Factor	%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
CO2 Removal	%	90.0%	90.0%	90.0%	90.0%	90.0%	90.0%
Capital costs							
Pre-licencing costs, Technical and design	£/kW	25.0	30.0	50.0	20.0	25.0	40.0
	£m	21.8	26.1	43.5	17.4	21.8	34.8
Regulatory + licencing + public enquiry	£/kW	2.8	2.8	2.9	2.8	2.8	2.9
	£m	2.4	2.5	2.5	2.4	2.5	2.5
EPC cost	£/kW	4,094.0	4,844.0	5,594.0	3,275.0	3,875.0	4,475.0
	£m	3,561.8	4,214.3	4,866.8	2,849.3	3,371.3	3,893.3
Infrastructure cost	£/kW	40.5	50.6	63.2	40.5	50.6	63.2
	£m	35.2	44.0	55.0	35.2	44.0	55.0
Owners' predevelopment costs as % of EPC price		0.7%	0.7%	0.9%	0.7%	0.7%	1.0%
Total Capital Cost (excl. IDC)	**£/kW**	**4,162.2**	**4,927.4**	**5,710.1**	**3,338.2**	**3,953.4**	**4,581.1**
Operating costs							
O&M fixed fee	£/MW/yr	60,000	81,000	105,600	50,000	67,500	88,000
	£m/yr	52.2	70.5	91.9	43.5	58.7	76.6
O&M variable fee	£/MWh	1.7	2.9	4.0	1.4	2.4	3.4
	£m/yr	12.1	20.3	28.8	10.1	17.0	24.0
Total O&M costs	**£m/yr**	**64.3**	**90.8**	**120.6**	**53.6**	**75.7**	**100.5**
		1.5%	1.7%	1.9%	1.5%	1.7%	2.0%
Insurance	£/MW/yr	3,015	4,950	8,100	3,015	4,500	6,750
	£m/yr	2.6	4.3	7.0	2.6	3.9	5.9
Connection and UoS charges	£/MW/yr	- 6,259	5,050	12,640	- 6,259	5,050	12,640
	£m/yr	- 5.4	4.4	11.0	- 5.4	4.4	11.0
CO2 transport and storage costs	£/MWh	7.0	7.8	8.6	5.6	6.3	6.9
	£m/yr	49.2	55.2	61.3	39.3	44.2	49.1
Total fixed costs: £/MW/yr		*56,756*	*91,000*	*126,340*	*46,756*	*77,050*	*107,390*
Total Operating Costs	**£m/yr**	**110.6**	**154.7**	**200.0**	**90.1**	**128.1**	**166.5**
Ratio of fixed O&M to EPC price: %		1.5%	1.7%	1.9%	1.5%	1.7%	2.0%

Nuclear PWR (multiple units)

Nuclear - PWR

		1st OF A KIND			Nth OF A KIND		
		Low	Medium	High	Low	Medium	High
Key Timings							
Total Pre-development Period (including pre-licensing, licensing & public enquiry)	years	5.0	5.0	6.0	5.0	5.0	6.0
Construction Period	years	5.0	6.0	8.0	5.0	5.0	8.0
Plant Operating Period	years	35.0	40.0	40.0	35.0	40.0	40.0
Technical data							
Net Power Output	MW	3,300	3,300	3,300	3,300	3,300	3,300
Net Efficiency	%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Average Degradation	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Average Availability	%	88.8%	90.8%	92.8%	88.8%	90.8%	92.8%
Average Load Factor	%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Auxiliary Power	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
CO2 Removal	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Capital costs							
Pre-licencing costs, Technical and design	£/kW	20.0	25.0	40.0	18.0	23.0	30.0
	£m	66.0	82.5	132.0	59.4	75.9	99.0
Regulatory + licencing + public enquiry	£/kW	2.2	2.9	3.8	2.2	2.9	3.8
	£m	7.4	9.5	12.5	7.4	9.5	12.5
EPC cost	£/kW	2,941.0	3,529.0	4,118.0	2,500.0	3,000.0	3,500.0
	£m	9,705.3	11,645.7	13,589.4	8,250.0	9,900.0	11,550.0
Infrastructure cost	£/kW	2.9	3.6	4.5	2.9	3.6	4.5
	£m	9.6	12.0	15.0	9.6	12.0	15.0
Owners' predevelopment costs as % of EPC price		0.8%	0.8%	1.1%	0.8%	0.9%	1.0%
Total Capital Cost (excl. IDC)	**£/kW**	**2,966.2**	**3,560.5**	**4,166.3**	**2,523.2**	**3,029.5**	**3,538.3**
Operating costs							
O&M fixed fee	£/MW/yr	60,000	72,000	84,000	50,000	60,000	70,000
	£m/yr	198.0	237.6	277.2	165.0	198.0	231.0
O&M variable fee	£/MWh	0.6	0.6	0.6	0.5	0.5	0.5
	£m/yr	15.3	15.6	15.9	12.7	13.0	13.3
Total O&M costs	**£m/yr**	**213.3**	**253.2**	**293.1**	**177.7**	**211.0**	**244.3**
		2.0%	2.0%	2.0%	2.0%	2.0%	2.0%
Insurance	£/MW/yr	8,000	10,000	12,000	8,000	10,000	12,000
	£m/yr	26.4	33.0	39.6	26.4	33.0	39.6
Connection and UoS charges	£/MW/yr	- 2,480	5,238	13,591	- 2,480	5,238	13,591
	£m/yr	- 8.2	17.3	44.9	- 8.2	17.3	44.9
CO2 transport and storage costs	£/MWh	-	-	-	-	-	-
	£m/yr	-	-	-	-	-	-
Total fixed costs: £/MW/yr		*65,520*	*87,238*	*109,591*	*55,520*	*75,238*	*95,591*
Total Operating Costs	**£m/yr**	**231.5**	**303.5**	**377.6**	**195.9**	**261.3**	**328.7**
Ratio of fixed O&M to EPC price: %		2.0%	2.0%	2.0%	2.0%	2.0%	2.0%

Pumped Storage

Hydro pumped storage

		1st OF A KIND			Nth OF A KIND		
		Low	Medium	High	Low	Medium	High
Key Timings							
Total Pre-development Period (including pre-licensing, licensing & public enquiry)	years	4.0	5.0	6.0	4.0	5.0	6.0
Construction Period	years	3.5	4.5	5.0	3.5	4.5	5.0
Plant Operating Period	years	40.0	50.0	60.0	40.0	50.0	60.0
Technical data							
Net Power Output	MW	400	400	400	400	400	400
Net Efficiency	%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Average Degradation	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Average Availability	%	96.1%	95.7%	95.2%	96.1%	95.7%	95.2%
Average Load Factor	%	40.0%	40.0%	40.0%	40.0%	40.0%	40.0%
CO2 Removal	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Capital costs							
Pre-licencing costs, Technical and design	£/kW	20.0	25.0	35.0	20.0	25.0	35.0
	£m	8.0	10.0	14.0	8.0	10.0	14.0
Regulatory + licencing + public enquiry	£/kW	0.8	0.9	6.2	0.8	0.9	6.2
	£m	0.3	0.4	2.5	0.3	0.4	2.5
EPC cost	£/kW	1,090.9	1,818.2	5,000.0	1,090.9	1,818.2	5,000.0
	£m	436.4	727.3	2,000.0	436.4	727.3	2,000.0
Infrastructure cost	£/kW	20.0	25.0	37.5	20.0	25.0	37.5
	£m	8.0	10.0	15.0	8.0	10.0	15.0
Owners' predevelopment costs as % of EPC price		1.9%	1.4%	0.8%	1.9%	1.4%	0.8%
Total Capital Cost (excl. IDC)	**£/kW**	**1,131.7**	**1,869.1**	**5,078.7**	**1,131.7**	**1,869.1**	**5,078.7**
Operating costs							
O&M fixed fee	£/MW/yr	10,200	12,000	14,400	10,200	12,000	14,400
	£m/yr	4.1	4.8	5.8	4.1	4.8	5.8
O&M variable fee	£/MWh	-	-	-	-	-	-
	£m/yr	-	-	-	-	-	-
Total O&M costs	**£m/yr**	**4.1**	**4.8**	**5.8**	**4.1**	**4.8**	**5.8**
		0.9%	0.7%	0.3%	0.9%	0.7%	0.3%
Insurance	£/MW/yr	4,020	6,600	10,800	4,020	6,000	9,000
	£m/yr	1.6	2.6	4.3	1.6	2.4	3.6
Connection and UoS charges	£/MW/yr	5,652	15,526	22,945	5,652	15,526	22,945
	£m/yr	2.3	6.2	9.2	2.3	6.2	9.2
CO2 transport and storage costs	£/MWh	-	-	-	-	-	-
	£m/yr	-	-	-	-	-	-
Total fixed costs: £/MW/yr		*19,872*	*34,126*	*48,145*	*19,872*	*33,526*	*46,345*
Total Operating Costs	**£m/yr**	**7.9**	**13.7**	**19.3**	**7.9**	**13.4**	**18.5**
Ratio of fixed O&M to EPC price: %		0.9%	0.7%	0.3%	0.9%	0.7%	0.3%

