Department of Energy & Climate Change

Electricity Generation Costs

2013

July 2013

Contents

Introduction

Electricity generation costs are a fundamental part of energy market analysis, and a good understanding of these costs is important when analysing and designing policy.

DECC regularly updates estimates of the costs and technical specifications for different generation technologies used in its analysis. Cost data is broken down into detailed expenditure per MW capacity or MWh generation for the full lifetime[1] of a plant including planning costs, construction costs, operating costs and eventual decommissioning costs.

These detailed data are used by DECC to calculate a 'levelised cost' for each technology. A 'levelised cost' is the average cost over the lifetime of the plant per MWh of electricity generated. They reflect the cost of building, operating and decommissioning a generic plant for each technology. Potential revenue streams are not considered[2].

There a number of reasons why strike prices for the Feed-in Tariff with Contracts for Difference (CfD) being introduced as part of Electricity Market Reform will be different to the estimates of levelised costs in this report. While the cost assumptions, summarised in this report, form an input to the calculation of strike prices, levelised costs are not the same as strike prices. Other inputs to strike prices include CfD contract terms, including length and risk allocation as well as revenue assumptions. For further details, please see 'Limitations of Levelised Costs' below.

This report is structured as follows:

1) The first section details the methodology, data and assumptions used to generate the levelised cost estimates. This section also includes a discussion of some of the limitations of these estimates.

2) The second section presents selected 'levelised cost' estimates generated using DECC's Levelised Cost Model and a standardised 10% hurdle rate for investors.

3) The final section discusses how cost information is used in DECC electricity market modelling, illustrating some of the cost estimates at technology specific hurdle rates, and further uncertainties.

4) The report has several annexes showing more detail about the levelised cost calculation, additional estimates for technologies not included in the main report and details of some further scenarios and sensitivities considered.

It is important to note there is a large amount of uncertainty when estimating current and future costs of electricity generation. This report has attempted to capture some of this uncertainty by portraying ranges. However, not all sensitivities and sources of uncertainty are captured. All estimates are in 2012 real prices.

[1] Including pre-development, construction, operation and de-commissioning costs

[2] With the exception of heat revenues for CHP technologies

How Levelised Costs are calculated

Definition of 'Levelised Costs of Electricity Generation'

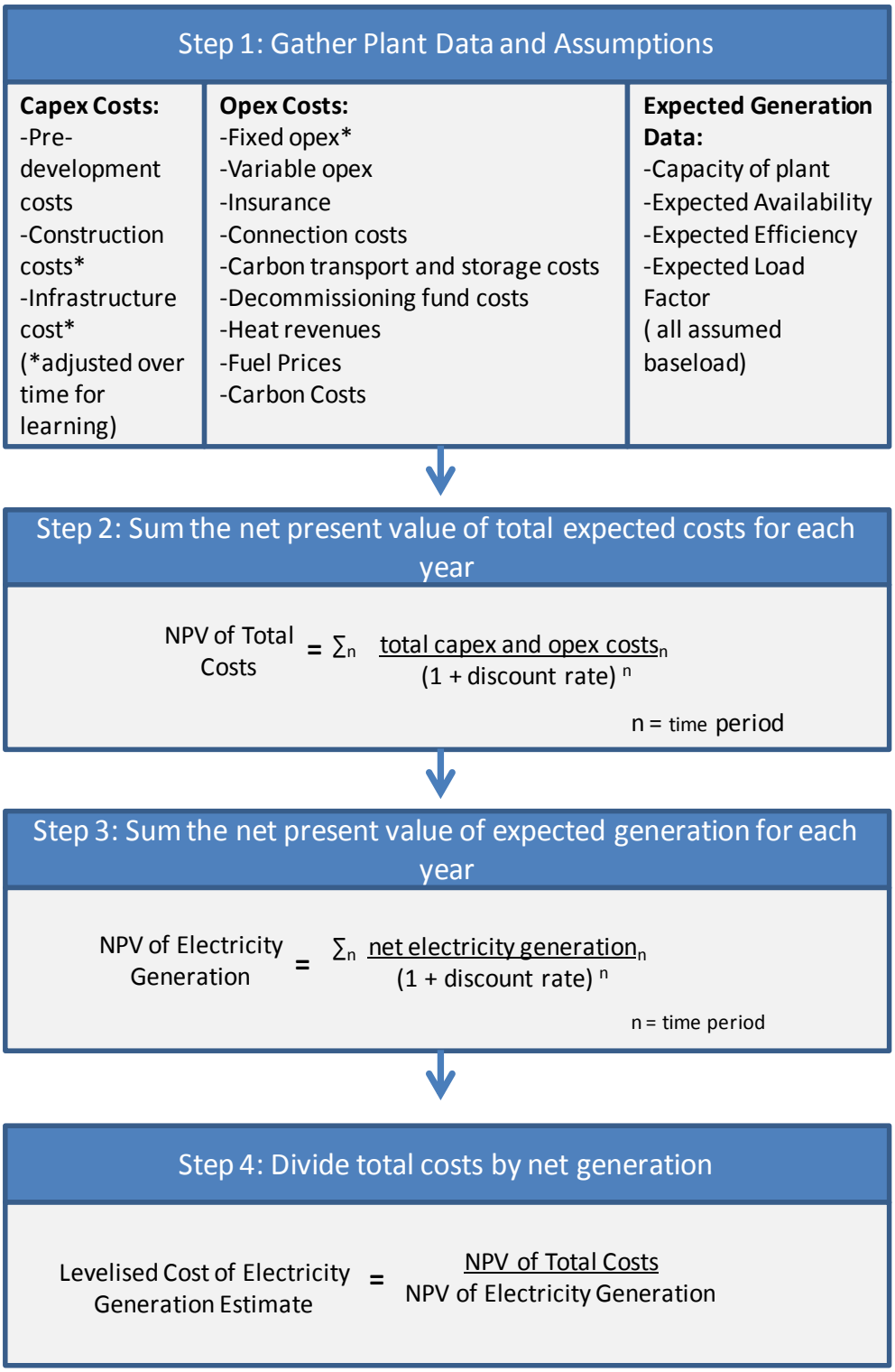
The Levelised Cost of Electricity Generation is the discounted lifetime cost of ownership and use of a generation asset, converted into an equivalent unit of cost of generation in £/MWh.

The levelised cost of a particular generation technology is the ratio of the total costs of a generic plant (including both capital and operating costs), to the total amount of electricity expected to be generated over the plant's lifetime. Both are expressed in net present value terms. This means that future costs and outputs are discounted, when compared to costs and outputs today.

This is sometimes called a life cycle cost, which emphasises the "cradle to grave" aspect of the definition. The levelised cost estimates do not consider revenue streams available to generators (e.g. from sale of electricity or revenues from other sources), with the exception of heat revenues for CHP plant which are included so that the estimates reflect the cost of electricity generation only.

As the definition of levelised costs relates only to those costs accruing to the owner/operator of the generation asset, it does not cover wider costs that may in part fall to others, such as the full cost of system balancing and network investment, or air quality impacts.

The figure on the next page demonstrates at a high level how Levelised Costs are calculated.



For further information on how levelised costs are calculated and DECC's Levelised Cost Model please refer to section 4.2 Mott MacDonald (2010)[3].

[3] http://www.decc.gov.uk/en/content/cms/about/ec_social_res/analytic_projs/gen_costs/gen_costs.aspx

Data Sources and Assumptions

Data Sources

The following data sources and assumptions were used to calculate the levelised costs estimates presented in this report. Table 1 shows the data source for each technology. Annex 2 provides further explanation on the data used to inform renewable electricity generation cost estimates.

The full list of capital costs and operating costs used in DECC electricity market modelling is shown at Annex 3. This Annex also lists hurdle rate and effective tax assumptions

Non – Renewable Technologies:

Fuel and decommissioning costs, carbon prices and hurdle rates were derived by DECC as described below under Further Assumptions. The rest of the underlying data on non-renewable technologies were provided by Parsons Brinckerhoff (PB). The underlying data and assumptions can be found in the PB (2013) report[4].

Renewable Technologies:

Nine data sources for various renewable technologies were used and/or considered by DECC. These are:

1. Government Response to the Banding Review (GRBR) - data and evidence underpinning the 'Government response to the consultation on proposals for the levels of banded support under the Renewables Obligation for the period 2013-17 and the Renewables Obligation Order 2012' for renewable technologies[5].
2. Large scale ground mounted solar PV data (>5MW)[6] - data and evidence on the costs and performance of large-scale solar PV underpinning 'Government response to further

[4] Unless referenced specifically, all documentation can be found on the 'Energy generation cost projections' page of the DECC website: https://www.gov.uk/government/organisations/department-of-energy-climate-change/series/energy-generation-cost-projections

[5] http://www.decc.gov.uk/assets/decc/11/consultation/ro-banding/5936-renewables-obligation-consultation-the-government.pdf. This is referred to as the 'Government Response to the Banding Review (GRBR)' throughout this report. Please note that the data has been inflated from 2010 to 2012 prices and heat revenues have been updated to reflect DECC's 2013 fuel and carbon prices when compared to those published as part of the Government Response to Banding Review.

[6] The Draft Delivery plan analysis for Large scale solar PV is based on the cost and performance assumptions for large-scale ground mounted solar PV developed as part of the consultation on RO support rates for solar PV. These assumptions can be viewed at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/66516/7328-renewables-obligation-banding-review-for-the-perio.pdf.

consultations on solar PV support, biomass affordability and retaining the minimum calorific value requirement in the RO'[7]

3. Small-scale Feed in Tarff (FiTs) data (PV, wind, hydro and AD below 5MW): Data and evidence from Parsons Brinckerhoff (PB) (2012) published as part of the government response to Phase 2A and 2B comprehensive review of feed in tariffs[89].
4. Onshore Wind Call for Evidence - Data received in response to DECC's Onshore Wind Call for Evidence and published in June 2013[10]
5. National Grid (NG) Call for Evidence - Data received as part of National Grid's Call for Evidence[11] (2013)
6. PB 2013 - a DECC commissioned report from Parsons Brinckerhoff (2013) on renewable technology costs[12].
7. TNEI 2013 Offshore Wind Generation Cost Variations Review[13]
8. The Crown Estate Offshore wind cost reduction pathways study[14].
9. Offshore Wind Cost Reduction Task Force Report June 2012[15].

Table 1 identifies the data sources used for each technology. A high-level description of the process undertaken and rationale for the data used for renewable technologies is included in Annex 2.

---

[7] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/66516/7328-renewables-obligation-banding-review-for-the-perio.pdf

[8] http://www.decc.gov.uk/assets/decc/11/meeting-energy-demand/renewable-energy/5381-solar-pv-cost-update.pdf.

[9] http://www.decc.gov.uk/assets/decc/Consultations/fits-review/5900-update-of-nonpv-data-for-feed-in-tariff-.pdf

[10] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/205423/onshore_wind_call_for_evidence_response.pdf

[11] Unless referenced specifically, all documentation can be found on the 'Energy generation cost projections' page of the DECC website: https://www.gov.uk/government/organisations/department-of-energy-climate-change/series/energy-generation-cost-projections

[12] Unless referenced specifically, all documentation can be found on the 'Energy generation cost projections' page of the DECC website: https://www.gov.uk/government/organisations/department-of-energy-climate-change/series/energy-generation-cost-projections

[13] Unless referenced specifically, all documentation can be found on the 'Energy generation cost projections' page of the DECC website: https://www.gov.uk/government/organisations/department-of-energy-climate-change/series/energy-generation-cost-projections

[14] http://www.thecrownestate.co.uk/media/305094/Offshore%20wind%20cost%20reduction%20pathways%20study.pdf. This is referred to as the 'Crown Estate Study' throughout this report.

[15] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/66776/5584-offshore-wind-cost-reduction-task-force-report.pdf. This is referred to as the 'Offshore Wind CRTF report' throughout this report.

Table 1: Data Sources for Individual Technologies

Non-Renewables Technologies:	**Data Source**
CCGT with/without CHP	PB 2013
OCGT	PB 2013
Coal Plant with 300MW of CCS	PB 2013
Gas and Coal with CCS	PB 2013
Nuclear	PB 2013
Renewable Technologies:	**Data Source**
Onshore Wind	Onshore Wind Call for Evidence
Offshore Wind	GRBR, Crown Estate Study, Offshore Wind CRTF report
Biomass Conversion	GRBR
Dedicated biomass with/without CHP	GRBR
Cofiring conventional/Cofiring enhanced	GRBR
Co-firing standard CHP	GRBR
Hydropower	GRBR
Wave	NG Call for Evidence
Tidal Stream – shallow	GRBR (load factor updated in line with evidence from the NG Call for Evidence)
Tidal Stream – deep	GRBR
Tidal Range	GRBR
AD power with/without CHP	GRBR
ACT CHP	GRBR
Energy from Waste w/without CHP	GRBR
Landfill gas	GRBR
Sewage gas	GRBR
ACT advanced	GRBR
ACT standard	GRBR
Bioliquids with/without CHP	GRBR
Geothermal with/without CHP	GRBR
Large scale solar PV (>5MW)[16]	Large scale solar PV data
AD 0-5MW	FiTs data
Onshore wind under 5MW	FiTs data
Solar PV under 5MW	FiTs data
Hydro under 5MW	FiTs data
Biomass with CCS	PB 2013

The cost assumptions presented in this report are those used in National Grid's modelling for the draft Delivery Plan, with the exception of OCGT costs. National Grid's modelling used draft

[16] Large scale ground mounted solar PV

PB (2013) OCGT cost assumptions whereas those presented here are the final costs presented in PB (2013). Further details are given in Annex 3.

Further Assumptions

The following assumptions have also been used:

- Fuel and Carbon Prices: DECC's 2013 projected fossil fuel prices and Carbon Price Support[17]
- Technology Specific Hurdle Rates: Where used, technology specific hurdle rates are the same as those used in DECC's Dynamic Dispatch Model. These are presented in Annex 3.

All estimates are in 2012 real prices.

Future Cost Projections

There is significant uncertainty about how the costs of technologies will evolve over time.

In general, estimates of the capital and operating costs of different electricity generating technologies in the future are driven by expectations and assumptions of technology specific learning rates and by global and UK deployment levels.

The data sources referenced above provide detailed information about learning and deployment scenarios used in our analysis. IEA[18] projections are the main source for global deployment and learning rates for most technologies. However, for ACT, marine and renewable technologies under 5MW learning rates are driven by scenarios of technical potential for UK deployment[19]. A further exception is offshore wind where costs follow the cost reduction profiles used in the draft Delivery Plan analysis (July 2013) (please see Annex 2 for further details).

All estimates presented are for established plants - called Nth of a Kind (NOAK), unless stated otherwise. The exceptions are estimates for Carbon Capture and Storage CCS and Nuclear, which are shown on both a First of a Kind ('FOAK') and Nth of a Kind ('NOAK') basis. For these technologies with no commercial experience in the UK, FOAK was defined as the first plant

[17] Please note that the Carbon Price Floor does not apply in Northern Ireland.