OCGT

OCGT

		1st OF A KIND			Nth OF A KIND		
		Low	Medium	High	Low	Medium	High
Key Timings							
Total Pre-development Period (including pre-licensing, licensing & public enquiry)	years	1.5	2.1	4.5	1.5	2.1	4.5
Construction Period	years	1.7	1.9	2.5	1.7	1.9	2.5
Plant Operating Period	years	35.0	40.0	45.0	35.0	40.0	45.0
Technical data							
Net Power Output	MW	100	100	100	100	100	100
Net Efficiency	%	40.0%	41.0%	43.0%	40.0%	41.0%	43.0%
Average Degradation	%	3.3%	3.3%	3.3%	3.3%	3.3%	3.3%
Average Availability	%	91.0%	91.9%	92.8%	91.0%	91.9%	92.8%
Average Load Factor	%	5.0%	20.0%	20.0%	5.0%	20.0%	20.0%
CO2 Removal	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Capital costs							
Pre-licencing costs, Technical and design	£/kW	25.0	30.0	35.0	25.0	30.0	35.0
	£m	2.5	3.0	3.5	2.5	3.0	3.5
Regulatory + licencing + public enquiry	£/kW	3.0	3.5	4.0	3.0	3.5	4.0
	£m	0.3	0.4	0.4	0.3	0.4	0.4
EPC cost (excluding interest during construction)	£/kW	472.5	525.0	630.0	472.5	525.0	630.0
	£m	47.3	52.5	63.0	47.3	52.5	63.0
Infrastructure cost	£/kW	32.0	40.0	50.0	32.0	40.0	50.0
	£m	3.2	4.0	5.0	3.2	4.0	5.0
Total Capital Cost	**£/kW**	**532.5**	**598.5**	**719.0**	**532.5**	**598.5**	**719.0**
Owner's pre-development costs as % in EPC price		5.9%	6.4%	6.2%	5.9%	6.4%	6.2%
Operating costs							
O&M fixed fee	£/MW/yr	18,000	23,000	28,000	18,000	23,000	28,000
	£m/yr	1.8	2.3	2.8	1.8	2.3	2.8
O&M variable fee	£/MWh	-	-	-	-	-	-
	£m/yr	-	-	-	-	-	-
Total O&M costs	**£m/yr**	**1.8**	**2.3**	**2.8**	**1.8**	**2.3**	**2.8**
Insurance	£/MW/yr	1,675	2,500	3,750	1,675	2,500	3,750
	£m/yr	0.2	0.3	0.4	0.2	0.3	0.4
Connection and UoS charges	£/MW/yr	-6,259	-2,359	961	-6,259	-2,359	961
	£m/yr	-0.6	-0.2	0.1	-0.6	-0.2	0.1
CO2 transport and storage costs	£/MWh	-	-	-	-	-	-
	£m/yr	-	-	-	-	-	-
Total Operating Costs	**£m/yr**	**1.3**	**2.3**	**3.3**	**1.3**	**2.3**	**3.3**
Fixed O&M as % of EPC price		3.8%	4.4%	4.4%	3.8%	4.4%	4.4%

CHP 10MW

10MW Gas CHP

		1st OF A KIND			Nth OF A KIND		
		Low	Medium	High	Low	Medium	High
Key Timings							
Total Pre-development Period (including pre-licensing, licensing & public enquiry)	years	2.0	2.0	3.0	2.0	2.0	3.0
Construction Period	years	1.0	1.2	1.5	1.0	1.2	1.5
Plant Operating Period	years	12.0	15.0	20.0	12.0	15.0	20.0
Technical data							
Net Power Output	MW	13	13	13	13	13	13
Net Efficiency	%	33.0%	34.0%	35.0%	33.0%	34.0%	35.0%
Average Degradation	%	2.2%	2.2%	2.2%	2.2%	2.2%	2.2%
Average Availability	%	91.9%	92.8%	93.8%	91.9%	92.8%	93.8%
Average Load Factor	%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
CO2 Removal	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Capital costs							
Pre-licencing costs, Technical and design	£/kW	15.0	20.0	25.0	15.0	20.0	25.0
	£m	0.2	0.3	0.3	0.2	0.3	0.3
Regulatory + licencing + public enquiry	£/kW	13.4	17.0	20.2	13.4	17.0	20.2
	£m	0.2	0.2	0.3	0.2	0.2	0.3
EPC cost (excluding interest during construction)	£/kW	630.0	700.0	840.0	630.0	700.0	840.0
	£m	8.2	9.1	10.9	8.2	9.1	10.9
Infrastructure cost	£/kW	184.6	230.8	288.5	184.6	230.8	288.5
	£m	2.4	3.0	3.8	2.4	3.0	3.8
Total Capital Cost	**£/kW**	**843.0**	**967.7**	**1,173.7**	**843.0**	**967.7**	**1,173.7**
Owner's pre-development costs as % in EPC price		4.5%	5.3%	5.4%	4.5%	5.3%	5.4%
Operating costs							
O&M fixed fee	£/MW/yr	51,000	56,000	60,000	51,000	56,000	60,000
	£m/yr	0.7	0.7	0.8	0.7	0.7	0.8
O&M variable fee	£/MWh	-	0.1	0.2	-	0.1	0.2
	£m/yr	-	0.0	0.0	-	0.0	0.0
Total O&M costs	**£m/yr**	**0.7**	**0.7**	**0.8**	**0.7**	**0.7**	**0.8**
Insurance	£/MW/yr	1,675	2,500	3,750	1,675	2,500	3,750
	£m/yr	0.0	0.0	0.0	0.0	0.0	0.0
Connection and UoS charges	£/MW/yr	- 6,259	4,287	22,945	- 6,259	4,287	22,945
	£m/yr	- 0.1	0.1	0.3	- 0.1	0.1	0.3
CO2 transport and storage costs	£/MWh	-	-	-	-	-	-
	£m/yr	-	-	-	-	-	-
Total Operating Costs	**£m/yr**	**0.6**	**0.8**	**1.1**	**0.6**	**0.8**	**1.1**
Fixed O&M as % of EPC price		8.1%	8.0%	7.1%	8.1%	8.0%	7.1%

CHP 50MW

Small GT based CHP

		1st OF A KIND			Nth OF A KIND		
		Low	Medium	High	Low	Medium	High
Key Timings							
Total Pre-development Period (including pre-licensing, licensing & public enquiry)	years	2.0	2.0	3.0	2.0	2.0	3.0
Construction Period	years	1.0	1.5	1.8	1.0	1.5	1.8
Plant Operating Period	years	12.0	15.0	20.0	12.0	15.0	20.0
Technical data							
Net Power Output	MW	52	52	52	52	52	52
Net Efficiency	%	39.0%	40.0%	41.0%	39.0%	40.0%	41.0%
Average Degradation	%	2.2%	2.2%	2.2%	2.2%	2.2%	2.2%
Average Availability	%	91.9%	92.8%	93.8%	91.9%	92.8%	93.8%
Average Load Factor	%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
CO2 Removal	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Capital costs							
Pre-licencing costs, Technical and design	£/kW	17.0	20.0	23.0	17.0	20.0	23.0
	£m	0.9	1.0	1.2	0.9	1.0	1.2
Regulatory + licencing + public enquiry	£/kW	5.6	6.5	7.3	5.6	6.5	7.3
	£m	0.3	0.3	0.4	0.3	0.3	0.4
EPC cost (excluding interest during construction)	£/kW	585.0	650.0	780.0	585.0	650.0	780.0
	£m	30.4	33.8	40.6	30.4	33.8	40.6
Infrastructure cost	£/kW	107.7	134.6	168.3	107.7	134.6	168.3
	£m	5.6	7.0	8.8	5.6	7.0	8.8
Total Capital Cost	**£/kW**	**715.3**	**811.1**	**978.6**	**715.3**	**811.1**	**978.6**
Owner's pre-development costs as % in EPC price		3.9%	4.1%	3.9%	3.9%	4.1%	3.9%
Operating costs							
O&M fixed fee	£/MW/yr	29,000	34,000	39,000	29,000	34,000	39,000
	£m/yr	1.5	1.8	2.0	1.5	1.8	2.0
O&M variable fee	£/MWh	-	0.1	0.2	-	0.1	0.2
	£m/yr	-	0.0	0.1	-	0.0	0.1
Total O&M costs	**£m/yr**	**1.5**	**1.8**	**2.1**	**1.5**	**1.8**	**2.1**
Insurance	£/MW/yr	1,675	2,500	3,750	1,675	2,500	3,750
	£m/yr	0.1	0.1	0.2	0.1	0.1	0.2
Connection and UoS charges	£/MW/yr	- 6,259	8,796	22,945	- 6,259	8,796	22,945
	£m/yr	- 0.3	0.5	1.2	- 0.3	0.5	1.2
CO2 transport and storage costs	£/MWh	-	-	-	-	-	-
	£m/yr	-	-	-	-	-	-
Total Operating Costs	**£m/yr**	**1.3**	**2.4**	**3.5**	**1.3**	**2.4**	**3.5**
Fixed O&M as % of EPC price		5.0%	5.2%	5.0%	5.0%	5.2%	5.0%

CHP 500MW

CCGT CHP

		1st OF A KIND			Nth OF A KIND		
		Low	Medium	High	Low	Medium	High
Key Timings							
Total Pre-development Period (including pre-licensing, licensing & public enquiry)	years	2.5	2.8	5.0	2.5	2.8	5.0
Construction Period	years	2.0	2.2	2.7	2.0	2.2	2.7
Plant Operating Period	years	12.0	15.0	20.0	12.0	15.0	20.0
Technical data							
Net Power Output	MW	463	463	463	463	463	463
Net Efficiency	%	46.0%	47.0%	48.0%	46.0%	47.0%	48.0%
Average Degradation	%	2.2%	2.2%	2.2%	2.2%	2.2%	2.2%
Average Availability	%	91.9%	92.8%	93.8%	91.9%	92.8%	93.8%
Average Load Factor	%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
CO2 Removal	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Capital costs							
Pre-licencing costs, Technical and design	£/kW	18.0	21.0	24.0	18.0	21.0	24.0
	£m	8.3	9.7	11.1	8.3	9.7	11.1
Regulatory + licencing + public enquiry	£/kW	0.7	0.8	5.4	0.7	0.8	5.4
	£m	0.3	0.4	2.5	0.3	0.4	2.5
EPC cost (excluding interest during construction)	£/kW	522.0	580.0	696.0	522.0	580.0	696.0
	£m	241.7	268.5	322.2	241.7	268.5	322.2
Infrastructure cost	£/kW	20.7	25.9	32.4	20.7	25.9	32.4
	£m	9.6	12.0	15.0	9.6	12.0	15.0
Total Capital Cost	**£/kW**	**561.4**	**627.7**	**757.8**	**561.4**	**627.7**	**757.8**
Owner's pre-development costs as % in EPC price		3.6%	3.8%	4.2%	3.6%	3.8%	4.2%
Operating costs							
O&M fixed fee	£/MW/yr	22,500	26,400	30,500	22,500	26,400	30,500
	£m/yr	10.4	12.2	14.1	10.4	12.2	14.1
O&M variable fee	£/MWh	-	0.1	0.2	-	0.1	0.2
	£m/yr	-	0.4	0.8	-	0.4	0.8
Total O&M costs	**£m/yr**	**10.4**	**12.6**	**14.9**	**10.4**	**12.6**	**14.9**
Insurance	£/MW/yr	1,675	2,500	3,750	1,675	2,500	3,750
	£m/yr	0.8	1.2	1.7	0.8	1.2	1.7
Connection and UoS charges	£/MW/yr	- 1,207	4,680	17,788	- 1,207	4,680	17,788
	£m/yr	- 0.6	2.2	8.2	- 0.6	2.2	8.2
CO2 transport and storage costs	£/MWh	-	-	-	-	-	-
	£m/yr	-	-	-	-	-	-
Total Operating Costs	**£m/yr**	**10.6**	**15.9**	**24.9**	**10.6**	**15.9**	**24.9**
Fixed O&M as % of EPC price		4.3%	4.6%	4.4%	4.3%	4.6%	4.4%

APPENDIX C – ASSUMED START OF LEARNING DATES

The table below lists the assumed start of learning years for each technology and related low, medium and high levels.

		FOAK	NOAK
CCGT w CCS	High	2015	2018
	Med	2013	2016
	Low	2011	2014
Coal w CCS	High	2013	2016
	Med	2010	2014
	Low	2009	2012
IGCC w CCS	High	2015	2018
	Med	2013	2016
	Low	2011	2014
Nuclear PWR	High	2009	2016
	Med	2009	2014
	Low	2009	2012

APPENDIX D – TECHNOLOGY-BY-TECHNOLOGY ASSUMPTIONS

In this section detailed explanations to each figure for each technology are tabulated, in a technology-by-technology structure. The sheets will have the following structure:

A	General method and assumptions
B	CCGT
C	CCGT with CCS
D	Coal ASC with FGD
E	Coal ASC with FGD & CCS
F	IGCC
G	IGCC with CCS
H	Blank
I	Blank
J	Nuclear PWR (multiple units)
K	Pumped Storage
L	OCGT
M	CHP 10MW
N	CHP 50MW
O	CHP 500MW

Technology Choice

A - General

General Note
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Key Timings					
Pre-development period	**Construction period**	**Operational period**	**Decommissioning cool-down period**	**Decommissioning period**	**Annuity period**
N/A	N/A	N/A	N/A	N/A	unchanged from DECC assumptions

Technical Data									
Net power	**Av. steam**	**Steam take-up**	**Net efficiency LHV**	**HHV/LHV**	**Efficiency profile**	**Availability profile**	**Load factor**	**Auxiliary power**	**CO2 scrubbing**
Original model contained "gross power", with corresponding "gross efficiency", however most capital costs are quoted as per MW net, therefore to avoid scewed results, power is now quoted as "net". Adjusted to correllate with quoted capital costs or expected capacity of future developments (wind and nuclear). Each level, and FOAK and NOAK are the same. Actual value is cancelled out in calculations for all components except infrastructure cost (as this is a fixed value), however variation of net power by up to 100 MW makes less than 1p difference in the levelised cost for large plant (all except 10 MW and 50 MW CHP and OCGT).	Modelled using industry standard software. Appropriate topology chosen for the electrical output requred, then heat output for no SF calculated by model. Each level, and FOAK and NOAK are the same.	100% for CHP schemes Each level, and FOAK and NOAK are the same.	Net efficiency used instead of gross as net power is used instead of gross power. Therefore no modification of the model algorithms was required. Efficency quoted for base load for all technologies and all levels.	Conversion factor as some fuel costs are quoted as per unit energy HHV. Each level, and FOAK and NOAK are the same.	Accounts for annual efficiency degredation between major outages for maintenance and unrevovered efficiency degredation after major outages. Profiles do not account for changes in annual degradation that may be brought about by additional capital investment over the plant lifecycle as these events would be highly site specific. Each level, and FOAK and NOAK are the same.	Accounts for annual power degredation between major outages for maintenance and unrecovered power degredation afterwards for generation that includes gas turbines. Accounts for unavailability due to maintenance and due to forced outages. Forced outage rate assumed high for each level in first year of operation. Forced outage rate varies for high, med and low levels to reflect uncertainty and variation between plants. Degredation and major outage parameters remain the same for each level. Profiles do not account for changes in annual degradation that may be brought about by additional capital investment over the plant lifecycle as these events would be highly site specific. FOAK and NOAK are the same.	Assumed 100% for all dispatchable load except for OCGT due to economic reasons. Offshore wind and pumped storage detailed below. FOAK and NOAK are the same.	Set to zero for all technologies except offshore wind, as expleined below.	unchanged from DECC assumptions

Capital Costs								
Pre-development cost	**Pre-development phasing**	**Regulatory + licensing cost**	**Regulatory + licensing phasing**	**Capital cost**	**Capital cost adjustment**	**Capital phasing**	**Infrastructure cost**	**Infrastructure phasing**
Includes estimate for design and development activities, specification development, tendering, contracting, fuel sourcing and technical, financial and legal consulting up to financial close.	Set to match the pre-development period length	Planning application which was calculated from government figures and varies with area of plant, electrical connection agreement fee which was calculated from NG tariff and varies according to the location of the plant, design and development work specific to licenses and consents and public inquiry costs included where appropriate.	Assumed that all costs are paid eighteen months before the end of the development period as this is likely to be when most of the cost is charged. Some elements and fees may be paid at different times, however adjusting the phasing to reflect this would have negligible impact on the levelised costs.	FOAK prices are calculated from the NOAK prices and based on assumptions made in price adjustments	Includes long term market trend which is flat for the medium level, falling in accordance with the historical cost trend of CCGT for the low level and rising at the same rate for the high level. CCS, nuclear and offshore wind technologies also include learning profiles. High, med and low levels include adjusted market rates and differing years for first learning where learning is included.	Set to match the construction period length with a typical S-curve distribution of costs.	Includes construction of HV spur and substation at tee point, gas and CO2 pipelines (to national transmission system) and rail spurs where appropriate. FOAK and NOAK are the same as the costs of pipelines, rail spurs and electrical tees are well known and understood. Variation across cost levels reflects uncertainty and variation from site to site.	Set to be incurred over the first two years of construction at 50/50 ratio, for all technologies

Operating costs						
O&M fixed cost	**O&M variable cost**	**Insurance**	**UoS**	**CO2 transport & storage**	**Waste cost**	**Decommissioning**
N/A	N/A	Insurance prices are estimated on capital costs and estimated risk profiles for the relevant technology. A lack of reference data has meant these methods have had to be used. For all technologies costs are based on the medium NOAK figure. The NOAK low figure is -33% and the NOAK high figure is +50%. For FOAK prices (where applicable) the low price is equal to that of NOAK, the medium price is +10% from the NOAK medium figure, and the high price is +20% from the NOAK high figure. This is the case for all technologies, apart from CCGT and nuclear, where figures from similar project have been used.	Based on NG UoS charge zones. Zones in which generation could be built were selected, then max, average and min selected as high, med and low levels.	unchanged from DECC assumptions	unchanged from DECC assumptions	unchanged from DECC assumptions