[18] Estimates for renewable technologies are based on IEA Bluemap (see ARUP 2011 for details), and non-renewable technologies are IEA Energy Technology Perspectives (2012). Future deployment scenarios are not based on year-on-year data and therefore there is uncertainty about how costs will evolve overtime. This approach is intended to capture trends in cost reduction rather than precise year-on-year changes.

[19] Please see Arup 2011 and PB 2012 for FiTs for more details.

within the UK, not including demonstration projects. For these technologies, FOAK costs assume experience has been gained from international and demonstration projects[2021].

All levelised costs for marine technologies (wave and tidal stream) in this report illustrate the costs of commercial projects commissioning from the early 2020s onwards. Where technology-specific hurdle rates are used in this report, these are the hurdle rates for commercial projects.

Load factors

Levelised costs are sensitive to assumptions on load factor. For non-renewable technologies, with the exception of OCGTs, plants are assumed to operate at baseload with high load factors. OCGTs are assumed to operate as peaking plants (operating at times of higher system stress). The load factors for wind and marine technologies reflect that they operate as intermittent electricity generation technologies. Assumed load factors for key technologies are listed in Annex 3.

Financing and Hurdle Rates

The levelised cost measure does not explicitly include the financing costs attached to new generating stations[22]. In most cases, this report includes estimates using a standard 10% discount rate across all technologies, in line with the 'tradition' used in reports produced by other organisations. These estimates allow estimates to be viewed as neutral in financing and risk terms when comparison is made across technologies.

In practice, financing costs of individual projects will vary depending on a range of factors, including financing type, project developer, conditions in financial markets, maturity of technology, and risk and political factors. We have included some levelised cost estimates using technology specific hurdle rates in the section 'DECC Electricity Market Modelling'. Further details on the technology specific hurdle rates used can be found in Annex 3.

[20] All estimates for Carbon Capture and Storage (CCS) presented in this document are intended to illustrate the cost of CCS for a commercial plant. In practice CCS would have be successfully demonstrated first. We have not included estimates for the costs for initial CCS demonstration projects.

[21] The period in which the cost moves from FOAK to NOAK is entirely dependent on the assumed learning rate and the assumed build rate. For nuclear we have assumed a move to NOAK for plants starting development in 2018 onwards. In practice this may occur later than we have assumed. The movement between FOAK and NOAK for CCS is even more uncertain and as such we have only used FOAK estimates in this report.

[22] While financing costs are included implicitly through the choice of discount rate used to produce the levelised cost this is an approximation.

Changes from 2012 published estimates

There have been several changes in data and assumptions to selected technologies when comparing against previously published estimates[23]. These are summarised below:

- Data: The source data has been updated for the following technologies: CCGTs, all CCS technologies, Nuclear, Onshore Wind > 5MW, Wave, Tidal Stream Shallow[24] and large scale ground-mounted solar PV. Data sources are listed in Table 1.
- Hurdle Rates: where technology specific hurdle rates have been used, these have been updated to match those used in the draft Delivery Plan analysis (July 2013). Further details can be found in Annex 3.
- Fuel Prices: DECC 2013 fossil fuel price projections have been used. Biomass conversion fuel price assumptions have been updated to reflect 100% imports[25].
- Heat Revenues: heat revenues for all CHP technologies have been updated to reflect the latest published fuel and carbon price assumptions.

The following changes have also been made:

- The load factor for **onshore wind > 5MW** has been updated to reflect a UK average load factor of 28% from 1998 to 2011 in line with DECC'S electricity market modelling assumptions. Please note that the capital and operating costs, connection and insurance charges are in line with those published in response to the Onshore Wind Call for Evidence[26].
- Learning profiles have been updated for **offshore wind** to match the cost reduction profiles in the draft Delivery Plan analysis. Please see Annex 3 for more details.
- Load factors for **biomass conversion, sewage gas and landfill** have been updated to match the load factor assumption of a conversion plant in the draft Delivery Plan analysis (July 2013)[27]
- Learning profiles have been updated for **wave** to reflect its stage of development and potential for cost reductions.
- Estimate for **coal-fired power station** now include 300MW of CCS in line with Government policy which states that new coal-fired power stations are required to be constructed with a full CCS chain fitted on at least 300MW (net) of their generating capacity.

---

[23] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/65713/6883-electricity-generation-costs.pdf

[24] Load factor only

[25] This adds £1/MWh to the input fuel price used in the Government Response to the RO Banding Review.

[26] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/205423/onshore_wind_call_for_evidence_response.pdf

[27] A net load factor of 65% was used for biomass conversion, 44% for sewage gas and 57% for landfill. Please note that this is a generic estimate, and load factors by plant are expected to vary.

Please note Annex 3 contains further information about cost data and assumptions for all technologies.

Limitations of 'Levelised Costs'

Levelised Costs are uncertain

Levelised cost estimates are highly sensitive to the underlying data and assumptions including those on capital costs, fuel and carbon costs, operating costs, operating profile, load factor and discount rates. Future levelised cost estimates are significantly driven by assumptions of global and UK deployment and assumed learning rates.

This report captures some of these uncertainties through ranges presented around key estimates. A range of costs is presented for capex and fuel, depending on the estimates. However, not all uncertainties are captured in these ranges and estimates should be viewed in this context. It is often more appropriate to consider a range of costs rather than point estimates.

It should also be noted that levelised costs are generic, rather than site specific.

Levelised Costs are not Strike Prices

The levelised cost estimates in this report do not provide an indication of potential future strike prices for a particular technology or plant under the Feed-in Tariff with Contracts for Difference (CfD) being introduced as part of Electricity Market Reform.

A CfD stabilises revenues for a particular generating station at a fixed price level known as the 'strike price' over a specified term. Generation costs data, summarised here in the form of levelised costs, are one input into setting strike prices. Other inputs may include:

- Revenue assumptions;
- Other costs not included in DECC's definition of levelised cost;
- CfD contract terms including length and risk allocation;
- Financing costs (reflected in the levelised costs calculated at technology-specific hurdle rates but not in those calculated at 10% discount rate); and
- Wider policy considerations.

The generation costs data used here will, in some cases, be different from that used as part of the strike price setting process. This is particularly where project-specific cost discovery processes are undertaken. These reflect a site-specific, highly granular assessment of costs, whereas the estimates here are more high-level and generic.

For all these reasons, the levelised costs presented here may be quite different from the strike prices that are set for CfDs.

Timing

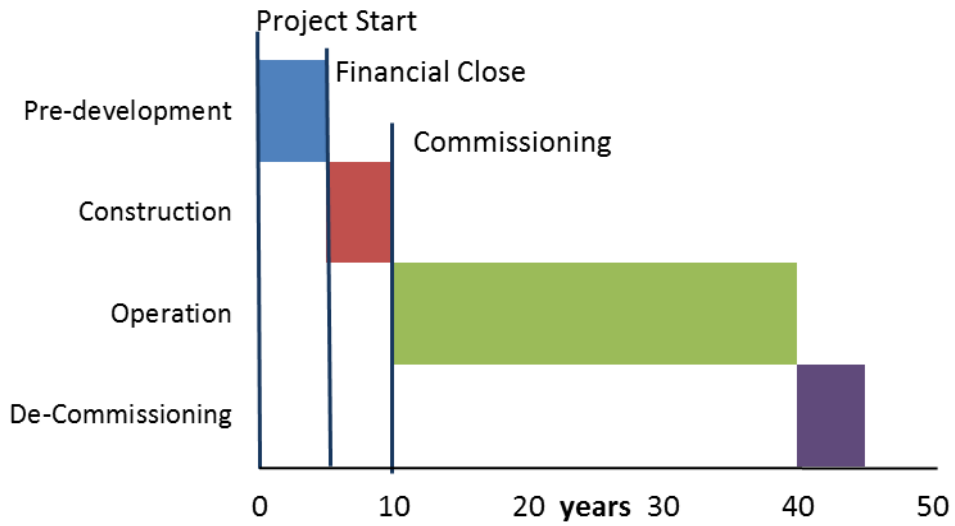
When looking at levelised cost estimates it is important to consider how they have been reported in terms of project timing and what sensitivities (if any) are included. These are discussed in more detail below.

Levelised cost estimates can be reported for different milestones associated with a project including 'Project Start', 'Financial Close' and 'Commissioning'. These are illustrated in Chart 1 below for an illustrative technology which has a 5 year pre-development period and a 5 year construction period.

For instance, if the levelised cost of this technology was £50/MWh for a project starting in 2012, this would be the same as saying £50/MWh for a project reaching financial close in 2017, or £50/MWh for a project commissioning in 2022. This is illustrated in Chart 1 below.

Pre-development and construction timings will vary by technology and therefore estimates reported for 'project start' or 'financial close'[28] for different technologies may not be commissioning in the same year as each other. Central estimates for pre-development and construction timings are presented for key technologies in Annex 3.

Chart 1: Illustrative Timings



Sensitivities

Levelised cost estimates are highly sensitive to the underlying data and assumptions used including those on capital costs, fuel prices, carbon costs, operating costs, load factor and discount rates. As such it is often more appropriate to consider a range of cost estimates rather than point estimates.

[28] Financial close can also be known as the point of main Financial Investment Decision or FID.

In order to illustrate some of these sensitivities, ranges of estimates have been shown. The key sensitivities explored are:

High and Low capital costs (including pre-development)

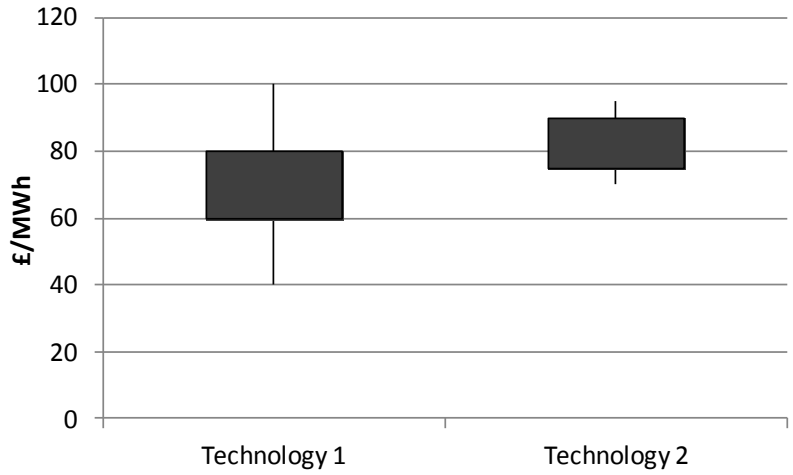
Unless specified, all 'high' and 'low' estimates in this report incorporate 'high' and 'low' capital costs including 'high' and 'low' pre-development costs.

It should also be noted that the ranges across different capital cost estimates for technologies have different interpretations between the renewable and non-renewable technologies. For renewable technologies, the ranges represent variability across potential sites, i.e. the range of levelised costs represents a supply curve of potential projects at different costs within the technology in a given year. For non-renewable technologies, the capital cost range represents uncertainty for any given project.

High and Low fuel and capital costs

For some technologies (e.g CCGT, CCS, biomass and waste technologies), fuel costs are a major driver of the levelised cost. In order to demonstrate this some sensitivities which explore uncertainty over both fuel costs and capex costs are provided. These are shown in charts like Chart 2 below. In these cases the thick blocks represent 'high/low' sensitivities around capex (including pre-development) costs and the thin lines represent 'high/low' sensitivities around fuel prices on top of the uncertainty around capex (including pre-development) costs.

Chart 2: Illustrative Sensitivities



Generation Cost Estimates at a 10% discount rate

This section summarises the analysis of the levelised cost of electricity generation at a 10% discount rate.

Comparing levelised cost estimates across technologies at a 10% discount rate allows estimates to be viewed as neutral in terms of financing and risk. This approach is in line with the 'tradition' used in reports produced by other organisations. As noted above, these estimates do not reflect differentials in financing costs between technologies. Where flexible technologies such as CCGTs operate at lower load factors, their levelised costs will be higher than those presented here.

This section focuses primarily on the main technologies likely to be deployed in the UK over the next decade and a half[29]. A full set of estimates for those renewable and CCS technologies not covered in the main report can be found in Annex 1

Levelised cost estimates for all cases have been calculated using the DECC Levelised Cost Model. The following 'cases' are considered in this section of the report:

Case No.		
1	Projects Starting in 2013	All at 10% discount rate. Technologies are mixture of FOAK and NOAK
2	Projects Starting in 2019	
3	Projects Commissioning in 2014, 2016, 2020, 2025, 2030	

Case 1: Projects starting in 2013, FOAK/ NOAK, 10% discount rate[30]

Case 1 shows the levelised costs for projects starting pre-development in 2013. A 10% discount rate has been applied. Chart 3 shows the breakdown of central cost estimates, while Chart 4 shows the sensitivities of these estimates to capital costs[31], and to capital and fuel costs. As noted above, the range of capital costs for renewable technologies represents site/project variability, whereas the range of capital costs for non-renewable technologies represents uncertainty for any given site/project.

The ranges for renewable technologies generally show a large range of variability across different sites/projects, whilst the ranges for non-renewable technologies show there is a large

[29] Please note for carbon capture and storage we have illustrated three of the types of fossil fuel plant and the three main types of capture process in the main report rather than illustrate which types we expect most deployment to come from.

[30] Please note these estimates should be viewed in the context of the sensitivities and uncertainties highlighted in the text of this report.

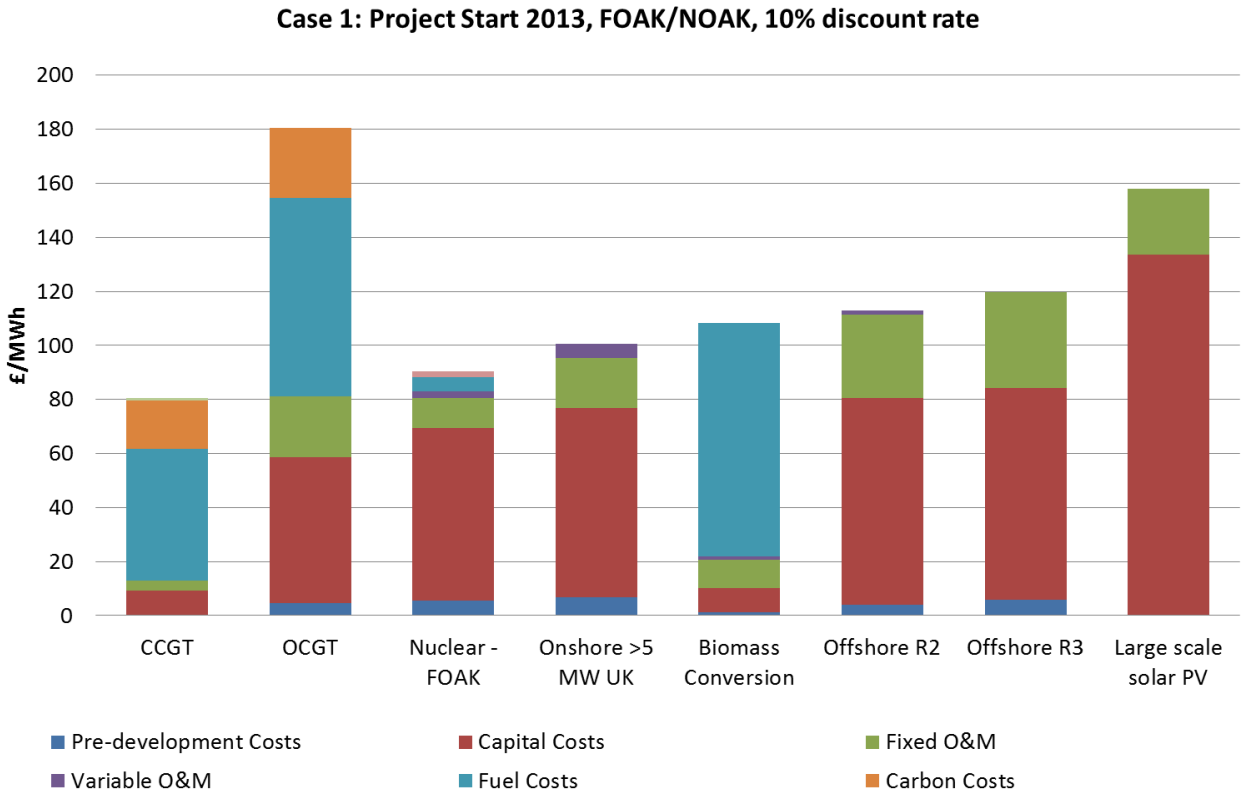
[31] Including pre-development

amount of uncertainty over these costs for any given project, without necessarily illustrating all the uncertainty as discussed in preceding sections.

It should also be noted that all the estimates for non-renewable technologies reflect generic cost data from PB (2013) and do not reflect site-specific considerations which may become apparent through detailed cost discovery process for strike-price setting. The estimates at a 10% discount rate also do not reflect financing costs. Furthermore, as explained above, these levelised costs should not be seen as a guide to potential strike prices.

The figures used in these charts can be found in Tables 2 and 3. The load factor assumptions used to calculate these levelised cost assumptions are summarised in Annex 3[32].

Chart 3: Levelised Cost Estimates for Projects Starting in 2013, 10% discount rate



[32] OCGT levelised costs have been calculated at a low load factor to reflect the fact that it tends to operate as a peaking plant. This low load factor results in a higher levelised cost for OCGT.

Chart 4: Levelised Cost Estimates for Projects Starting in 2013, 10% discount rate, sensitivities[33]

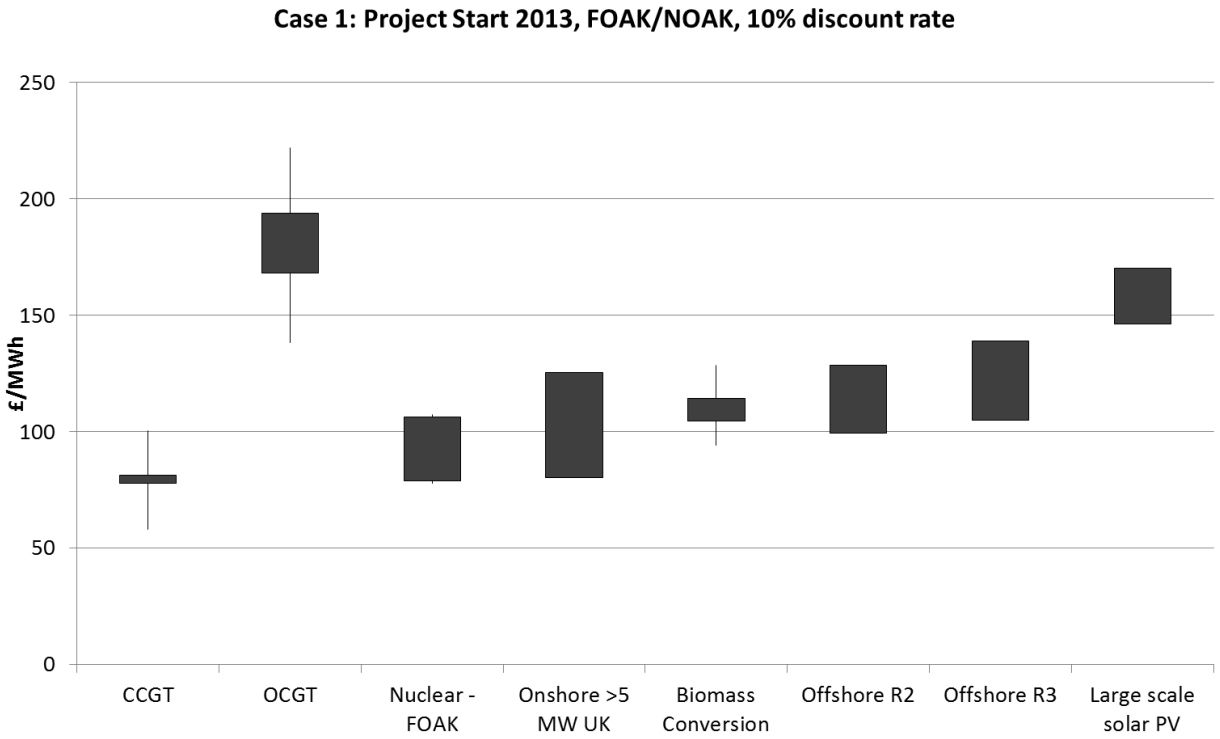


Table 2: Levelised Cost Estimates for Projects Starting in 2013, 10% discount rate, £/MWh

	CCGT	OCGT	Nuclear - FOAK	Onshore >5 MW UK	Biomass Conversion	Offshore R2	Offshore R3	Large scale solar PV
Pre-development Costs	0	5	6	7	1	4	6	0
Capital Costs	9	54	64	70	9	77	78	134
Fixed O&M	4	23	11	18	10	31	36	24
Variable O&M	0	0	3	5	1	1	0	0
Fuel Costs	49	73	5	0	86	0	0	0
Carbon Costs	18	26	0	0	0	0	0	0
CO2 Capture and Storage Costs	0	0	0	0	0	0	0	0
Decommissioning and Waste Fund	0	0	2	0	0	0	0	0
Total Levelised Costs	80	181	90	101	108	113	120	158

[33] See the 'Sensitivities' section above for an explanation of this chart

Table 3: Levelised Cost Estimates for Projects Starting in 2013, 10% discount rate, sensitivities (£/MWh)

	CCGT	OCGT	Nuclear - FOAK	Onshore >5 MW UK	Biomass Conversion	Offshore R2	Offshore R3	Large scale solar PV
Central	80	181	90	101	108	113	120	158
High capex	81	194	106	125	114	129	139	170
High capex, high fuel	100	222	107	n/a	129	n/a	n/a	n/a
Low capex	78	168	79	80	105	100	105	146
Low capex, low fuel	58	138	78	n/a	94	n/a	n/a	n/a

Case 2: Projects starting in 2019, FOAK/ NOAK, 10% discount rate[34]

Case 2 shows the levelised costs for projects starting pre-development in 2019. A 10% discount rate has been applied. Chart 5 shows the breakdown of central cost estimates, while Chart 6 shows the sensitivities of these estimates to capital costs[35], and to capital and fuel costs.

As noted above, the range of capital costs for renewable technologies represents site/project variability, whereas the range of capital costs for non-renewable technologies represents uncertainty for any given site/project.

The ranges for renewable technologies generally show a large range of variability across different sites/projects, whilst the ranges for non-renewable technologies show there is a large amount of uncertainty over these costs for any given project, without necessarily illustrating all the uncertainty as discussed in preceding sections.

It should also be noted that all the estimates for non-renewable technologies reflect generic cost data from PB (2013) and do not reflect site-specific considerations which may become apparent through detailed cost discovery process for strike-price setting. The estimates at a 10% discount rate also do not reflect financing costs. Furthermore, as explained on above, these levelised costs should not be seen as a guide to potential strike prices.

The figures used in these charts can be found in Tables 4 and 5. The load factor assumptions used to calculate these levelised cost assumptions are summarised in Annex 3[36].

[34] Please note these estimates should be viewed in the context of the sensitivities and uncertainties highlighted in the text of this report.

[35] Including pre-development

[36] OCGT levelised costs have been calculated at a low load factor to reflect the fact that it tends to operate as a peaking plant. This low load factor results in a higher levelised cost for OCGT.

Chart 5: Levelised Cost Estimates for Projects Starting in 2019, 10% discount rate

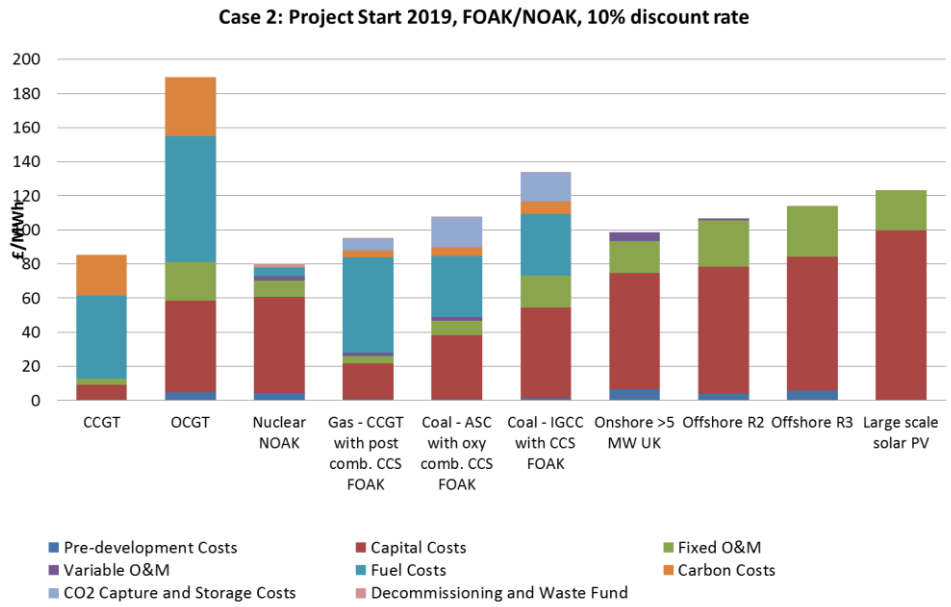
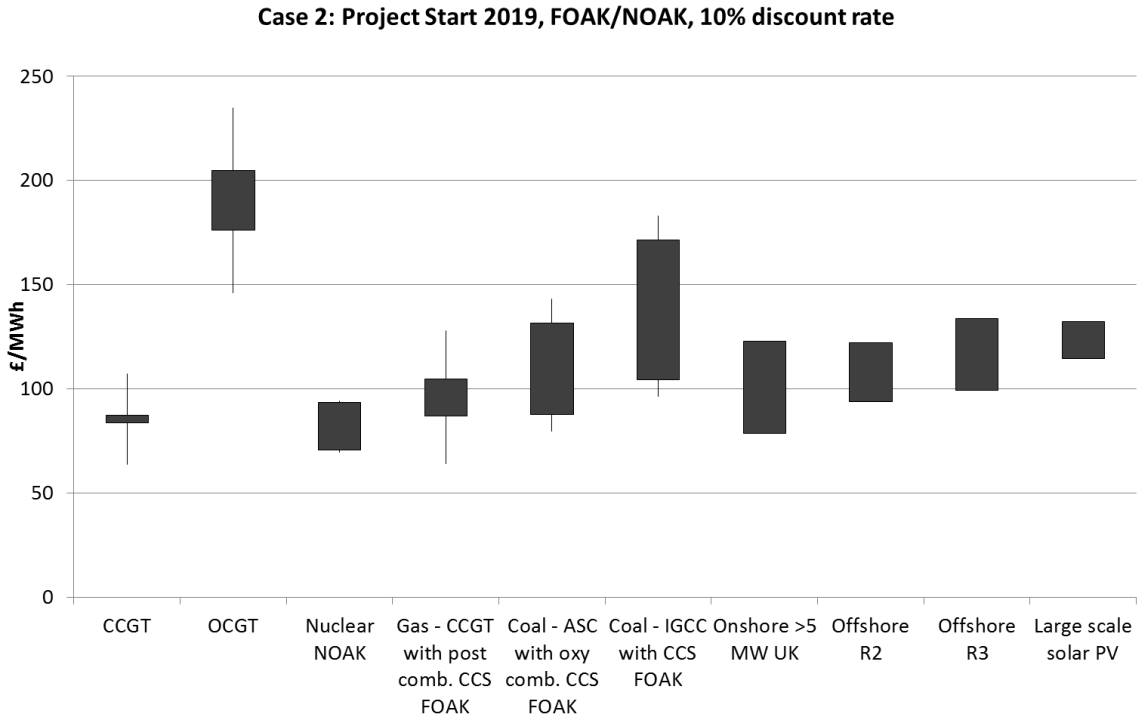


Chart 6: Levelised Cost Estimates for Projects Starting in 2019, 10% discount rate, sensitivities[37]



[37] See 'sensitivities' for explanation of chart

Table 4: Levelised Cost Estimates for Projects Starting in 2019, 10% discount rate, £/MWh

	CCGT	OCGT	Nuclear NOAK	Gas - CCGT with post comb. CCS FOAK	Coal - ASC with oxy comb. CCS FOAK	Coal - IGCC with CCS FOAK	Onshore >5 MW UK	Offshore R2	Offshore R3	Large scale solar PV
Pre-development Costs	0	5	5	1	1	1	7	4	6	0
Capital Costs	9	54	56	21	37	53	68	75	78	100
Fixed O&M	4	23	10	4	8	19	19	27	30	23
Variable O&M	0	0	3	2	2	0	5	1	0	0
Fuel Costs	49	74	5	56	36	36	0	0	0	0
Carbon Costs	24	35	0	4	5	7	0	0	0	0
CO2 Capture and Storage C	0	0	0	7	18	17	0	0	0	0
Decommissioning and Wast	0	0	2	0	0	0	0	0	0	0
Total Levelised Costs	85	190	80	95	107	134	99	107	114	123

Table 5: Levelised Cost Estimates for Projects Starting in 2019, 10% discount rate, sensitivities (£/MWh)

	CCGT	OCGT	Nuclear NOAK	Gas - CCGT with post comb. CCS FOAK	Coal - ASC with oxy comb. CCS FOAK	Coal - IGCC with CCS FOAK	Onshore >5 MW UK	Offshore R2	Offshore R3	Large scale solar PV
Central	85	190	80	95	107	134	99	107	114	123
High capex	87	205	93	105	132	172	123	122	134	132
High capex, high fuel	107	235	94	128	143	183	n/a	n/a	n/a	n/a
Low capex	84	176	71	87	88	104	79	94	99	115
Low capex, low fuel	64	146	70	64	80	96	n/a	n/a	n/a	n/a

Case 3: Commissioning in 2014, 2016, 2020, 2025, 2030, FOAK/ NOAK, 10% discount rate[38]

In order to allow the comparison of the costs across different energy technologies commissioning, or starting operation, in the same year Case 3 illustrates the levelised costs for projects commissioning in 2014, 2016, 2020, 2025 and 2030. A 10% discount rate has been applied. 'High' and 'Low' estimates represent sensitivities around capex costs only.