Technology Choice

B - CCGT

General Note
FOAK = NOAK for all parameters as technology is well established

Key Timings					
Pre-development period	**Construction period**	**Operational period**	**Decommissioning cool-down period**	**Decommissioning period**	**Annuity period**
Assumed to include - feasibility studies - specification preparation, tender documents, bid reviews and negotiations (6-9months) - electrical connection application (10-12 months) - environmental assessment and approval (12 months) This equates to the medium figure of just under 2.3 years. High figure is deemed to be the length of time after which the project is no longer economically viable, but still possible (which has been experienced in the past).	Mainly constrained by the lead time for large forgings, i.e. ST rotor. OEM's currently quoting approximately 18 months, which suggests an overall construction period of 24 months. Low figure represents shortest construction period which PB is aware of being achieved.	From experience the typical design life for CCGT plant is 30 years. Low and high figures are representative for plants which are badly or well maintained, respectively.	N/A	Figures reflect typical time periods incurred for decommissioning of CCGT plant, which don't tend to vary too much. These figures are based both on expectations and experience.	unchanged from DECC assumptions

Technical Data									
Net power	**Av. steam**	**Steam take-up**	**Net efficiency LHV**	**HHV/LHV**	**Efficiency profile**	**Availability profile**	**Load factor**	**Auxiliary power**	**CO2 scrubbing**
Updated to 850 MW to match current reference projects.	N/A	N/A	Low and med levels reflect typical efficiency for plants of 850 MW. High is efficiency that could be reached in near future. Efficiency of smaller plants would be lower but would not be economical to build a plant of this size at a lower efficiency.	Updated to more representative figure of 92.6%.	Typical annual degredation and unrecovered degredation for reference projects of this size. Slight variation exists from plant to plant due to design differences.	Typical values for annual power degredation, unrecovered degradation, maintenance periods, time between major maintenance events and forced outage rates obtained from reference plants. Standard availability modelling methodology applied in order to obtain trends.	100% at all levels for dispatchable load	Set to 0 as Net power is used, not gross.	unchanged from DECC assumptions

Capital Costs								
Pre-development cost	**Pre-development phasing**	**Regulatory + licensing cost**	**Regulatory + licensing phasing**	**Capital cost**	**Capital cost adjustment**	**Capital phasing**	**Infrastructure cost**	**Infrastructure phasing**
Medium level reflects total development costs of approximately £10m. Little variation between high and low levels as the development costs for this technology are fairly well understood and there is little variation between sites.	See General explanation	Includes planning application fee, electrical connection, design and development work carried out specifically for regulation and licenses and the cost of a public inquiry (only in high level).	See General explanation	Based on example projects collected from different internal sources within PB. Medium figure calculated as an average of relevant projects. Low price = -10% High price = +20%	Market projections taken from CCGT historical price trends for med level. Rates for high and low adjusted by +/- 20% to reflect uncertainty.	See General explanation	Includes electrical spur and gas delivery pipeline.	See General explanation

Operating costs						
O&M fixed cost	**O&M variable cost**	**Insurance**	**UoS**	**CO2 transport & storage**	**Waste cost**	**Decommissioning**
Based on real data from three example European CCGT projects. High and low figures are indicative of the range of prices from the example projects.	Based on real data from three example European CCGT projects. High and low figures are indicative of the range of prices from the example projects. Cost mainly incurred from water treatment costs.	Based on example projects collected from different internal sources within PB. Medium figure calculated as an average of relevant projects.	See General explanation	unchanged from DECC assumptions	unchanged from DECC assumptions	unchanged from DECC assumptions

Technology Choice

C - CCGT w CCS

General Note
FOAK defined as first of a kind within the UK. Therefore learning for capital cost reduction from international projects can reduce forward price for the UK.

Key Timings					
Pre-development period	**Construction period**	**Operational period**	**Decommissioning cool-down period**	**Decommissioning period**	**Annuity period**
Nominally based on that for CCGT plant, but more time allowed in this phase due to - sub-surface reservoir engineering - pipeline activities - more complex planning & environmental approvals, associated with CO2.	Construction period for FOAK plants is based on typical value for demonstration plants, which is 5 years. Typically slightly longer than coal + CCS because it will involve the construction of bigger vessels.	Operational periods similar to that of just CCGT plant, but with slight reductions due to the operation of the CCS technology. CCS technology is not as established and experience as CCGT and other technologies, therefore it is expected that the operational life will be shorter.	N/A	Based on time scale for CCGT with additional time allowed for decommissioning of CCS plant. Additional time varies as this is unknown at the moment, i.e. no reference examples.	unchanged from DECC assumptions

Technical Data									
Net power	**Av. steam**	**Steam take-up**	**Net efficiency LHV**	**HHV/LHV**	**Efficiency profile**	**Availability profile**	**Load factor**	**Auxiliary power**	**CO2 scrubbing**
Updated to 850 MW to match current reference projects.	N/A	N/A	If PC CCS were not applied to any plant, it is predicted that the plant output would increase by 20%. CCGT plant efficiency was therefore divided by 1.2 at each level to give an approximate CCGT with CCS efficiency.	Updated to more representative figure of 92.6%.	Assumed the same as for CCGT.	Assumed the same as for CCGT.	100% at all levels for dispatchable load	Set to 0 as Net power is used, not gross.	unchanged from DECC assumptions

Capital Costs								
Pre-development cost	**Pre-development phasing**	**Regulatory + licensing cost**	**Regulatory + licensing phasing**	**Capital cost**	**Capital cost adjustment**	**Capital phasing**	**Infrastructure cost**	**Infrastructure phasing**
Approximately double the cost of a standard CCGT plant due to additional design costs that are undertaken up front and not passed on to the EPC contractor. Wide variation in costs due to uncertainty. FOAK and NOAK costs to developer likely to be similar due to government subsidies for FOAK and some costs passed to the EPC contractor for NOAK.	See General explanation	Includes planning application fee, electrical connection, design and development work carried out specifically for regulation and licenses and the cost of a public inquiry (included at all levels).	See General explanation	CCGT + CCS CAPEX price based on CCGT price. No readily available information was found for CCGT CCS technology. Therefore the incremental price for Coal CCS technology has been used and scaled appropriately. The incremental price has been scaled by 0.5 to account for the cleaner exhaust gases in CCGT plant (compared to coal). Therefore less equipment is required to clean up the gases before the carbon capture process. A factor of 0.67 has also been applied as the capture capacity requirement of CCGT will be less than that of coal technology, as the starting levels of carbon in the exhaust gases are less than that of coal. Therefore less carbon capture is required to achieve the regulatory levels. A factor of 1.5 has been applied because of the increased mass flow rate experienced by the CCS equipment, in a CCGT plant. Low price = -10% High price = +15%	Market projections taken from CCGT historical price trends for med level. Rates for high and low adjusted by +60%, -35% to reflect greater uncertainty than for CCGT. Learning rates taken from Rubin report, FOAK learning limited when international capacity reaches 5000 MW due to UK specific issues.	See General explanation	Includes electrical spur, gas delivery pipeline and CO2 pipeline from plant to national transmission system.	See General explanation

Operating costs						
O&M fixed cost	**O&M variable cost**	**Insurance**	**UoS**	**CO2 transport & storage**	**Waste cost**	**Decommissioning**
Price made up of CCGT fixed O&M cost, with an additional allowance for the CCS technology. An additional £7500/MW is assumed for the fixed O&M of the CCS technology. FOAK prices assumed to be 20% higher than NOAK	Price made up of CCGT variable price (i.e. example projects) with additional £0.4MWh, which is approximately one-third of variable costs for coal + CCS. Based on the assumption that a coal station (with approximately double the capacity) will require three times the CCS capacity. FOAK prices assumed to be 20% higher than NOAK	See General explanation	See General explanation	unchanged from DECC assumptions	unchanged from DECC assumptions	unchanged from DECC assumptions

Technology Choice

D - Coal ASC w FGD

General Note
FOAK and NOAK same except for pre-dev costs

Key Timings					
Pre-development period	**Construction period**	**Operational period**	**Decommissioning cool-down period**	**Decommissioning period**	**Annuity period**
Coal technology is very well established in the power industry and the duration of project periods tends not to be suspectible to major fluctuations. These figures are based on many years of involvement with coal technology projects. The pre-development period has assumed a high figure, after which the project does not remain economically viable. The medium value is the typical/expected duration, and the low figure is the quickest time possible.	Coal technology is very well established in the power industry and the duration of project periods tends not to be suspectible to major fluctuations. These figures are based on many years of involvement with coal technology projects. There is a lot of experience for constructing a coal power station. Therefore the range of durations represents possible delays to the construction periods by any potential risks.	Coal technology is very well established in the power industry and the duration of project periods tends not to be suspectible to major fluctuations. These figures are based on many years of involvement with coal technology projects. Experience in the UK has shown that coal plants have a long plant life, with the correct maintenance and major overhaul schedule. The figures reflect the expected plant life.	N/A	Similar to the construction period, there is a lot of experience of decommissioning coal plants. Therefore the figures reflect the expected duration, with any possible delays.	unchanged from DECC assumptions

Technical Data									
Net power	**Av. steam**	**Steam take-up**	**Net efficiency LHV**	**HHV/LHV**	**Efficiency profile**	**Availability profile**	**Load factor**	**Auxiliary power**	**CO2 scrubbing**
Unchanged from DECC assumptions as it is a suitable plant size for this technology.	N/A	N/A	Low and med levels reflect typical efficiency for plants of 1600 MW. High is efficiency that could be reached in near future. Efficiency of smaller plants would be lower but would not be economical to build a plant of this size at a lower efficiency. Efficiency quoted for base load.	Unchanged from DECC assumptions, 95%	Typical annual degredation and unrecovered degredation for reference projects of this size. Slight variation exists from plant to plant due to design differences.	Typical values for annual power degredation, unrecovered degradation, maintenance periods, time between major maintenance events and forced outage rates obtained from reference plants. Standard availability modelling methodology applied in order to obtain trends.	100% at all levels for dispatchable load	Set to 0 as Net power is used, not gross.	unchanged from DECC assumptions

Capital Costs								
Pre-development cost	**Pre-development phasing**	**Regulatory + licensing cost**	**Regulatory + licensing phasing**	**Capital cost**	**Capital cost adjustment**	**Capital phasing**	**Infrastructure cost**	**Infrastructure phasing**
No ASC within UK, therefore additional up front design costs. Biomass (5% of input fuel) sourcing also increases costs. Coal also likely to be delivered by rail which introduces significant development costs.	See General explanation	Includes planning application fee, electrical connection, design and development work carried out specifically for regulation and licenses and the cost of a public inquiry (only in high level).	See General explanation	Coal price based project which PB has been involved with, which is 2004 build. This price has been adjusted to account for the time of build, and currency has been converted using exchange rates at the time of build. Low price = approx. -10% High price = approx. +10%	Market projections taken from CCGT historical price trends for med level. Rates for high and low adjusted by +/- 30% to reflect uncertainty.	See General explanation	Includes electrical spur and rail spur for fuel delivery.	See General explanation

Operating costs						
O&M fixed cost	**O&M variable cost**	**Insurance**	**UoS**	**CO2 transport & storage**	**Waste cost**	**Decommissioning**
Assumed that fixed maintenance price is £32000/MW + £5million a year for staff costs. (Staff levels are the same for low, medium and high cases) High and low figures are +/- 40% from the medium figure	Variable cost made up of a cost for FGD consumable (i.e. limestone) and cost for water treatment. Water treatment (and therefore costs) assumed to be 3 times the amount of CCGT (i.e. from the amount of steam used). FGD costs assume £30/tonne for limestone. Other assumptions are 2% coal sulphur content, +/- 25% (high & low figures). Therefore between £6m and £10m for limestone. 85% then taken for allowance of running time per year.	See General explanation	See General explanation	unchanged from DECC assumptions	unchanged from DECC assumptions	unchanged from DECC assumptions

Technology Choice

E - Coal ASC w FGD & CCS

General Note
FOAK defined as first of a kind within the UK. Therefore learning for capital cost reduction from international projects can reduce forward price for the UK.

Key Timings					
Pre-development period	**Construction period**	**Operational period**	**Decommissioning cool-down period**	**Decommissioning period**	**Annuity period**
Low figure is based on best case scenario of 0.5 years for planning application, 1 year waiting for planning approval, 1.5 year after planning for detailed design (i.e. total 3 years). High value is length of time it would take if design was started after planning was approved - or if design had to be reviewed because of planning. i.e. 7 years. Medium value is 'realistic' amount of time. FOAK time longer due to need for FEED study.	Low figure represents shortest time possible that the plant could be built in. Medium value is a more realistic amount of time to construct the whole plant. (FOAK) It is assumed that NOAK plants can be constructed in one year less than FOAK, due to learning and economies of scale. The figures reflect this.	Operational period is assumed (within the industry) to be between 15-25 years for the CCS process plant. Therefore this is the basis for plant operational period. NOAK operational periods are 5 years more due to better developed and trusted technology, once installed capacity increases.	N/A	Assumed to take approximately 0.5 years longer than coal technology without CCS. Low figure uses just 0.2 years increase in time, which is the best case scenario.	unchanged from DECC assumptions

Technical Data									
Net power	**Av. steam**	**Steam take-up**	**Net efficiency LHV**	**HHV/LHV**	**Efficiency profile**	**Availability profile**	**Load factor**	**Auxiliary power**	**CO2 scrubbing**
Unchanged from DECC assumptions as it is a suitable plant size for this technology.	N/A	N/A	If PC CCS were not applied to any plant, it is predicted that the plant output would increase by 20%. Coal plant efficiency was therefore divided by 1.2 at each level to give an approximate coal with CCS efficiency.	Unchanged from DECC assumptions, 95%	Assumed the same as for Coal ASC with FGD.	Assumed the same as for Coal ASC with FGD.	100% at all levels for dispatchable load	Set to 0 as Net power is used, not gross.	unchanged from DECC assumptions

Capital Costs								
Pre-development cost	**Pre-development phasing**	**Regulatory + licensing cost**	**Regulatory + licensing phasing**	**Capital cost**	**Capital cost adjustment**	**Capital phasing**	**Infrastructure cost**	**Infrastructure phasing**
Costs slightly lower than CCGT CCS due to larger plant, however additional design costs from fuel sourcing and delivery would increase costs. In FOAK, additional up front design costs for CCS plant included, however these are offset in part by government subsidies. CCS plant design costs may be passed to EPC contractor for NOAK plants.	See General explanation	Includes planning application fee, electrical connection, design and development work carried out specifically for regulation and licenses and the cost of a public inquiry (included at all levels).	See General explanation	Based on coal price (without CCS). Additional cost is the increment price for CCS technology supplied by PB CCS team. We have used the average figure of the medium values for the different CCS technologies, to increase all (low, medium and high) values of the CAPEX cost, as this is the figure which best represents the expected costs. CCS cost has been derived from various studies, articles and information in the public domain. Medium figures are 'confident' from PB.	Market projections taken from CCGT historical price trends for med level. Rates for high and low adjusted by +60%, -35% to reflect greater uncertainty than for CCGT. Learning rates taken from Rubin report, FOAK learning limited when international capacity reaches 5000 MW due to UK specific issues.	See General explanation	Includes electrical spur, rail spur for fuel delivery and CO2 pipeline from the plant to the transmission system.	See General explanation

Operating costs						
O&M fixed cost	**O&M variable cost**	**Insurance**	**UoS**	**CO2 transport & storage**	**Waste cost**	**Decommissioning**
Assumed that fixed maintenance price is £56500/MW + £5million a year for staff costs. (Staff levels are the same for low, medium and high cases) High and low figures are +/- 40% from the medium figure FOAK prices assumed to be 20% higher than NOAK	Based on variable O&M cost for coal (without CCS), plus an additional variable cost for CCS technology. Additional CCS variable O&M costs is taken as £1.12/MWh, which is based on various studies and confirmed by CCS experts. FOAK prices assumed to be 20% higher than NOAK	See General explanation	See General explanation	unchanged from DECC assumptions	unchanged from DECC assumptions	unchanged from DECC assumptions

Technology Choice

F - IGCC

General Note
FOAK and NOAK same except for pre-dev costs

Key Timings					
Pre-development period	**Construction period**	**Operational period**	**Decommissioning cool-down period**	**Decommissioning period**	**Annuity period**
Total pre-development period will be similar to that of coal technology, with additional time needed for the design work (and related activities). Due to the complexity of the IGCC plant and the interaction between the process/distallation equipment and the power generation equipment, the design work will take more time.	Similar to that of coal technology, but there will be additional time needs for the construction of the complex interfaces between the process/distallation and power generation equipment/systems (similar to the pre-development period).	Due to the technical capabilities of the IGCC technology the operational period tends to be shorter than that of coal technology. Typically this is approximately 5 years, which is reflected in the figures.	N/A	Similar to the construction period, there will be additional time required (compared to coal technology) for the decommissioning of the additional and more complex ancillary equipment.	unchanged from DECC assumptions

Technical Data									
Net power	**Av. steam**	**Steam take-up**	**Net efficiency LHV**	**HHV/LHV**	**Efficiency profile**	**Availability profile**	**Load factor**	**Auxiliary power**	**CO2 scrubbing**
Unchanged from DECC assumptions as it is a suitable plant size for this technology.	N/A	N/A	Wider variation between levels than for other plants due to smaller number of commercial plants and variation in design. Low level reflects current levels expected to be achieved by commercial plants under construction, medium and high represent the varying opinion on how high the efficiency could reach.	Unchanged from DECC assumptions, 95%	Assumed the same as for CCGT.	Assumed the same as for CCGT.	100% at all levels for dispatchable load	Set to 0 as Net power is used, not gross.	unchanged from DECC assumptions

Capital Costs								
Pre-development cost	**Pre-development phasing**	**Regulatory + licensing cost**	**Regulatory + licensing phasing**	**Capital cost**	**Capital cost adjustment**	**Capital phasing**	**Infrastructure cost**	**Infrastructure phasing**
Similar development costs to CCGT with CCS as assumed plant sizes are similar and additional design costs for gasificaiton would be undertaken up front. Additional health and safety design issues and no plant within UK currently.	See General explanation	Includes planning application fee, electrical connection, design and development work carried out specifically for regulation and licenses and the cost of a public inquiry (only in high level).	See General explanation	CAPEX price based on recent IGCC project. Slight adjustments made due to location of project. Low price = approx. -25% High price = approx. +25%	Market projections taken from CCGT historical price trends for med level. Rates for high and low adjusted by +/- 30% to reflect uncertainty.	See General explanation	Includes electrical spur and rail spur for fuel delivery.	See General explanation

Operating costs						
O&M fixed cost	**O&M variable cost**	**Insurance**	**UoS**	**CO2 transport & storage**	**Waste cost**	**Decommissioning**
Assumed that fixed maintenance price is £46000/MW + £5million a year for staff costs. (Staff levels are the same for low, medium and high cases) High figure is +30% and low figure is -25% from the medium figure	Assumed to be a similar cost to that for coal technology as there is a comparable amount (and cost) for consumables. Water treatment (and therefore costs) assumed to be 3 times the amount of CCGT (i.e. from the amount of steam used).	See General explanation	See General explanation	unchanged from DECC assumptions	unchanged from DECC assumptions	unchanged from DECC assumptions

Technology Choice

G - IGCC w CCS

General Note
FOAK defined as first of a kind within the UK. Therefore learning for capital cost reduction from international projects can reduce forward price for the UK.