As noted above, the range of capital costs for renewable technologies represents site/project variability, whereas the range of capital costs for non-renewable technologies represents uncertainty for any given site/project. The estimates at a 10% discount rate also do not reflect

[38] Please note these estimates should be viewed in the context of the sensitivities and uncertainties highlighted in the text of this report.

financing costs. Furthermore, as explained above, these levelised costs should not be seen as a guide to potential strike prices.

The ranges for renewable technologies generally show a large range of variability across different sites/projects, whilst the ranges for non-renewable technologies show there is a large amount of uncertainty over these costs for any given project, without necessarily illustrating all the uncertainty as discussed in preceding sections.

It should also be noted that all the estimates for non-renewable technologies reflect generic cost data from PB (2013) and do not reflect site-specific considerations which may become apparent through detailed cost discovery process for strike-price setting.

Table 6: Levelised Cost Estimates for Projects Commissioning in 2014, 2016, 2020, 2025 and 2030, 10% discount rate, £/MWh, highs and lows reflect high and low capital cost estimates

		2014	2016	2020	2025	2030
CCGT	High	76	79	83	88	90
	Central	75	77	82	86	88
	Low	73	76	80	84	86
OCGT	High	187	192	200	208	212
	Central	175	179	185	192	195
	Low	163	167	172	178	180
Nuclear FOAK/NOAK	High			108	106	94
	Central			93	90	80
	Low			83	78	70
CCGT with post comb. CCS - FOAK	High				105	105
	Central				95	95
	Low				88	87
Coal - ASC with oxy comb. CCS - FOAK	High				133	132
	Central				109	108
	Low				89	88
Coal - IGCC with CCS - FOAK	High				173	172
	Central				135	133
	Low				106	104
Onshore >5MW UK	High	129	128	123	121	118
	Central	104	103	100	99	97
	Low	83	82	84	84	84
Onshore >5MW E&W	High	140	138	133	130	127
	Central	112	111	108	106	104
	Low	89	88	91	91	91
Biomass conversion	High	115	114			
	Central	108	108			
	Low	105	105			
Offshore Round 2	High	166	153	129	124	120
	Central	146	135	114	109	105
	Low	129	119	100	96	92
Offshore Round 3	High	184	171	142	136	129
	Central	159	148	123	116	111
	Low	141	131	108	102	96
Large scale solar PV	High	170	154	132	112	96
	Central	158	144	123	105	90
	Low	146	133	115	98	84

DECC Electricity Market Modelling, Levelised Costs and Uncertainty

The estimates outlined in the above sections are intended to provide a high-level view on the costs of different generating technologies.

In practice, DECC's electricity market modelling, including modelling for the Updated Energy & Emissions Projections and DECC's Dynamic Dispatch Model (DDM), does not use 'levelised cost estimates' per se. Instead it models private investment decisions, at the financial close for a project, using the same Capex and Opex assumptions incorporated in the levelised cost estimates reported above; assumptions on investors' foresight over fossil fuel, carbon and wholesale electricity prices; and the financial incentives from policies e.g. the RO or CfDs.

In order to model the investment decision, the internal rate of return of a potential plant is compared to a technology specific hurdle rate. The technology specific hurdle rates reflect different financing costs for different technologies and the estimated impact of policy interventions (e.g. Electricity Market Reform) on these costs.

This section shows illustrative levelised cost estimates using technology-specific 'hurdle' rates[39], in line with those used in DECC electricity market modelling[40].

These estimates at technology-specific hurdle rates reflect differentials in financing costs between technologies. Where flexible technologies such as CCGT operate at lower load factors, their levelised costs will be higher than those presented here.

[39] Please note that hurdle rates are themselves uncertain and likely to vary between projects and financing structures/providers.

[40] Table showing the hurdle rates used can be found in Annex 2. Please note that while we have aligned this methodology as far as possible with the Dynamic Dispatch Model (DDM) modelling there are some differences including that heat revenues for CHP technologies are modelled endogenously in the DDM but we have applied an exogenous profile..

Case 4: Commissioning in 2014, 2016, 2020, 2025, 2030, FOAK/ NOAK, technology specific hurdle rates[41]

As noted above, the range of capital costs for renewable technologies represents site/project variability, whereas the range of capital costs for non-renewable technologies represents uncertainty for any given site/project.

The ranges for renewable technologies generally show a large range of variability across different sites/projects, whilst the ranges for non-renewable technologies show there is a large amount of uncertainty over these costs for any given project, without necessarily illustrating all the uncertainty as discussed in preceding sections.

Furthermore, as explained above, these levelised costs should not be seen as a guide to potential strike prices. It should be noted that all the estimates for non-renewable technologies reflect generic cost data from PB (2013) and do not reflect site-specific considerations which may become apparent through detailed cost discovery process for strike-price setting.

Table 7: Levelised Cost Estimates for Projects Commissioning in 2014, 2016, 2020, 2025 and 2030, technology specific hurdle rates, £/MWh, highs and lows reflect high and low capital cost estimates

		2014	2016	2020	2025	2030
CCGT	High	75	78	82	86	88
	Central	74	77	81	84	86
	Low	73	75	79	83	85
OCGT	High	175	179	186	194	197
	Central	165	169	175	181	184
	Low	155	159	164	170	172
Nuclear FOAK/NOAK	High			102	101	89
	Central			89	86	77
	Low			79	75	67
CCGT with post comb. CCS - FOAK	High				118	118
	Central				105	104
	Low				94	93
Coal - ASC with oxy comb. CCS - FOAK	High				159	157
	Central				125	123
	Low				97	95
Coal - IGCC with CCS - FOAK	High				209	206
	Central				156	154
	Low				116	114

[41] Please note these estimates should be viewed in the context of the sensitivities and uncertainties highlighted in the text of this report.

		2014	2016	2020	2025	2030
Onshore >5MW UK	High	115	110	108	106	104
	Central	93	90	88	86	85
	Low	75	72	71	70	69
Onshore >5MW E&W	High	124	119	116	114	112
	Central	100	96	94	93	91
	Low	81	78	76	75	74
Biomass conversion	High	117	115			
	Central	110	109			
	Low	106	105			
Offshore Round 2	High	168	149	126	121	117
	Central	148	132	111	106	102
	Low	131	116	98	93	90
Offshore Round 3	High	208	186	154	148	141
	Central	179	160	133	126	120
	Low	157	141	116	110	104
Large scale solar PV	High	131	116	100	86	74
	Central	122	108	94	80	70
	Low	114	101	87	75	66

Further key uncertainties accounted for in DECC's electricity market modelling

Load factors

For non-renewable technologies, with the exception of OCGT, plants are assumed to operate at baseload with high load factors. OCGT is assumed to operate as a peaking plant. The load factors for some renewable technologies reflect that they operate as intermittent electricity generation technologies. Load factors for key technologies are listed in Annex 3

It should be noted that in DECC's electricity market modelling, it is not only OCGT but also other flexible technologies such as CCGT which may operate at lower load factors than baseload. Where this is the case, the levelised costs will be higher than those presented above.

Carbon price

The carbon price assumed in the levelised costs presented is at the level of the Carbon Price Floor, which is assumed to stay flat in real terms beyond 2030 at £76/t in 2012 prices.

An alternative carbon price scenario, considered in DECC's electricity market modelling, assumes that up to 2030 the Carbon Price Floor gives the level of the carbon price, but that after 2030 a global carbon market emerges under the auspices of a global deal on climate change action, leading to a rising global traded carbon market price after 2030 as cheaper

abatement options are used up.[42] Use of this second carbon price scenario would increase levelised costs for fossil fuel technologies.

Annex 1: Additional Estimates for Renewable and CCS Technologies

Case 1: Projects starting in 2013, NOAK, 10% discount rate[43]

Table 8: Central Levelised Cost Estimates for Projects Starting in 2013, 10% discount rate, £/MWh

	CCGT	OCGT	Nuclear - FOAK	Onshore >5 MW UK	Biomass Conversion	Offshore R2	Offshore R3	Large scale solar PV
Pre-development Costs	0	5	6	7	1	4	6	0
Capital Costs	9	54	64	70	9	77	78	134
Fixed O&M	4	23	11	18	10	31	36	24
Variable O&M	0	0	3	5	1	1	0	0
Fuel Costs	49	73	5	0	86	0	0	0
Carbon Costs	18	26	0	0	0	0	0	0
CO2 Capture and Storage Costs	0	0	0	0	0	0	0	0
Decommissioning and Waste Fund	0	0	2	0	0	0	0	0
Total Levelised Costs	80	181	90	101	108	113	120	158

	EfW CHP	EfW	Geo-thermal CHP	Landfill	Sewage Gas	Geo-thermal	AD CHP	Cofiring Conventional	AD
Pre-development Costs	0	0	3	4	0	3	3	0	3
Capital Costs	95	75	71	57	105	66	66	5	63
Fixed O&M	36	30	14	13	28	14	58	5	50
Variable O&M	30	24	10	9	0	11	21	1	31
Fuel Costs	-121	-100	0	0	0	0	-41	84	-41
Carbon Costs	0	0	0	0	0	0	0	0	0
CO2 Capture and Storage Costs	0	0	0	0	0	0	0	0	0
Decommissioning and Waste Fund	0	0	0	0	0	0	0	0	0
Heat Revenues	-13	0	-52	0	0	0	-14	0	0
Total Levelised Costs	26	29	47	84	134	93	94	95	106

[42] The carbon price values for this scenario are sourced from modelling by DECC using the GLOCAF model. They are also used as the Government's carbon price values for policy appraisal purposes. See the appraisal guidance for further details at: https://www.gov.uk/government/policies/using-evidence-and-analysis-to-inform-energy-and-climate-change-policies/supporting-pages/policy-appraisal

[43] Please note these estimates should be viewed in the context of the sensitivities and uncertainties highlighted in the text of this report

	Dedicated biomass >50MW	Dedicated biomass 5-50MW	Hydropower 5-16MW	ACT standard	ACT CHP	ACT advanced	Biomass CHP	Bioliquids CHP	Bioliquids
Pre-development Costs	1	2	2	7	2	8	0	5	5
Capital Costs	37	52	112	83	100	103	63	21	20
Fixed O&M	14	16	14	58	66	58	24	22	22
Variable O&M	4	5	6	24	24	13	9	6	6
Fuel Costs	65	41	0	-27	-31	-23	119	270	270
Carbon Costs	0	0	0	0	0	0	0	0	0
CO2 Capture and Storage Costs	0	0	0	0	0	0	0	0	0
Decommissioning and Waste Fund	0	0	0	0	0	0	0	0	0
Heat Revenues	0	0	0	0	-15	0	-33	-14	0
Total Levelised Costs	122	116	134	144	145	158	182	310	323

	Co-firing Standard CHP	Hydro large storage	Solar<4kW	Onshore <15kW	Onshore 1MW<5MW	AD < 250kW	AD > 500kW	Hydropower <15kW	Hydropower 100kW-1000kW
Pre-development Costs	0	2	0	0	0	0	0	0	0
Capital Costs	62	92	253	414	107	134	75	341	162
Fixed O&M	32	8	28	49	14	176	102	36	34
Variable O&M	2	6	0	0	0	0	0	0	0
Fuel Costs	63	0	0	0	0	0	-54	0	0
Carbon Costs	0	0	0	0	0	0	0	0	0
CO2 Capture and Storage Costs	0	0	0	0	0	0	0	0	0
Decommissioning and Waste Fund	0	0	0	0	0	0	0	0	0
Heat Revenues	-52	0	0	0	0	0	0	0	0
Total Levelised Costs	108	108	282	463	121	310	123	377	196

Table 9: Levelised Cost Estimates for Projects Starting in 2013, 10% discount rate, £/MWh, highs and lows reflect high and low capital and fuel cost estimates

	CCGT	OCGT	Nuclear - FOAK	Onshore >5 MW UK	Biomass Conversion	Offshore R2	Offshore R3	Large scale solar PV
Central	80	181	90	101	108	113	120	158
High capex	81	194	106	125	114	129	139	170
High capex, high fuel	100	222	107	n/a	129	n/a	n/a	n/a
Low capex	78	168	79	80	105	100	105	146
Low capex, low fuel	58	138	78	n/a	94	n/a	n/a	n/a

	EfW CHP	EfW	Geothermal CHP	Landfill	Sewage Gas	Geo-thermal	AD CHP	Cofiring Conventional	AD
Central	26	29	47	84	134	93	94	95	106
High capex	37	34	79	124	201	125	149	96	165
High capex, high fuel	56	48	n/a	n/a	n/a	n/a	179	110	198
Low capex	15	23	10	52	95	58	54	91	68
Low capex, low fuel	-3	9	n/a	n/a	n/a	n/a	-37	81	-32

	Dedicated biomass >50MW	Dedicated biomass 5-50MW	Hydropower 5-16MW	ACT standard	ACT CHP	ACT advanced	Biomass CHP	Bioliquids CHP	Bioliquids
Central	122	116	134	144	145	158	182	310	323
High capex	154	138	149	223	226	171	200	364	375
High capex, high fuel	164	160	n/a	243	250	188	218	379	390
Low capex	115	100	80	71	61	128	163	297	310
Low capex, low fuel	106	81	n/a	57	45	116	146	211	224

	Co-firing Standard CHP	Hydro large storage	Solar <4kW	Onshore <15kW	Onshore 1MW<5MW	AD < 250kW	AD > 500kW	Hydropower <15kW	Hydropower 100kW-1000kW
Central	108	108	282	463	121	310	123	377	196
High capex	n/a	n/a	381	507	138	360	151	813	397
High capex, high fuel	n/a	n/a	n/a	n/a	n/a	n/a	183	n/a	n/a
Low capex	n/a	n/a	205	429	99	265	98	187	106
Low capex, low fuel	n/a	n/a	n/a	n/a	n/a	n/a	2	n/a	n/a

Case 2: Projects starting in 2019, NOAK, 10% discount rate[44]