Key Timings					
Pre-development period	**Construction period**	**Operational period**	**Decommissioning cool-down period**	**Decommissioning period**	**Annuity period**
Low figure is based on best case scenario of 0.5 years for planning application, 1 year waiting for planning approval, 1.5 year after planning for detailed design (i.e. total 3 years). High value is length of time it would take if design was started after planning was approved - or if design had to be reviewed because of planning. i.e. 7 years. Medium value is 'realistic' amount of time. FOAK time longer due to need for FEED study.	Similar duration to other CCS technologies, which equates to the same amount of time for IGCC (without CCS). NOAK = FOAK	FOAK operational period assumed on the same basis of Coal CCS, with a range of 15-25 years. NOAK operational periods are 5 years more due to better developed and trusted technology, once installed capacity increases.	N/A	Decommissioning period is assumed to be 0.5 years longer than IGCC technology without CCS, for low, medium and high cases. FOAK high value has an additional 0.5 years due to potential complications.	unchanged from DECC assumptions

Technical Data									
Net power	**Av. steam**	**Steam take-up**	**Net efficiency LHV**	**HHV/LHV**	**Efficiency profile**	**Availability profile**	**Load factor**	**Auxiliary power**	**CO2 scrubbing**
Unchanged from DECC assumptions as it is a suitable plant size for this technology.	N/A	N/A	If CCS were not applied to an IGCC plant, it is predicted that the plant output would increase by 10%. Coal plant efficiency was therefore divided by 1.1 at each level to give an approximate coal with CCS efficiency.	Unchanged from DECC assumptions, 95%	Assumed the same as for CCGT.	Assumed the same as for CCGT.	100% at all levels for dispatchable load	Set to 0 as Net power is used, not gross.	unchanged from DECC assumptions

Capital Costs								
Pre-development cost	**Pre-development phasing**	**Regulatory + licensing cost**	**Regulatory + licensing phasing**	**Capital cost**	**Capital cost adjustment**	**Capital phasing**	**Infrastructure cost**	**Infrastructure phasing**
Same as above, at this scale the additional design and development costs for the capture and compression of CO2 would be minimal compared to cost of gassificaiton process.	See General explanation	Includes planning application fee, electrical connection, design and development work carried out specifically for regulation and licenses and the cost of a public inquiry (included at all levels).	See General explanation	Based on IGCC CAPEX with additional increment cost for CCS technology as supplied by PB CCS team. Similar to the coal technology, the cost has been increased with the 'medium' figure for the CCS increment, as this is the figure which PB are confident in to represent the expected cost. CCS cost has been derived from various studies, articles and information in the public domain. Medium figures are 'confident' from PB.	Market projections taken from CCGT historical price trends for med level. Rates for high and low adjusted by +60%, -35% to reflect greater uncertainty than for CCGT. Learning rates taken from Rubin report, FOAK learning limited at 7% reduction on 2009 price due to UK specific issues.	See General explanation	Includes electrical spur, rail spur for fuel delivery and CO2 pipeline from the plant to the transmission system.	See General explanation

Operating costs						
O&M fixed cost	**O&M variable cost**	**Insurance**	**UoS**	**CO2 transport & storage**	**Waste cost**	**Decommissioning**
Figure is based on value used for IGCC + £15750/MW for CCS technology. High figure is +30% and low figure is -25% from the medium figure FOAK prices assumed to be 20% higher than NOAK	Additional CCS cost is assumed as £1.40/MWh, which is also based on various studies and expert opinion. This is relatively comparable to the CAPEX increments for CCS technology. Additional allowance made for water treatment - assumed to be three times the amount of CCGT (on the same basis of coal assumption) High and low figures are +/- 40% from the medium figure FOAK prices assumed to be 20% higher than NOAK	See General explanation	See General explanation	unchanged from DECC assumptions	unchanged from DECC assumptions	unchanged from DECC assumptions

Technology Choice

J - Nuclear PWR

General Note
FOAK defined as first of a kind within the UK. Therefore learning for capital cost reduction from international projects can reduce forward price for the UK.

Key Timings					
Pre-development period	**Construction period**	**Operational period**	**Decommissioning cool-down period**	**Decommissioning period**	**Annuity period**
Predevelopment times based on information from HSE website for Generic Design Assessments (GDA). Website shows that minimum time allowed for environament assessments, design reviews, assessment for security plan, etc, is at least 5 years. http://www.hse.gov.uk/newreactors/timeline.htm	Avera say construction is likely to take 42 months, i.e. 6 months longer than Westinghouse. The figures show this 6 months difference.	Current reactor manufacturers are quoting a technical life of 60 years. Timings supplied are less due to licensing restrictions. Extension to the license period of the plant is likely (to utilise the whole technical life of the reactor) but is likely to included repowering and therefore additional capital costs, and therefore this has not been included.	Based on time needed for processing of fuel rods, etc. Figures dictated by this and nothing to influence a shorter time.	Based on time needed for processing of fuel rods, etc. Figures dictated by this and nothing to influence a shorter time.	unchanged from DECC assumptions

Technical Data									
Net power	**Av. steam**	**Steam take-up**	**Net efficiency LHV**	**HHV/LHV**	**Efficiency profile**	**Availability profile**	**Load factor**	**Auxiliary power**	**CO2 scrubbing**
Updated to 3200 MW, comprising of 2 units.	N/A	N/A	NA	NA	NA	Accounts for outage every year and a half to change out fuel rods. Uncertainty and variability as to how long this takes are reflected by varying the outage duration for each level. Steam turbine maintenance is assumed to be carried out in parallel with one of these outages. No power degradation assumed as no significant degradation occurs.	100% at all levels for dispatchable load	Set to 0 as Net power is used, not gross.	unchanged from DECC assumptions

Capital Costs								
Pre-development cost	**Pre-development phasing**	**Regulatory + licensing cost**	**Regulatory + licensing phasing**	**Capital cost**	**Capital cost adjustment**	**Capital phasing**	**Infrastructure cost**	**Infrastructure phasing**
Same development costs for both nuclear technologies. Major up front design work, safety assessments, logistics and fuel sourcing.	See General explanation	Includes planning application fee, electrical connection, design and development work carried out specifically for regulation and licenses and the cost of an extended public inquiry, the cost of which varies with each level.	See General explanation	Prices based on the last UK based project - and adjusted due to any learning from conferences, projects, studies, etc. (Figures match PtN figures, with a decrease in the 'High' value)	Market projections taken from CCGT historical price trends for med level. Rates for high and low adjusted by +/- 30% to reflect uncertainty. Learning rate of 3% adopted for FOAK and 5% for NOAK as there is less scope for price reduction due to improved manufacture processes than for the Westinghouse.	See General explanation	Includes electrical infrastucture only. Fuel delivery and waste disposal infrastructure costs accounted for as part of waste disposal or capital costs.	See General explanation

Operating costs						
O&M fixed cost	**O&M variable cost**	**Insurance**	**UoS**	**CO2 transport & storage**	**Waste cost**	**Decommissioning**
Prices based on the last UK based project - and adjusted due to any learning from studies, conferences, projects, etc. FOAK prices assumed to be 20% higher than NOAK	Variable prices based on prices for water treatment for CCGT. Scaled up from the amount used for coal plant, by 50%. FOAK prices assumed to be 20% higher than NOAK	Figures based on current nuclear experience within the UK	See General explanation	unchanged from DECC assumptions	unchanged from DECC assumptions	unchanged from DECC assumptions

Technology Choice

K - Pumped Storage

General Note
FOAK and NOAK same except for price adjustment

Key Timings					
Pre-development period	**Construction period**	**Operational period**	**Decommissioning cool-down period**	**Decommissioning period**	**Annuity period**
unchanged from DECC assumptions	unchanged from DECC assumptions	unchanged from DECC assumptions	N/A	unchanged from Motts	unchanged from DECC assumptions

Technical Data									
Net power	**Av. steam**	**Steam take-up**	**Net efficiency LHV**	**HHV/LHV**	**Efficiency profile**	**Availability profile**	**Load factor**	**Auxiliary power**	**CO2 scrubbing**
Updated to 400 MW to match price estimates	N/A	N/A	NA	NA	NA	Accounts for unavailability due to planned maintenance. No power degradation assumed as no significant degradation occurs.	40% for all levels as charging takes longer than discharging.	Set to 0 as Net power is used, not gross.	unchanged from DECC assumptions