Table 10: Central Levelised Cost Estimates for Projects Starting in 2019, 10% discount rate, £/MWh

	CCGT	OCGT	Nuclear NOAK	Gas - CCGT with post comb. CCS FOAK	Coal - ASC with oxy comb. CCS FOAK	Coal - IGCC with CCS FOAK	Onshore >5 MW UK	Offshore R2	Offshore R3	Large scale solar PV
Pre-development Costs	0	5	5	1	1	1	7	4	6	0
Capital Costs	9	54	56	21	37	53	68	75	78	100
Fixed O&M	4	23	10	4	8	19	19	27	30	23
Variable O&M	0	0	3	2	2	0	5	1	0	0
Fuel Costs	49	74	5	56	36	36	0	0	0	0
Carbon Costs	24	35	0	4	5	7	0	0	0	0
CO2 Capture and Storage C	0	0	0	7	18	17	0	0	0	0
Decommissioning and Was	0	0	2	0	0	0	0	0	0	0
Total Levelised Costs	85	190	80	95	107	134	99	107	114	123

	Gas - CCGT retro post comb. CCS FOAK	Gas - CCGT with pre comb. CCS FOAK	CCGT with oxy comb. CCS FOAK	ASC FGD with 300MW CCS FOAK	ASC with post comb. CCS FOAK	Coal - ASC with ammonia FOAK	ASC ret post comb. CCS FOAK	Coal - IGCC with 300MW CCS FOAK	Coal - IGCC with retro CCS FOAK	Biomass CCS FOAK
Pre-development Costs	1	1	1	1	1	1	1	1	1	0
Capital Costs	15	24	24	31	44	42	27	49	27	63
Fixed O&M	4	5	13	7	10	10	10	16	19	12
Variable O&M	2	1	1	1	2	0	2	0	0	4
Fuel Costs	56	69	71	29	36	40	37	32	38	89
Carbon Costs	4	4	3	47	8	10	8	42	10	0
CO2 Capture and Storage C	7	9	9	3	17	18	17	6	18	0
Decommissioning and Was	0	0	0	0	0	0	0	0	0	0
Total Levelised Costs	88	113	122	119	118	121	102	146	112	168

[44] Please note these estimates should be viewed in the context of the sensitivities and uncertainties highlighted in the text of this report

	EfW CHP	EfW	Geo-thermal CHP	Landfill	Sewage Gas	Geothermal	AD CHP	Cofiring con-ventional	AD
Pre-development Costs	0	0	3	4	0	3	3	0	3
Capital Costs	93	73	70	57	102	64	63	5	60
Fixed O&M	36	30	14	14	28	14	59	5	50
Variable O&M	30	24	10	9	0	11	21	1	31
Fuel Costs	-121	-100	0	0	0	0	0	84	0
Carbon Costs	0	0	0	0	0	0	0	0	0
CO2 Capture and Storage C	0	0	0	0	0	0	0	0	0
Decommissioning and Was	0	0	0	0	0	0	0	0	0
Heat Revenues	-13	0	-53	0	0	0	-14	0	0
Total Levelised Costs	25	28	45	83	130	92	132	94	145

	Dedicated biomass >50MW	Dedicated biomass 5-50MW	Hydro-power 5-16MW	ACT standard	ACT CHP	ACT advanced	Biomass CHP	Bioliquids CHP	Bioliquids
Pre-development Costs	1	2	2	7	2	8	0	5	5
Capital Costs	37	51	123	80	96	100	62	21	20
Fixed O&M	14	16	14	54	63	54	23	21	21
Variable O&M	4	5	6	22	22	12	9	5	5
Fuel Costs	65	41	0	-24	-28	-21	119	263	263
Carbon Costs	0	0	0	0	0	0	0	0	0
CO2 Capture and Storage C	0	0	0	0	0	0	0	0	0
Decommissioning and Was	0	0	0	0	0	0	0	0	0
Heat Revenues	0	0	0	0	-15	0	-33	-14	0
Total Levelised Costs	121	115	146	139	140	153	180	302	315

	Co-firing Standard CHP	Hydro_LargeSTORE	Solar<4kW	Onshore <15kW	Onshore 1MW<5MW	AD < 250kW	AD > 500kW	Hydropower <15kW	Hydropower 100kW-1000kW
Pre-development Costs	0	2	0	0	0	0	0	0	0
Capital Costs	62	104	197	414	107	134	75	341	162
Fixed O&M	32	9	28	49	13	176	102	36	34
Variable O&M	2	6	0	0	0	0	0	0	0
Fuel Costs	63	0	0	0	0	0	0	0	0
Carbon Costs	0	0	0	0	0	0	0	0	0
CO2 Capture and Storage C	0	0	0	0	0	0	0	0	0
Decommissioning and Was	0	0	0	0	0	0	0	0	0
Heat Revenues	-53	0	0	0	0	0	0	0	0
Total Levelised Costs	107	120	224	463	120	310	177	377	196

Table 11: Levelised Cost Estimates for Projects Starting in 2019, 10% discount rate, highs and lows reflect high and low capital cost estimates, £/MWh

	CCGT	OCGT	Nuclear NOAK	Gas - CCGT with post comb. CCS FOAK	Coal - ASC with oxy comb. CCS FOAK	Coal - IGCC with CCS FOAK	Onshore >5 MW UK	Offshore R2	Offshore R3	Large scale solar PV
Central	85	190	80	95	107	134	99	107	114	123
High capex	87	205	93	105	132	172	123	122	134	132
High capex, high fuel	107	235	94	128	143	183	n/a	n/a	n/a	n/a
Low capex	84	176	71	87	88	104	79	94	99	115
Low capex, low fuel	64	146	70	64	80	96	n/a	n/a	n/a	n/a

	Gas - CCGT retro post comb. CCS FOAK	Gas - CCGT with pre comb. CCS FOAK	Gas - CCGT with oxy comb. CCS FOAK	Coal - ASC FGD with 300MW CCS FOAK	Coal - ASC with post comb. CCS FOAK	Coal - ASC with ammonia FOAK	Coal - ASC ret post comb. CCS FOAK	Coal - IGCC with 300MW CCS FOAK	Coal - IGCC with retro CCS FOAK	Biomass CCS FOAK
Central	88	113	122	119	118	121	102	146	112	168
High capex	95	127	139	125	137	142	114	181	130	206
High capex, high fuel	118	155	168	134	149	155	125	191	142	219
Low capex	83	102	109	115	104	106	93	119	97	157
Low capex, low fuel	60	74	79	108	96	97	85	112	89	144

	EfW CHP	EfW	Geothermal CHP	Landfill	Sewage Gas	Geo-thermal	AD CHP	Cofiring Conventional	AD
Central	25	28	45	83	130	92	132	94	145
High capex	36	32	76	123	195	122	185	96	201
High capex, high fuel	54	47	n/a	n/a	n/a	n/a	215	110	235
Low capex	14	23	8	52	93	58	94	91	108
Low capex, low fuel	-4	8	n/a	n/a	n/a	n/a	3	81	8

	Dedicated biomass >50MW	Dedicated biomass 5-50MW	Hydro-power 5-16MW	ACT standard	ACT CHP	ACT advanced	Biomass CHP	Bioliquids CHP	Bioliquids
Central	121	115	146	139	140	153	180	302	315
High capex	153	137	161	216	218	166	198	356	367
High capex, high fuel	162	158	n/a	237	242	183	216	372	383
Low capex	114	99	87	69	59	124	162	289	303
Low capex, low fuel	105	80	n/a	55	43	112	144	210	224

	Co-firing Standard CHP	Hydro large storage	Solar <4kW	Onshore <15kW	Onshore 1MW<5MW	AD < 250kW	AD > 500kW	Hydropower <15kW	Hydropower 100kW-1000kW
Central	107	120	224	463	120	310	177	377	196
High capex	n/a	n/a	354	535	145	371	212	860	419
High capex, high fuel	n/a	n/a	n/a	n/a	n/a	n/a	244	n/a	n/a
Low capex	n/a	n/a	160	424	98	263	151	185	105
Low capex, low fuel	n/a	n/a	n/a	n/a	n/a	n/a	55	n/a	n/a

Case 3: Commissioning in 2014, 2016, 2020, 2025, 2030, NOAK, 10% discount rate[45]

Table 12: Levelised Cost Estimates for Projects Commissioning in 2014, 2016, 2020, 2025, 2030, 10% discount rate, £/MWh, highs and lows reflect high and low capital cost estimates

		2014	2016	2020	2025	2030
CCGT	High	76	79	83	88	90
	Central	75	77	82	86	88
	Low	73	76	80	84	86
CCGT CHP	High	83	83	90	96	99
	Central	81	81	87	93	96
	Low	79	79	85	91	94
OCGT	High	187	192	200	208	212
	Central	175	179	185	192	195
	Low	163	167	172	178	180
Nuclear - FOAK/NOAK	High			108	106	94
	Central			93	90	80
	Low			83	78	70
CCGT with post comb. CCS - FOAK	High				105	105
	Central				95	95
	Low				88	87
CCGT retro post comb. CCS - FOAK	High				95	95
	Central				89	88
	Low				83	83
CCGT with pre comb. CCS - FOAK	High				127	127
	Central				113	113
	Low				102	102
CCGT with oxy comb. CCS - FOAK	High				139	139
	Central				123	122
	Low				110	109

[45] Please note these estimates should be viewed in the context of the sensitivities and uncertainties highlighted in the text of this report

		2014	2016	2020	2025	2030
Coal - ASC FGD with 300MW CCS - FOAK	High				121	125
	Central				116	119
	Low				112	115
Coal - ASC with post comb. CCS - FOAK	High				138	137
	Central				120	118
	Low				105	104
Coal ASC with ammonia - FOAK	High				145	142
	Central				124	121
	Low				108	106
Coal - ASC ret post comb. CCS - FOAK	High				115	113
	Central				103	102
	Low				94	92
Coal - ASC with oxy comb. CCS - FOAK	High				133	132
	Central				109	108
	Low				89	88
Coal - IGCC with 300MW CCS - FOAK	High				177	181
	Central				143	146
	Low				117	119
Coal - IGCC with CCS - FOAK	High				173	172
	Central				135	133
	Low				106	104
Coal - IGCC with retro CCS - FOAK	High				139	139
	Central				123	122
	Low				110	109
Biomass with CCS	High				206	206
	Central				168	168
	Low				157	157
Dedicated biomass >50MW	High	157	156	153	152	151
	Central	123	123	122	121	120
	Low	117	116	116	116	116
Dedicated biomass 5-50MW	High	141	140	137	136	135
	Central	118	118	116	115	115
	Low	102	101	101	101	101
Onshore >5MW E&W	High	140	138	133	130	127
	Central	112	111	108	106	104
	Low	89	88	91	91	91
Onshore >5MW UK	High	129	128	123	121	118
	Central	104	103	100	99	97
	Low	83	82	84	84	84
Offshore Round 2	High	166	153	129	124	120
	Central	146	135	114	109	105
	Low	129	119	100	96	92
Offshore Round 3	High	184	171	142	136	129
	Central	159	148	123	116	111
	Low	141	131	108	102	96

		2014	2016	2020	2025	2030
Biomass conversion	High	115	114			
	Central	108	108			
	Low	105	105			
Large scale solar PV	High	170	154	132	112	96
	Central	158	144	123	105	90
	Low	146	133	115	98	84
EfW CHP	High	40	38	37	36	35
	Central	28	27	26	25	25
	Low	17	16	15	14	14
EfW	High	35	34	33	32	32
	Central	30	29	28	28	27
	Low	25	24	23	23	22
Geothermal CHP	High	109	93	79	76	73
	Central	69	57	47	45	43
	Low	21	15	9	8	7
Landfill	High	125	124	123	123	123
	Central	84	84	84	83	83
	Low	52	52	52	52	52
Sewage gas	High	203	201	196	194	192
	Central	135	134	131	130	128
	Low	96	95	93	92	92
Geothermal	High	150	137	124	122	120
	Central	111	102	93	92	90
	Low	67	63	58	58	57
AD CHP	High	135	161	186	184	183
	Central	80	106	132	131	131
	Low	40	66	94	94	93
Cofiring conventional	High	97	96	96	96	96
	Central	95	95	94	94	94
	Low	91	91	91	91	91
AD	High	151	177	202	200	199
	Central	92	118	145	144	144
	Low	54	81	108	108	108
Cofiring standard CHP	Central	108	107	107	107	107
Hydro large storage	Central	106	110	117	122	122
Hydropower 5-16MW	High	142	146	156	161	162
	Central	127	132	141	146	146
	Low	77	79	84	87	87
ACT standard	High	228	225	218	214	209
	Central	147	145	141	138	133
	Low	73	72	70	68	64
ACT CHP	High	233	228	221	216	210
	Central	149	146	141	138	133
	Low	63	62	60	58	54

		2014	2016	2020	2025	2030
ACT advanced	High	175	172	168	164	160
	Central	162	159	155	152	147
	Low	131	129	125	122	118
Biomass CHP	High	205	203	200	198	197
	Central	186	184	182	180	179
	Low	167	166	163	162	161
Bioliquids	High	378	373	367	366	365
	Central	325	321	316	314	314
	Low	313	308	303	302	301
Bioliquids CHP	High	367	362	357	355	353
	Central	312	308	303	301	299
	Low	299	295	290	288	287
Wave	High				259	201
	Central				246	191
	Low				215	167
Tidal stream shallow	High				207	185
	Central				190	171
	Low				155	140
Tidal stream deep	High				165	144
	Central				148	129
	Low				131	115
Tidal range	High				283	283
	Central				230	230
	Low				173	173
Solar<4kW	High	381	373	354	330	310
	Central	282	258	224	198	181
	Low	205	183	160	144	134
Onshore <15kW	High	507	517	535	560	586
	Central	463	463	463	463	463
	Low	429	429	424	414	405
Onshore 1MW<5MW	High	138	141	145	152	159
	Central	121	121	120	120	120
	Low	99	99	98	95	93
AD < 250kW	High	360	364	371	381	392
	Central	310	310	310	310	310
	Low	265	265	263	261	259
AD > 500kW	High	151	180	212	218	223
	Central	123	150	177	177	177
	Low	98	125	151	150	149
Hydropower <15kW	High	813	828	860	902	947
	Central	377	377	377	377	377
	Low	187	187	185	181	177
Hydropower 100kW-1000kW	High	397	404	419	439	459
	Central	196	196	196	196	196
	Low	106	106	105	103	101

		2014	2016	2020	2025	2030
Dedicated biomass >50MW(ecrops)	High	172	171	171	170	168
	Central	139	139	139	138	137
	Low	133	132	132	131	131
Dedicated biomass 5-50MW(ecrop)	High	194	193	193	192	191
	Central	172	171	171	170	170
	Low	155	155	155	155	154