Capital Costs								
Pre-development cost	**Pre-development phasing**	**Regulatory + licensing cost**	**Regulatory + licensing phasing**	**Capital cost**	**Capital cost adjustment**	**Capital phasing**	**Infrastructure cost**	**Infrastructure phasing**
FOAK and NOAK costs the same as technology is fairly well known. Development and design costs may vary from site to site, so levels reflect this uncertainty.	See General explanation	Includes planning application fee, electrical connection, design and development work carried out specifically for regulation and licenses and the cost of a public inquiry (only in high level).	See General explanation	CAPEX is sourced from from 2010 report Deane et al. Figures have been scaled appropriately as costs from report do not account for the current availability of suitable UK sites. I.e. because the most suitable sites are all ready operational, extra costs will be incurred due to the requirement of a more complex site. The 'high' case has been assumed to be a 'typical' lagoon pumped storage option, which is realistic due to the lack of available sites for conventional pumped storage projects.	Market projections taken from CCGT historical price trends for med level. Rates for high and low adjusted by +/- 30% to reflect uncertainty.	See General explanation	Includes electrical infrastructure only, allowing for greater spur length to account for more remote siting.	See General explanation

Operating costs						
O&M fixed cost	**O&M variable cost**	**Insurance**	**UoS**	**CO2 transport & storage**	**Waste cost**	**Decommissioning**
Unchanged from Mott's figures - no better data to suggest they are incorrect. Amounts seems reasonable.	No costs as fuel costs (i.e. electricity) are not considered as advised by DECC	See General explanation	See General explanation	unchanged from DECC assumptions	unchanged from DECC assumptions	unchanged from DECC assumptions

Technology Choice

L - OCGT

General Note
FOAK = NOAK for all parameters as technology is well known

Key Timings					
Pre-development period	**Construction period**	**Operational period**	**Decommissioning cool-down period**	**Decommissioning period**	**Annuity period**
Baaed on pre development period for a CCGT plant as activities are largely similar. The only difference between the figures accounts for OCGT having a less onerous water abstraction license application process (which is needed for CCGT plant) and lesss design work.	Low figure represents a guarenteed construction period of one project. Medium figure represents a typical figure for OCGT projects, which is an average figure of various projects. The high figure reflects a construction period experienced on one project (not PB), and deemed to be worse case.	OCGT tend to have extended life due to being peaking plants. Experience shows that a typical OCGT design life is 40 years. Low and high figures are given as realistic but 'outlier' cases.	N/A	Medium and high figures unchanged from Motts figures as they are realistic. Low figure has been increased to 0.6 years, as 0.4 years seems unrealistic for any size of plant.	unchanged from DECC assumptions

Technical Data									
Net power	**Av. steam**	**Steam take-up**	**Net efficiency LHV**	**HHV/LHV**	**Efficiency profile**	**Availability profile**	**Load factor**	**Auxiliary power**	**CO2 scrubbing**
Unchanged from DECC assumptions as it is a suitable plant size for this technology.	N/A	N/A	Low and med levels reflect typical efficiency for plants of 100 MW. High is efficiency that could be reached if the plant were designed for high efficiency. Efficiency of smaller plants would be lower but would not be economical to build a plant of this size at a lower efficiency.	Updated to more representative figure of 92.6%.	Assumed the same as for CCGT.	Assumed the same as for CCGT.	20% for med and low levels as this would be typical for a gas fired OCGT. High is 50% as OCGTs could operate economically at this level if the amount of intermittent generation increases.	Set to 0 as Net power is used, not gross.	unchanged from DECC assumptions

Capital Costs								
Pre-development cost	**Pre-development phasing**	**Regulatory + licensing cost**	**Regulatory + licensing phasing**	**Capital cost**	**Capital cost adjustment**	**Capital phasing**	**Infrastructure cost**	**Infrastructure phasing**
Medium level reflects total development costs of approximately £3m. Little variation between high and low levels as the development costs for this technology are fairly well understood and there is little variation between sites.	See General explanation	Includes planning application fee, electrical connection and design and development work carried out specifically for regulation and licenses. No public inquiry included at any level because if one were required for a specific site it would likely make the project uneconomical.	See General explanation	Medium price is equal to that of PtN figure, as technology is unchanged and there is no reason to alter. Low price = -10% High price = +20% (as for CCGT - i.e. same technology)	Market projections taken from CCGT historical price trends for med level. Rates for high and low adjusted by +/- 20% to reflect uncertainty. No learning for FOAK or NOAK, but price accellerates into future as each new site shall be more difficult than the last, ie easy sites will be used first, leaving increasingly less attractive options. Price for low and med levels tend towards £5000 per MW, as at this price, lagoon technologies become the more attractive option.	See General explanation	0	See General explanation

Operating costs						
O&M fixed cost	**O&M variable cost**	**Insurance**	**UoS**	**CO2 transport & storage**	**Waste cost**	**Decommissioning**
Based on £21000/MW (based on comparable projects) for fixed maintenance and £400,000 for annual staff costs. High and low figures are approximately +/- 10% from medium value	N/A	See General explanation	See General explanation	unchanged from DECC assumptions	unchanged from DECC assumptions	unchanged from DECC assumptions

Technology Choice

M - CHP 10MW

General Note
FOAK = NOAK for all parameters as technology is well known

Key Timings					
Pre-development period	**Construction period**	**Operational period**	**Decommissioning cool-down period**	**Decommissioning period**	**Annuity period**
Based on timings expected for same capacity CCGT plant. Compared with large CCGT, only slightly different because same planning and assessment processes still exist. Some time saved on design work, etc.	Based on timings expected for same capacity CCGT plant. I.e. it is relative to the construction period of a 500MW CHP plant	Operational period is normally dependent on the terms in the contract. From experience this is typically between 15 and 20 years. The figures reflect this. Low figure reflects worst possible case if plant is poorly maintained.	N/A	Based on timings expected for same capacity CCGT plant. I.e. it is relative to the construction period of a 500MW CHP plant	unchanged from DECC assumptions

Technical Data									
Net power	**Av. steam**	**Steam take-up**	**Net efficiency LHV**	**HHV/LHV**	**Efficiency profile**	**Availability profile**	**Load factor**	**Auxiliary power**	**CO2 scrubbing**
Modelled output of 13 MW	Heat available from modelled plant with desired output and no supplementary firing or aux boilers etc.	Unchanged from Mott's, 100%	Modelled efficiency for CHP plant of this size based on 1 GT and heat delivery from HRSG with no supplementary firing. High and low levels are +/- 10%.	Updated to more representative figure of 92.6%.	Assumed the same as for CCGT.	Assumed the same as for CCGT.	100% at all levels for dispatchable load	Set to 0 as Net power is used, not gross.	unchanged from DECC assumptions

Capital Costs								
Pre-development cost	**Pre-development phasing**	**Regulatory + licensing cost**	**Regulatory + licensing phasing**	**Capital cost**	**Capital cost adjustment**	**Capital phasing**	**Infrastructure cost**	**Infrastructure phasing**
Medium level reflects total development costs of approximately £0.25m. Little variation between high and low levels as the development costs for this technology are fairly well understood and there is little variation between sites.	See General explanation	Includes planning application fee which is charged at a lower rate as the plant is small, andelectrical connection. No additional design or development costs. No public inquiry needed.	See General explanation	Based on a project known to PB, but price scaled to account for omissions in price, as project is designed for future increase of capacity. Low price = -10% High price = +20% (as for CCGT - i.e. same technology)	Market projections taken from CCGT historical price trends for med level. Rates for high and low adjusted by +/- 20% to reflect uncertainty.	See General explanation	Includes electrical spur and gas delivery pipeline.	See General explanation

Operating costs						
O&M fixed cost	**O&M variable cost**	**Insurance**	**UoS**	**CO2 transport & storage**	**Waste cost**	**Decommissioning**
Based on £28000/MW (based on comparable projects) for fixed maintenance and £280,000 for annual staff costs. High and low figures are approximately +/- 10% from medium value	assumed to be at same level as CCGT variable costs. Therefore same figures used.	See General explanation	See General explanation	unchanged from DECC assumptions	unchanged from DECC assumptions	unchanged from DECC assumptions

Technology Choice

N - CHP 50MW

General Note
FOAK = NOAK for all parameters as technology is well known

Key Timings					
Pre-development period	**Construction period**	**Operational period**	**Decommissioning cool-down period**	**Decommissioning period**	**Annuity period**
Based on timings expected for same capacity CCGT plant. Compared with large CCGT, only slightly different because same planning and assessment processes still exist. Some time saved on design work, etc.	Based on timings expected for same capacity CCGT plant. I.e. it is relative to the construction period of a 500MW CHP plant	Operational period is normally dependent on the terms in the contract. From experience this is typically between 15 and 20 years. The figures reflect this. Low figure reflects worst possible case if plant is poorly maintained.	N/A	Based on timings expected for same capacity CCGT plant. I.e. it is relative to the construction period of a 500MW CHP plant	unchanged from DECC assumptions

Technical Data									
Net power	**Av. steam**	**Steam take-up**	**Net efficiency LHV**	**HHV/LHV**	**Efficiency profile**	**Availability profile**	**Load factor**	**Auxiliary power**	**CO2 scrubbing**
Modelled output of 52 MW	Heat available from modelled plant with desired output and no supplementary firing or aux boilers etc.	Unchanged from Mott's, 100%	Modelled efficiency for CHP plant of this size based on 1 GT, 1 ST and heat delivery directly from the ST exhaust. HRSG has no supplementary firing. High and low levels are +/- 10%.	Updated to more representative figure of 92.6%.	Assumed the same as for CCGT.	Assumed the same as for CCGT.	100% at all levels for dispatchable load	Set to 0 as Net power is used, not gross.	unchanged from DECC assumptions

Capital Costs								
Pre-development cost	**Pre-development phasing**	**Regulatory + licensing cost**	**Regulatory + licensing phasing**	**Capital cost**	**Capital cost adjustment**	**Capital phasing**	**Infrastructure cost**	**Infrastructure phasing**
Medium level reflects total development costs of approximately £1m. Little variation between high and low levels as the development costs for this technology are fairly well understood and there is little variation between sites.	See General explanation	Includes planning application fee which is charged at a lower rate as the plant is small, andelectrical connection. No additional design or development costs. No public inquiry needed.	See General explanation	Cost based on budget quote for similar sized plant under development. The cost was adjusted to reflect the utilisation of gas as a fuel. Low price = -10% High price = +20% (as for CCGT - i.e. same technology)	Market projections taken from CCGT historical price trends for med level. Rates for high and low adjusted by +/- 20% to reflect uncertainty.	See General explanation	Includes electrical spur and gas delivery pipeline.	See General explanation

Operating costs						
O&M fixed cost	**O&M variable cost**	**Insurance**	**UoS**	**CO2 transport & storage**	**Waste cost**	**Decommissioning**
Based on £26000/MW (based on comparable projects) for fixed maintenance and £400,000 for annual staff costs. High and low figures are approximately +/- 15% from medium value	assumed to be at same level as CCGT variable costs. Therefore same figures used.	See General explanation	See General explanation	unchanged from DECC assumptions	unchanged from DECC assumptions	unchanged from DECC assumptions

Technology Choice

O - CHP 500MW

General Note
FOAK = NOAK for all parameters as technology is well known

Key Timings					
Pre-development period	**Construction period**	**Operational period**	**Decommissioning cool-down period**	**Decommissioning period**	**Annuity period**
Based on timings expected for same capacity CCGT plant. Compared with large CCGT, only slightly different because same planning and assessment processes still exist. Some time saved on design work, etc.	Based on timings expected for same capacity CCGT plant. I.e. it is relative to the construction period of a 500MW CHP plant	Operational period is normally dependent on the terms in the contract. From experience this is typically between 15 and 20 years. The figures reflect this. Low figure reflects worst possible case if plant is poorly maintained.	N/A	Based on timings expected for same capacity CCGT plant. I.e. it is relative to the construction period of a 500MW CHP plant	unchanged from DECC assumptions

Technical Data									
Net power	**Av. steam**	**Steam take-up**	**Net efficiency LHV**	**HHV/LHV**	**Efficiency profile**	**Availability profile**	**Load factor**	**Auxiliary power**	**CO2 scrubbing**
Modelled output of 463 MW	Heat available from modelled plant with desired output and no supplementary firing or aux boilers etc.	Unchanged from Mott's, 100%	Modelled efficiency for CHP plant of this size based on 2 GTs and 1 condensing ST. Steam delivered from ST extractions and no supplementary firing. High and low levels are +/- 10%.	Updated to more representative figure of 92.6%.	Assumed the same as for CCGT.	Assumed the same as for CCGT.	100% at all levels for dispatchable load	Set to 0 as Net power is used, not gross.	unchanged from DECC assumptions

Capital Costs								
Pre-development cost	**Pre-development phasing**	**Regulatory + licensing cost**	**Regulatory + licensing phasing**	**Capital cost**	**Capital cost adjustment**	**Capital phasing**	**Infrastructure cost**	**Infrastructure phasing**
Medium level reflects total development costs of approximately £10m (same as CCGT). Little variation between high and low levels as the development costs for this technology are fairly well understood and there is little variation between sites.	See General explanation	Includes planning application fee, electrical connection, design and development work carried out specifically for regulation and licenses and the cost of a public inquiry (only in high level).	See General explanation	Judgement made that CHP plant is slightly cheaper (approx. 10%) than an equivalent CCGT plant. Low price = -10% High price = +20% (as for CCGT - i.e. same technology)	Market projections taken from CCGT historical price trends for med level. Rates for high and low adjusted by +/- 20% to reflect uncertainty.	See General explanation	Includes electrical spur and gas delivery pipeline.	See General explanation

Operating costs						
O&M fixed cost	**O&M variable cost**	**Insurance**	**UoS**	**CO2 transport & storage**	**Waste cost**	**Decommissioning**
Based on £23200/MW (based on comparable projects) for fixed maintenance and £1.6million for annual staff costs. High and low figures are approximately +/- 15% from medium value	assumed to be at same level as CCGT variable costs. Therefore same figures used.	See General explanation	See General explanation	unchanged from DECC assumptions	unchanged from DECC assumptions	unchanged from DECC assumptions

APPENDIX E – CCS DATA SOURCES

	Capital Construction Cost	O&M Costs
Oxyfuel cost sources	Redpoint: analysis of policies on CCS & financial incentive schemes	Redpoint: analysis of policies on CCS & financial incentive schemes
	European Commission Joint Research Centre (JRC): The Cost of Carbon Capture and Storage Demonstration Projects in Europe	European Commission Joint Research Centre (JRC): The Cost of Carbon Capture and Storage Demonstration Projects in Europe
	DOE/NETL: CCS RD&D Roadmap (Dec 2010)	ICEM 2002, Rubin et al Int Journal of GHG
	DOE/NETL: Cost and performance baseline for fossil energy plants, revision 2 (Dec 2010)	
	Published information on cost of schwarze pumpe	
	CERA (2008), quoted in MIT paper	
	BERR/CPCC (2007), quoted in MIT paper	
	ICEM 2002, Rubin et al Int Journal of GHG	
Post-combustion cost sources	Redpoint: analysis of policies on CCS & financial incentive schemes	Redpoint: analysis of policies on CCS & financial incentive schemes
	PB: Powering the Nation	PB: Powering the Nation
	European Commission Joint Research Centre (JRC): The Cost of Carbon Capture and Storage Demonstration Projects in Europe	European Commission Joint Research Centre (JRC): The Cost of Carbon Capture and Storage Demonstration Projects in Europe
	DOE/NETL: CCS RD&D Roadmap (Dec 2010)	
	DOE/NETL: Cost and performance baseline for fossil energy plants, revision 2 (Dec 2010)	
	DOE/NETL: Cost and performance baseline for fossil energy plants, revision 1 (2007)	
	IPCC special report on CCS (2005), quoted in IMechE article	
	IEA GHG PH4-33: Improvement in Power Generation with Post combustion Capture of Carbon Dioxide, 2004	
	Woodhead: Developments and Innovation in CCS technology (2010)	
	Mott update to COE costs for DECC (2010)	
	MIT paper 2009	
	CERA (2008), quoted in MIT paper	
	S&P (2007), quoted in MIT paper	
	BERR/CPCC (2007), quoted in MIT paper	
	Rubin et al: Use of experience curves to estimate the future costs of power plant with CO2 capture (2007)	
Pre-combustion cost sources	Redpoint: analysis of policies on CCS & financial incentive schemes	Redpoint: analysis of policies on CCS & financial incentive schemes
	PB: Powering the Nation	PB: Powering the Nation
	European Commission Joint Research Centre (JRC): The Cost of Carbon Capture and Storage Demonstration Projects in Europe	European Commission Joint Research Centre (JRC): The Cost of Carbon Capture and Storage Demonstration Projects in Europe
	DOE/NETL: Cost and performance baseline for fossil energy plants, revision 2 (Dec 2010)	
	Mott update to COE costs for DECC (2010)	
	ICEM 2002, Rubin et al Int Journal of GHG	

APPENDIX F – IRP 18R-97

	Primary Characteristic	*Secondary Characteristic*			
ESTIMATE CLASS	**LEVEL OF PROJECT DEFINITION** Expressed as % of complete definition	**END USAGE** Typical purpose of estimate	**METHODOLOGY** Typical estimating method	**EXPECTED ACCURACY RANGE** Typical variation in low and high ranges [a]	**PREPARATION EFFORT** Typical degree of effort relative to least cost index of 1 [b]
Class 5	0% to 2%	Concept Screening	Capacity Factored, Parametric Models, Judgment, or Analogy	L: -20% to -50% H: +30% to +100%	1
Class 4	1% to 15%	Study or Feasibility	Equipment Factored or Parametric Models	L: -15% to -30% H: +20% to +50%	2 to 4
Class 3	10% to 40%	Budget, Authorization, or Control	Semi-Detailed Unit Costs with Assembly Level Line Items	L: -10% to -20% H: +10% to +30%	3 to 10
Class 2	30% to 70%	Control or Bid/ Tender	Detailed Unit Cost with Forced Detailed Take-Off	L: -5% to -15% H: +5% to +20%	4 to 20
Class 1	50% to 100%	Check Estimate or Bid/Tender	Detailed Unit Cost with Detailed Take-Off	L: -3% to -10% H: +3% to +15%	5 to 100

Notes: [a] The state of process technology and availability of applicable reference cost data affect the range markedly. The +/- value represents typical percentage variation of actual costs from the cost estimate after application of contingency (typically at a 50% level of confidence) for given scope.

[b] If the range index value of "1" represents 0.005% of project costs, then an index value of 100 represents 0.5%. Estimate preparation effort is highly dependent upon the size of the project and the quality of estimating data and tools.