Case 4: Commissioning in 2014, 2016, 2020, 2025, 2030, NOAK, tech specific hurdle rates[46]

Table 13: Levelised Cost Estimates for Projects Commissioning in 2014, 2016, 2020, 2025, 2030, technology specific hurdle rate, £/MWh, highs and lows reflect high and low capital cost estimates

		2014	2016	2020	2025	2030
CCGT	High	75	78	82	86	88
	Central	74	77	81	84	86
	Low	73	75	79	83	85
CCGT CHP	High	85	85	91	97	100
	Central	83	83	89	95	97
	Low	82	82	88	93	96
OCGT	High	175	179	186	194	197
	Central	165	169	175	181	184
	Low	155	159	164	170	172
Nuclear - FOAK/NOAK	High			102	101	89
	Central			89	86	77
	Low			79	75	67
CCGT with post comb. CCS - FOAK	High				118	118
	Central				105	104
	Low				94	93
CCGT retro post comb. CCS - FOAK	High				103	102
	Central				94	93
	Low				87	86
CCGT with pre comb. CCS - FOAK	High				143	143
	Central				124	123
	Low				109	107
CCGT with oxy comb. CCS - FOAK	High				158	156
	Central				134	133
	Low				115	114

[46] Please note these estimates should be viewed in the context of the sensitivities and uncertainties highlighted in the text of this report

		2014	2016	2020	2025	2030
Coal - ASC FGD with 300MW CCS - FOAK	High				134	139
	Central				127	131
	Low				122	125
Coal - ASC with post comb. CCS - FOAK	High				162	161
	Central				137	135
	Low				117	115
Coal ASC with ammonia - FOAK	High				170	165
	Central				141	137
	Low				120	116
Coal - ASC ret post comb. CCS - FOAK	High				126	124
	Central				111	109
	Low				99	97
Coal - ASC with oxy comb. CCS - FOAK	High				159	157
	Central				125	123
	Low				97	95
Coal - IGCC with 300MW CCS - FOAK	High				207	213
	Central				161	165
	Low				125	128
Coal - IGCC with CCS - FOAK	High				209	206
	Central				156	154
	Low				116	114
Coal - IGCC with retro CCS - FOAK	High				139	139
	Central				123	122
	Low				110	109
Biomass with CCS	High				239	239
	Central				188	188
	Low				174	174
Dedicated biomass >50MW	High	173	172	170	168	167
	Central	132	132	130	129	129
	Low	124	123	122	121	121
Dedicated biomass 5-50MW	High	157	156	154	153	152
	Central	130	129	127	127	126
	Low	110	109	108	107	106
Onshore >5MW E&W	High	124	119	116	114	112
	Central	100	96	94	93	91
	Low	81	78	76	75	74
Onshore >5MW UK	High	115	110	108	106	104
	Central	93	90	88	86	85
	Low	75	72	71	70	69
Offshore Round 2	High	168	149	126	121	117
	Central	148	132	111	106	102
	Low	131	116	98	93	90
Offshore Round 3	High	208	186	154	148	141
	Central	179	160	133	126	120
	Low	157	141	116	110	104

		2014	2016	2020	2025	2030
Biomass conversion	High	117	115			
	Central	110	109			
	Low	106	105			
Large scale solar PV	High	131	116	100	86	74
	Central	122	108	94	80	70
	Low	114	101	87	75	66
EfW CHP	High	58	50	48	47	46
	Central	45	37	36	35	34
	Low	32	25	23	23	22
EfW	High	41	41	39	39	38
	Central	36	35	34	34	33
	Low	30	30	29	28	28
Geothermal CHP	High	312	248	214	208	201
	Central	206	161	136	132	127
	Low	82	59	46	43	41
Landfill	High	116	114	113	113	113
	Central	79	78	77	77	77
	Low	50	49	49	49	49
Sewage gas	High	195	186	182	180	178
	Central	130	125	122	121	120
	Low	93	89	88	87	86
Geothermal	High	337	282	253	248	243
	Central	239	200	181	177	173
	Low	130	111	101	99	98
AD CHP	High	154	177	205	203	202
	Central	86	113	142	141	141
	Low	37	67	98	97	97
Cofiring conventional	High	97	97	97	97	97
	Central	95	95	95	95	95
	Low	91	91	91	91	91
AD	High	164	191	219	217	216
	Central	96	125	154	153	152
	Low	53	82	112	112	112
Co-firing standard CHP	Central	118	117	116	116	116
Hydro large storage	Central	80	83	89	92	92
Hydropower 5-16MW	High	107	107	113	117	117
	Central	97	97	103	107	107
	Low	61	61	64	66	66
ACT standard	High	207	198	193	189	183
	Central	136	131	128	124	120
	Low	71	69	68	65	62
ACT CHP	High	224	214	207	202	196
	Central	144	138	134	130	125
	Low	63	61	59	57	53

		2014	2016	2020	2025	2030
ACT advanced	High	187	178	173	170	165
	Central	173	165	160	157	152
	Low	139	133	129	126	122
Biomass CHP	High	229	221	218	215	214
	Central	204	198	194	193	191
	Low	179	174	171	170	169
Bioliquids	High	388	380	375	373	372
	Central	329	323	318	317	316
	Low	314	310	305	303	303
Bioliquids CHP	High	382	377	371	369	367
	Central	317	313	307	305	304
	Low	302	297	292	290	289
Wave	High				276	214
	Central				261	203
	Low				228	177
Tidal stream shallow	High				247	220
	Central				225	202
	Low				181	163
Tidal stream deep	High				195	169
	Central				174	151
	Low				152	133
Tidal range	High				192	192
	Central				157	157
	Low				120	120
Solar<4kW	High	305	291	279	268	259
	Central	238	228	218	210	203
	Low	192	184	176	170	164
Onshore <15kW	High	400	400	400	400	400
	Central	369	369	369	369	369
	Low	343	343	343	343	343
Onshore 1MW<5MW	High	109	109	109	109	109
	Central	97	96	96	96	96
	Low	80	80	80	80	80
AD < 250kW	High	314	314	314	314	314
	Central	279	279	279	279	279
	Low	245	245	245	245	245
AD > 500kW	High	134	147	157	166	173
	Central	115	127	138	146	153
	Low	95	108	118	127	134
Hydropower <15kW	High	608	608	608	608	608
	Central	290	290	290	290	290
	Low	148	148	148	148	148
Hydropower 100kW-1000kW	High	301	301	301	301	301
	Central	154	154	154	154	154
	Low	87	87	87	87	87

		2014	2016	2020	2025	2030
Dedicated biomass >50MW(ecrops)	High	189	184	184	183	183
	Central	149	146	146	145	145
	Low	140	138	138	137	137
Dedicated biomass 5-50MW(ecrop)	High	212	212	207	206	205
	Central	185	185	181	181	180
	Low	165	164	162	162	161

Annex 2: Data Sources Considered for Renewable Technologies

The purpose of this annex is to capture the sources of technology cost considered and explain the justification for the dataset used.

Nine data sources for various renewable technologies have been used and/or considered by DECC. These are:

1. Government Response to the Banding Review (GRBR) - data and evidence underpinning the 'Government response to the consultation on proposals for the levels of banded support under the Renewables Obligation for the period 2013-17 and the Renewables Obligation Order 2012' for renewable technologies[47].
2. Large scale ground mounted solar PV (>5MW) - data and evidence on the costs and performance of large-scale solar PV underpinning 'Government response to further consultations on solar PV support, biomass affordability and retaining the minimum calorific value requirement in the RO'[48]
3. Small-scale Feed in Tariff (FiTs) data (PV, wind, hydro and AD below 5MW): Data and evidence from Parsons Brinckerhoff (PB) (2012) published as part of the government response to Phase 2A and 2B comprehensive review of feed in tariffs[4950].
4. Onshore Wind Call for Evidence - Data received in response to DECC's Onshore Wind Call for Evidence and published in June 2013[51]
5. National Grid (NG) Call for Evidence - Data received as part of National Grid's Call for Evidence[52] (2013)
6. PB 2013 - a DECC commissioned report from Parsons Brinckerhoff (2013) on renewable technology costs[53].

---

[47] http://www.decc.gov.uk/assets/decc/11/consultation/ro-banding/5936-renewables-obligation-consultation-the-government.pdf. This is referred to as the 'Government Response to the Banding Review (GRBR)' throughout this report. Please note that the data has been inflated from 2010 to 2012 prices and heat revenues have been updated to reflect DECC's 2013 fuel and carbon prices when compared to those published as part of the Government Response to Banding Review.

[48] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/66516/7328-renewables-obligation-banding-review-for-the-perio.pdf

[49] http://www.decc.gov.uk/assets/decc/11/meeting-energy-demand/renewable-energy/5381-solar-pv-cost-update.pdf.

[50] http://www.decc.gov.uk/assets/decc/Consultations/fits-review/5900-update-of-nonpv-data-for-feed-in-tariff-.pdf

[51] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/205423/onshore_wind_call_for_evidence_response.pdf

[52] Unless referenced specifically, all documentation can be found on the 'Energy generation cost projections' page of the DECC website: https://www.gov.uk/government/organisations/department-of-energy-climate-change/series/energy-generation-cost-projections

7. TNEI Offshore Wind Generation Cost Variations Review[54]
8. The Crown Estate Offshore wind cost reduction pathways study[55].
9. Offshore Wind Cost Reduction Task Force Report June 2012[56].

The first three data sources listed above were existing DECC electricity generation cost datasets. The sources listed 4 – 9 above show new evidence, which was considered in the process of updating cost assumptions for renewable technologies.

Due to lack of new information we will continue to use the ROBR dataset ("the baseline RO dataset") for the following technologies:

1. ACT (standard)
2. Biomass Co-firing and Enhanced Co-firing
3. Hydro
4. Solar PV
5. Bioliquids with and without CHP
6. Geothermal with and without CHP
7. Biomass Co-firing CHP
8. AD power with and without CHP
9. ACT CHP
10. Energy from Waste with and without CHP
11. Landfill gas
12. Sewage gas

In addition there was limited new data from the National Grid Call for Evidence[57] for the following technologies:

1. Hydro with storage
2. ACT (advanced)
3. Dedicated biomass

---

[53] Unless referenced specifically, all documentation can be found on the 'Energy generation cost projections' page of the DECC website: https://www.gov.uk/government/organisations/department-of-energy-climate-change/series/energy-generation-cost-projections

[54] Unless referenced specifically, all documentation can be found on the 'Energy generation cost projections' page of the DECC website: https://www.gov.uk/government/organisations/department-of-energy-climate-change/series/energy-generation-cost-projections

[55] http://www.thecrownestate.co.uk/media/305094/Offshore%20wind%20cost%20reduction%20pathways%20study.pdf. This is referred to as the 'Crown Estate Study' throughout this report.

[56] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/66776/5584-offshore-wind-cost-reduction-task-force-report.pdf. This is referred to as the 'Offshore Wind CRTF report' throughout this report.

[57] This was defined as 2 or fewer additional data points. While a statistical analysis would reveal almost all the new data was too small a set to avoid random errors affecting the results. Where there was fewer than 2 new data points we felt unable to draw any conclusions. Differences could be due to range, or outliers.

We examined the new data for technologies where we received three or more data points in line with expert opinions and additional sources. These are explained in more details below.

1. **Onshore Wind:** In addition to the Onshore Wind Call for Evidence dataset we considered data from the National Grid Call for Evidence. We believe the Onshore Wind Call for Evidence dataset is the most robust dataset as it has the largest number of independent data points. It is corroborated by the National Grid dataset.

2. **Offshore Wind:** In addition to the baseline RO dataset we considered data submitted as part of the National Grid Call for Evidence. There was significant uncertainty around both sets of estimates and differences were not sufficiently explained and justified by respondents and the change in costs was counter to expectations. DECC therefore asked TNEI to perform an independent review of the offshore wind data received to determine which data set was more robust.

TNEI concluded 'there is no evidence to suggest which of either the ROBR or CfE costs is likely to be more valid' and that there are considerable cost variations in individual schemes depending on the engineering parameters required. Given the uncertainty and a low number of data points, and the lack of clear steer or clear drivers of differences between the two dataset from a range of expert sources, we do not believe that the rationale for moving away from to the RO data is sufficiently clear and robust based on the evidence given and the views of experts sought.

4. **Biomass Conversion:** In addition to the baseline RO dataset we considered data from two new sources; data submitted as part of the National Grid Call for Evidence and the PB 2013 Renewables Update.

Parsons Brinckerhoff recommended that 'no changes should be made to the RO baseline dataset'. The National Grid Call for Evidence received only three data points for biomass conversion.

The data collected from these two separate datasets largely validates the RO data, therefore we continue to use the RO dataset.

4. **Wave Technologies:** In addition to the baseline RO dataset we considered data submitted as part of the National Grid Call for Evidence. Wave is still in a demonstration phase, and has not progressed as quickly as initially expected when the RO dataset for Wave was generated, thus we believe the NG dataset is more robust. This dataset is also consistent with other sources.

5. **Tidal Stream:** In addition to the baseline RO dataset we considered data from the National Grid Call for Evidence. While the range of data for capex collected under the NG CfE overlaps with the RO, the NG CfE data is skewed upwards and outside the high-range of the RO data. It was noted that respondents to the CfE suggested that the RO dataset 'retains some validity' or are 'broadly applicable' and it was unclear why the CfE data did not reflect these comments.

We also examined the data for load factors. The data for load factor was significantly lower in the NG CfE than the RO dataset (31% versus 40%). It was noted that respondents to the NG CfE 'broadly agreed with ROBR costs, the ROBR load factor was far too high'. It is our

understanding that recent evidence from actual project testing has suggested that a lower load factor is appropriate.

Tidal stream has reached a greater stage of maturity and we believe the cost assumptions used under the RO remain appropriate. However we adjusted the load factor for shallow water (sites <40m depth considered to be accessed before deep sites are used) projects used in this report to reflect more robust evidence collected as part of the NG CfE (to 31% post availability). We will continue to use the ROBR data for deep water projects (sites >40m depth considered to be accessed after shallow sites) as no further data was forthcoming in the Call for Evidence.

Future Offshore Wind Costs

DECC considered two major sources of evidence on the costs of offshore wind commissioning from 2017 for use in the draft Delivery Plan analysis and reflected in this report:

1. *Cost Reductions based on modelled deployment and learning rates based on the approach used for the Renewables Obligation Banding Review (ROBR)*
2. *Recent evidence from the Crown Estate and the Offshore Wind Cost Reduction Task Force which demonstrates pathways to £100/MWh by 2020*

There is considerable uncertainty surrounding the future costs of offshore wind. The Crown Estate and Offshore Wind Cost Reduction Task Force profiles for offshore wind costs are more stretching than those derived from modelled deployment and the learning rates from the ROBR. In light of this uncertainty we have taken a balanced view and an equal weighting has been placed on the two evidence sources.

A. Offshore Wind Costs

The cost of offshore wind comprises of the costs of building and operating the plant[58] along with factors that affect how the plant operates and financing costs. In the long run we expect costs to be driven down by several factors including:

- A movement to larger, more efficient turbines
- Higher load factors
- Learning and innovation (technology and processes)
- More developed and competitive supply chains
- Improved financing (cost of capital assumptions).

DECC electricity market modelling uses variation in capital costs to derive a 'supply curve' of potential projects that could deploy in any year. This supply curve is then shifted over time to reflect learning. The underlying cost data reflects data used in the Government Response to the RO Banding Review. This dataset was split into projects above and below 100MW, and in effect represent data sets for early stage Round 1 and later stage Round 1/Round 2 projects. Round 3 projects were then classified separately.

[58] The cost of major cost components can also be affected by external factors including the price of labour, steel, exchange rates, supply chains and vessel costs

Offshore wind costs vary considerably depending on the engineering parameters and requirements of the sites being developed. These parameters include distance from shore, cable length, depth of water and distance from port of supply. Consequently, in practice there is unlikely to be a clear distinction between all R2 and all R3 projects, as costs will vary on a project by project basis. The cost data does overlap to reflect this, but it should be noted that we recognise the limitations of the data in this respect.

B. Evidence Sources for Future Costs of Offshore Wind Considered

Two sources of evidence on the profile of future offshore wind costs have been considered:

1. *Cost Reductions based on modelled deployment and learning rates based on the approach used for the Renewables Obligation Banding Review*

   The modelling for the Renewables Obligation used a methodology for modelling cost reductions endogenously over time. Under this approach learning is linked to UK deployment[59], so that cost reductions are endogenous to the modelling. A learning rate of 12% is used for offshore wind (Arup 2011) i.e. every doubling of cumulative deployment is associated with a reduction in capital costs of 12%.

2. *Recent evidence from the Crown Estate and the Offshore Wind Cost Reduction Task Force which demonstrates paths to £100/MWh by 2020*

   The Crown Estate's Offshore Wind Cost Reduction Pathways Study (CRPS) explored 4 cost reduction 'pathways' which focuses on key uncertainties faced by the offshore wind industry: rate of build, pace of technological change, maturity of supply chains and depth of financial markets.

   The study uses a bottom-up methodology where deployment is exogenous and learning is driven by both technological improvements and establishment of UK supply chains[60]. In three out of four of these scenarios the Levelised Cost of Offshore Wind was £100/MWh or less for projects reaching financial close in 2020.

   The Offshore Wind Cost Reduction Task Force considered evidence from the Crown Estate and additional sources and concluded that "the offshore wind levelised cost of energy can be reduced to £100/MWh by 2020 if there is sufficient project momentum, supply chain competition and stronger intra-industry and stakeholder cooperation"[61]

C. Conclusion

[59] Note this is a different approach from other technologies where cost reductions are exogenous and driven by global deployment and learning. The rationale for this is that the UK is the largest offshore wind market and therefore drives cost reductions. We also considered using global deployment rates, but this did not lead to significant changes.

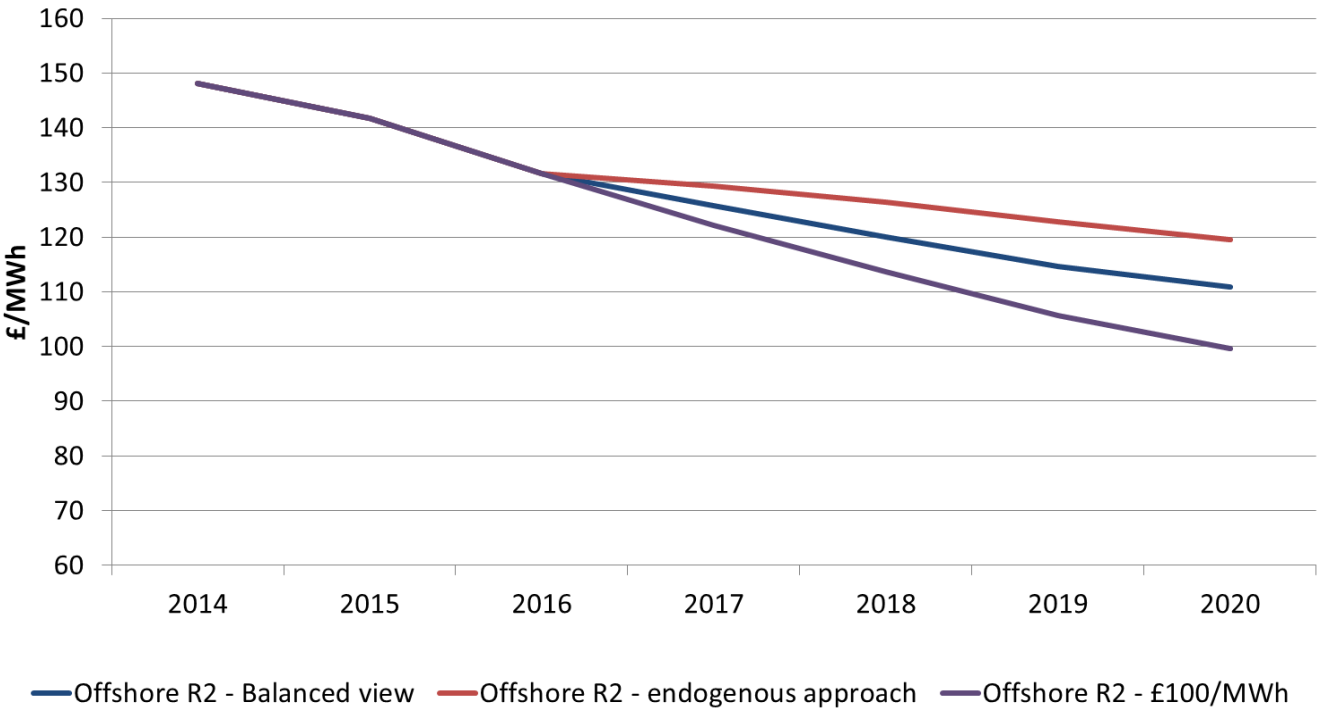
[60] i.e it is difficult to unpick cost reductions and deployment

[61] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/66776/5584-offshore-wind-cost-reduction-task-force-report.pdf

There is considerable uncertainty surrounding the future costs of offshore wind. In light of this uncertainty we have taken a balanced view and an equal weighting has been placed on the two evidence sources.

In order to achieve this DECC derived an exogenous capital cost reduction profile for the costs of offshore wind commissioning between 2017 and 2020 based an average between the two sources. This has been used in this report and in the draft Delivery Plan analysis. This is illustrated in Chart 7 below where all three profiles have been illustrated for a central offshore R2 estimate

Chart 7. Levelised costs for Central R2 offshore wind using different learning approaches, projects commissioning between 2014 and 2020, technology specific hurdle rates



Annex 3: Key Data and Assumptions

This annex presents key data and assumptions used to calculate the levelised costs in this report.

Hurdle Rates

The technology specific hurdle rates used for the Levelised Cost estimates presented in this report represent estimates of pre-tax real hurdle rates. The starting point for the renewable hurdle rate estimates are the post-tax nominal hurdle rates underlying the Renewables Obligation Banding Review Government Response (2012). The post-tax nominal rates are based on evidence from Arup (2011)[62], Oxera (2011)[63] and Redpoint (2010)[64].These post-tax nominal rates are adjusted using the following assumptions:

- To convert post-tax nominal to pre-tax real hurdle rates, updated effective tax rate assumptions from work undertaken by KPMG (2013)[65] (further explained below) and a 2% inflation assumption consistent with the Government's inflation target have been applied.
- For technologies offered CfDs, estimated hurdle rate reductions due to the introduction of CfDs are included, which draw on analysis by Redpoint (2010).

The resulting pre-tax real hurdle rates used are shown in Table 14 below.

[62] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/42843/3237-cons-ro-banding-arup-report.pdf

[63] http://hmccc.s3.amazonaws.com/Renewables%20Review/Oxera%20low%20carbon%20discount%20 rates%20180411.pdf

[64] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/42638/1043-emr-analysis-policy-options.pdf

[65] Electricity Market Reform: Review of effective tax rates for renewable technologies, KPMG, July 2013 [URL]

Table 14: Technology specific hurdle rates for renewable technologies[66]

	RO pre-tax real hurdle rates used for draft Delivery Plan[67]	Pre-tax real hurdle rates under CfDs[68]
ACT advanced	11.2%	10.6%
ACT CHP	9.4%	9.0%
ACT standard	8.4%	8.0%
AD >5MW	12.0%	11.3%
AD CHP	13.0%	12.3%
Bioliquids	12.7%	
Bioliquids CHP	13.7%	
Biomass Conversion	11.6%	10.9%
Dedicated Biomass CHP	13.5%	12.7%
EfW	10.9%	
EfW CHP	11.9%	11.2%
Enhanced co-firing	11.6%	
Geothermal	22.5%	21.1%
Geothermal CHP	23.5%	22.0%

[66] Pre-tax real hurdle rates for CHP technologies are assumed to be 1 percentage point higher than the equivalent power only technology

[67] These have also been adjusted for the latest Effective Tax Rate estimates.

[68] RO is assumed to be switched to CfD for commissioning 2016 onwards.

	RO pre-tax real hurdle rates used for draft Delivery Plan[69]	Pre-tax real hurdle rates under CfDs[70]
Hydropower	7.0%	6.7%
Landfill gas	8.4%	8.0%
Large dedicated biomass	12.5%	
Large scale solar PV	6.2%	5.8%
Offshore Wind	10.2%	9.6%
Offshore Wind R3	12.0%	11.3%
Onshore Wind	8.3%	7.9%
Sewage Gas	9.4%	9.0%
Small dedicated biomass	12.5%	
Standard co-firing	11.6%	
Standard co-firing CHP	12.6%	
Tidal range	7.0%	6.6%
Tidal stream (pre-commercial)[71]	8.0%	7.3%
Wave (pre-commercial)[72]	8.0%	7.4%

[69] These have also been adjusted for the latest Effective Tax Rate estimates.

[70] RO is assumed to be switched to CfD for commissioning 2016 onwards.

[71] Pre-tax real hurdle rates for commercial tidal stream are estimated to be 12.9% under CfDs.

[72] Pre-tax real hurdle rates for commercial wave are estimated to be 11.0% under CfDs.

If a technology is being offered a CfD in the draft Delivery Plan the "Pre-tax real hurdle rates under CfDs" is used for the technology specific hurdle rate, otherwise the "RO pre-tax real hurdle rates used for draft Delivery Plan" figure is used.

Effective Tax Rates

We have updated assumptions on effective tax rates (ETRs) for renewable technologies to take into account the effect of capital allowances. This is based on advice from KPMG.[73] KPMG modelled project cash flows including the impact of capital allowance on corporation tax paid based on their recent experiences of such projects.

The KPMG report derives indicative ETRs for three electricity generating technologies: onshore wind, offshore wind and biomass conversions. The report then applies a high-level qualitative analysis for other renewable technologies to assess whether the ETR for offshore wind or converted biomass is an appropriate proxy. For technologies that do not show similar characteristics to either offshore wind or converted biomass the main rate of corporation tax rate from 2015-16 (20%)[74] is used as an estimate for the ETR.

The ETRs which have been used are shown in Table 15 below.

[73] Electricity Market Reform: Review of effective tax rates for renewable technologies, KPMG, July 2013.

[74] http://www.hmrc.gov.uk/rates/corp.htm

Table 15: Effective Tax Rates[75][76]

	Estimated Effective tax rate[77]
ACT advanced	12%
ACT CHP	12%
ACT standard	12%
AD >5MW	12%
AD CHP	12%
Bioliquids	21%
Bioliquids CHP	21%
Biomass Conversion*	21%
Dedicated biomass CHP	20%
Enhanced co-firing	21%
EfW	12%
EfW CHP	12%
Geothermal	20%
Geothermal CHP	20%

[75] Standard and enhanced cofiring and cofiring CHP were not included in the KPMG report. These technologies have been linked to the Biomass Conversion ETR assumption

[76] KPMG's analysis of the ETR for biomass conversions was based on a 15 year CfD contract length (compared to CfDs for biomass conversions ending in 2027 as now announced). We do not believe this difference has an impact on the biomass conversion strike prices proposed in the draft Delivery Plan, given strike prices have been set in £5 increments. We tested the implication for the calculated biomass conversion RO-X equivalent strike price if biomass conversion hurdle rates were between 5 percentage points lower and 5 percentage points higher than the assumed hurdle rates for biomass conversions in Table 14. This variation in hurdle rates would capture a very substantial variation in the ETR for biomass conversions. The RO-X equivalent biomass conversion strike price remained at £105/MWh for each of 2014/15, 2015/16 and 2016/17.

[77] These are the "Strawman 2b" estimates from the KPMG which calculate the ETR with reference to the post tax WACC.

	Estimated Effective tax rate[78]
Hydropower	20%
Landfill gas	12%
Large dedicated biomass	20%
Large scale solar PV	12%
Offshore Wind	12%
Offshore Wind R3	12%
Onshore Wind	11.4%
Sewage Gas	20%
Small dedicated biomass	20%
Standard co-firing	21%
Standard co-firing CHP	21%
Tidal range	20%
Tidal stream (deep and shallow)	20%
Wave	12%

For non-renewable technologies the post-tax nominal rates are based on evidence from Oxera (2011). To convert post-tax nominal to pre-tax real hurdle rates, a 2% inflation assumption and a 20% ETR assumption is used. For technologies offered CfDs, estimated hurdle rate reductions due to the introduction of CfDs are included, which draws on analysis by Redpoint (2010).

Table 16: Technology specific hurdle rates for non-renewable technologies[79]

[78] These are the "Strawman 2b" estimates from the KPMG which calculate the ETR with reference to the post tax WACC.

[79] Standard and enhanced cofiring and cofiring CHP were not included in the KPMG report. These technologies have been linked to the Biomass Conversion ETR assumption

	Pre-tax real hurdle rate
CCGT	7.5%
OCGT	7.5%
CCGT CHP	7.5%
Coal – IGCC with 300MW CCS	13.5%
Coal ASC CCS*	13.5%
Coal IGCC CCS*	13.5%
Gas CCS*	13.8%
Nuclear	9.5%

*The pre-tax hurdle rates refers to the hurdle rate under CfDs

Load factors for selected technologies

The table below summarises the load factor assumptions used to calculate levelised costs for key technologies in this report. The sources for these assumptions are summarised in Table 1 Data sources for individual technologies.

Table 17. Load factor assumptions for selected technologies

Technology	Average lifetime load factor (net of plant availability)
CCGT	93%
OCGT	7%
Nuclear – FOAK	91%
Gas - CCGT with post comb. CCS – FOAK	93%
Coal - ASC with oxy comb. CCS – FOAK	93%
Coal - IGCC with CCS – FOAK	90%
Onshore >5 MW UK	28%

Technology	Average lifetime load factor (net of plant availability)
Offshore Round 2	38%
Offshore Round 3	39%
Large scale solar PV	11%
Biomass conversion	65%

Project timings for selected technologies

Table 19: Central pre-development and construction period assumptions for selected technologies

Technology	Pre-development period	Construction period	Operating Period
CCGT	2	3	25
OCGT	2	5	25
Nuclear - FOAK	5	6	60
Gas - CCGT with post combustion CCS – FOAK	5	5	25
Coal - ASC with oxy combustion CCS - FOAK	6	6	25
Coal - IGCC with CCS - FOAK	5	5	25
Onshore >5 MW UK	4	2	24
Offshore Round 2	5	3	23
Offshore Round 3	6	3	22
Large scale solar PV	0	1	25
Biomass conversion	2	1	22

OCGT costs used in draft Delivery Plan Modelling

The OCGT cost input assumptions used in the National Grid's modelling for the draft Delivery Plan were the draft central cost assumptions from PB (2013). The costs presented in this report are final PB (2013) costs, which were also used in the reliability standard analysis in the draft Delivery Plan. The differences are outlined in Table 19 below.

Table 18. Differences between OCGT costs presented in this report and those used in draft Delivery Plan modelling.

	OCGT cost assumptions used in draft Delivery Plan	**OCGT costs presented in this report**
Construction (£/kW)	300	290
Fixed O&M (£/MW)	10980	9880
Variable O&M (£/MWh)	0.04	0.03
Insurance (£/MW)	1000	960

Capital and operating cost assumptions

Table 20: Capital and operating cost assumptions for all technologies

Gas - CCGT				
		Commissioning		
		2016	2017	2020
Pre-development	High	20	20	20
£/kW	Medium	10	10	10
	Low	5	5	5
Construction costs	High	700	700	700
£/kW	Medium	600	600	600
	Low	500	500	500
Fixed O+M				
£/MW/yr	Medium	22000	22000	22000
Variable O+M				
£/MWh	Medium	0.1	0.1	0.1
Insurance				
£/MW/yr	Medium	1990	1990	1990
Connection and Use of System charges				
£/MW/yr	Medium	6840	6840	6840

OCGT				
		Commissioning		
		2016	2017	2020
Pre-development	High	30	30	30
£/kW	Medium	20	20	20
	Low	20	20	20
Construction costs	High	300	300	300
£/kW	Medium	300	300	300
	Low	200	200	200
Fixed O+M				
£/MW/yr	Medium	9900	9900	9900
Variable O+M				
£/MWh	Medium	0.1	0.1	0.1
Insurance				
£/MW/yr	Medium	960	960	960
Connection and Use of System charges				
£/MW/yr	Medium	3440	3440	3440

Gas - CCGT with post combustion CCS (FOAK)		
	Commissioning	
FOAK		2025
Pre-development	High	45
£/kW	Medium	30
	Low	25
Construction costs	High	1500
£/kW	Medium	1300
	Low	1100
Fixed O+M		
£/MW/yr	Medium	25000
Variable O+M		
£/MWh	Medium	2
Insurance		
£/MW/yr	Medium	4600
Connection and Use of System charges		
£/MW/yr	Medium	6800

Coal - IGCC with CCS (FOAK)		
	Commissioning	
FOAK		2025
Pre-development	High	60
£/kW	Medium	50
	Low	45
Construction costs	High	3800
£/kW	Medium	3300
	Low	2700
Fixed O+M		
£/MW/yr	Medium	134800
Variable O+M		
£/MWh	Medium	2
Insurance		
£/MW/yr	Medium	5100
Connection and Use of System charges		
£/MW/yr	Medium	8800

Coal - ASC with oxy combustion CCS - FOAK		
		Commissioning
		2025
Pre-development	High	45
£/kW	Medium	25
	Low	20
Construction costs	High	2500
£/kW	Medium	2200
	Low	2000
Fixed O+M		
£/MW/yr	Medium	56900
Variable O+M		
£/MWh	Medium	2
Insurance		
£/MW/yr	Medium	3400
Connection and Use of System charges		
£/MW/yr	Medium	8800

Nuclear - FOAK		
		Commissioning
		2020
Pre-development	High	470
£/kW	Medium	210
	Low	110
Construction costs	High	4600
£/kW	Medium	4100
	Low	3700
Fixed O+M		
£/MW/yr	Medium	72000
Variable O+M		
£/MWh	Medium	3
Insurance		
£/MW/yr	Medium	10000
Connection and Use of System charges		
£/MW/yr	Medium	7400

CCGT CHP				
		Commissioning		
		2016	2017	2020
Pre-development	High	75	75	75
£/kW	Medium	50	50	50
	Low	30	30	30
Construction costs	High	700	700	700
£/kW	Medium	600	600	600
	Low	500	500	500
Fixed O+M				
£/MW/yr	Medium	46300	46300	46300
Variable O+M				
£/MWh	Medium	0.1	0.1	0.1
Insurance				
£/MW/yr	Medium	2000	2000	2000
Connection and Use of System charges				
£/MW/yr	Medium	6700	6700	6700

Co-firing Standard CHP				
		Commissioning		
		2016	2017	2020
Pre-development	High			
£/kW	Medium	*Included in Construction cos*		
	Low			
Construction costs	High			
£/kW	Medium	4300	4300	4300
	Low			
Fixed O+M				
£/MW/yr	Medium	260000	260000	260000
Variable O+M				
£/MWh	Medium	2	2	2
Insurance				
£/MW/yr	Medium	*Included in fixed O+M*		
Connection and Use of System charges				
£/MW/yr	Medium	*Included in fixed O+M*		

ACT Advanced				
		Commissioning		
		2016	2017	2020
Pre-development	High	1000	1000	1000
£/kW	Medium	410	410	410
	Low	170	170	170
Construction costs	High	6900	6800	6600
£/kW	Medium	6800	6700	6500
	Low	5100	5000	4900
Fixed O+M				
£/MW/yr	Medium	414800	410900	399500
Variable O+M				
£/MWh	Medium	13	13	13
Insurance				
£/MW/yr	Medium	21900	21700	21050
Connection and Use of System charges				
£/MW/yr	Medium	*Included in fixed O+M*		

ACT standard				
		Commissioning		
		2016	2017	2020
Pre-development	High	1005	1005	1005
£/kW	Medium	360	360	360
	Low	165	165	165
Construction costs	High	10100	10000	9800
£/kW	Medium	5600	5500	5400
	Low	900	900	900
Fixed O+M				
£/MW/yr	Medium	426000	422000	410000
Variable O+M				
£/MWh	Medium	25	25	25
Insurance				
£/MW/yr	Medium	21890	21680	21070
Connection and Use of System charges				
£/MW/yr	Medium	5570	5520	5360

Dedicated biomass >50MW				
		Commissioning		
		2016	2017	2020
Pre-development	High	40	40	40
£/kW	Medium	30	30	30
	Low	15	15	15
Construction costs	High	4600	4600	4500
£/kW	Medium	2500	2500	2400
	Low	2000	2100	2000
Fixed O+M				
£/MW/yr	Medium	96500	95900	94400
Variable O+M				
£/MWh	Medium	5	5	5
Insurance				
£/MW/yr	Medium	14320	14240	14020
Connection and Use of System charges				
£/MW/yr	Medium	1380	1370	1350

Dedicated biomass 5-50MW				
		Commissioning		
		2016	2017	2020
Pre-development	High	110	110	110
£/kW	Medium	95	95	95
	Low	40	40	40
Construction costs	High	5100	5000	4900
£/kW	Medium	3600	3500	3500
	Low	2500	2500	2500
Fixed O+M				
£/MW/yr	Medium	112000	111000	109000
Variable O+M				
£/MWh	Medium	5	5	5
Insurance				
£/MW/yr	Medium	16600	16500	16200
Connection and Use of System charges				
£/MW/yr	Medium	1600	1600	1600

Onshore >5 MW

		Commissioning		
		2016	2017	2020
Pre-development	High	240	240	240
£/kW	Medium	100	100	100
	Low	30	30	30
Construction costs	High	1800	1800	1700
£/kW	Medium	1500	1500	1400
	Low	1100	1100	1100
Fixed O+M				
£/MW/yr	Medium	37100	37100	37200
Variable O+M				
£/MWh	Medium	5	5	5
Insurance				
£/MW/yr	Medium	3000	3010	3010
Connection and Use of System charges				
£/MW/yr	Medium	4510	4510	4510

Offshore Round 2

		Commissioning		
		2016	2017	2020
Pre-development	High	120	120	120
£/kW	Medium	70	70	70
	Low	50	50	50
Construction costs	High	2900	2700	2400
£/kW	Medium	2500	2300	2000
	Low	2100	2000	1700
Fixed O+M				
£/MW/yr	Medium	62900	60500	54600
Variable O+M				
£/MWh	Medium	2	2	2
Insurance				
£/MW/yr	Medium	11600	11100	10000
Connection and Use of System charges				
£/MW/yr	Medium	45900	44200	39900

Offshore Round 3

		Commissioning		
		2016	2017	2020
Pre-development	High	150	150	150
£/kW	Medium	105	105	105
	Low	50	50	50
Construction costs	High	3100	3000	2600
£/kW	Medium	2600	2400	2100
	Low	2200	2100	1800
Fixed O+M				
£/MW/yr	Medium	70900	67000	57800
Variable O+M				
£/MWh	Medium	*Included in fixed O+M*		
Insurance				
£/MW/yr	Medium	32800	31000	26700
Connection and Use of System charges				
£/MW/yr	Medium	60600	57200	49400

Bioliquids

		Commissioning		
		2016	2017	2020
Pre-development	High	1040	1040	1040
£/kW	Medium	180	180	180
	Low	30	30	30
Construction costs	High	1900	1900	1900
£/kW	Medium	800	800	800
	Low	500	500	500
Fixed O+M				
£/MW/yr	Medium	121000	120700	120200
Variable O+M				
£/MWh	Medium	6	7	8
Insurance				
£/MW/yr	Medium	4900	4900	4800
Connection and Use of System charges				
£/MW/yr	Medium	12000	12000	11900

Bioliquids CHP

		Commissioning		
		2016	2017	2020
Pre-development	High	1000	1000	1000
£/kW	Medium	180	180	180
	Low	30	30	30
Construction costs	High	2000	2000	2000
£/kW	Medium	800	800	800
	Low	500	500	500
Fixed O+M				
£/MW/yr	Medium	121000	120700	120200
Variable O+M				
£/MWh	Medium	6	7	8
Insurance				
£/MW/yr	Medium	4900	4900	4800
Connection and Use of System charges				
£/MW/yr	Medium	12000	12000	11900

Cofiring Conventional

		Commissioning		
		2016	2017	2020
Pre-development	High	7	7	7
£/kW	Medium	5	5	5
	Low	2	2	2
Construction costs	High	170	170	160
£/kW	Medium	120	120	120
	Low	40	40	40
Fixed O+M				
£/MW/yr	Medium	10100	10100	10200
Variable O+M				
£/MWh	Medium	1	2	3
Insurance				
£/MW/yr	Medium	900	900	900
Connection and Use of System charges				
£/MW/yr	Medium	9200	9200	9200

Cofiring Enhanced

		Commissioning		
		2016	2017	2020
Pre-development	High	60	60	60
£/kW	Medium	60	60	60
	Low	60	60	60
Construction costs	High	700	700	700
£/kW	Medium	400	400	400
	Low	300	300	300
Fixed O+M				
£/MW/yr	Medium	40900	41000	41000
Variable O+M				
£/MWh	Medium	1	2	3
Insurance				
£/MW/yr	Medium	1300	1300	1300
Connection and Use of System charges				
£/MW/yr	Medium	17500	17500	17500

Biomass conversion

		Commissioning		
		2016	2017	2020
Pre-development	High	60	60	60
£/kW	Medium	60	60	60
	Low	60	60	60
Construction costs	High	700	700	700
£/kW	Medium	400	400	400
	Low	300	300	300
Fixed O+M				
£/MW/yr	Medium	40900	41000	41000
Variable O+M				
£/MWh	Medium	1	2	3
Insurance				
£/MW/yr	Medium	1300	1300	1300
Connection and Use of System charges				
£/MW/yr	Medium	17500	17500	17500

Wave			Tidal stream shallow		
	Commissioning			Commissioning	
	2025			2025	
Pre-development	High	130	**Pre-development**	High	
£/kW	Medium	110	£/kW	Medium	*Included in construction costs*
	Low	100		Low	
Construction costs	High	4700	**Construction costs**	High	3100
£/kW	Medium	4500	£/kW	Medium	2700
	Low	3800		Low	2000
Fixed O+M			**Fixed O+M**		
£/MW/yr	Medium	97800	£/MW/yr	Medium	143300
Variable O+M			**Variable O+M**		
£/MWh	Medium	*Included in fixed O+M*	£/MWh	Medium	1
Insurance			**Insurance**		
£/MW/yr	Medium	*Included in fixed O+M*	£/MW/yr	Medium	*Included in fixed O+M*
Connection and Use of System charges			**Connection and Use of System charges**		
£/MW/yr	Medium	*Included in fixed O+M*	£/MW/yr	Medium	*Included in fixed O+M*

Tidal stream deep			Tidal range		
	Commissioning			Commissioning	
	2025			2025	
Pre-development	High		**Pre-development**	High	
£/kW	Medium	*Included in construction costs*	£/kW	Medium	*Included in construction costs*
	Low			Low	
Construction costs	High	3600	**Construction costs**	High	3800
£/kW	Medium	3200	£/kW	Medium	3000
	Low	2700		Low	2200
Fixed O+M			**Fixed O+M**		
£/MW/yr	Medium	114000	£/MW/yr	Medium	38000
Variable O+M			**Variable O+M**		
£/MWh	Medium	1	£/MWh	Medium	*Included in fixed O+M*
Insurance			**Insurance**		
£/MW/yr	Medium	*Included in fixed O+M*	£/MW/yr	Medium	*Included in fixed O+M*
Connection and Use of System charges			**Connection and Use of System charges**		
£/MW/yr	Medium	*Included in fixed O+M*	£/MW/yr	Medium	*Included in fixed O+M*

Hydropower 5-16MW				
		Commissioning		
		2016	2017	2020
Pre-development	High			
£/kW	Medium	50	50	50
	Low			
Construction costs	High			
£/kW	Medium	3100	3100	3300
	Low			
Fixed O+M				
£/MW/yr	Medium	43500	43600	43700
Variable O+M				
£/MWh	Medium	10	11	12
Insurance				
£/MW/yr	Medium	*Included in fixed O+M*		
Connection and Use of System charges				
£/MW/yr	Medium	*Included in fixed O+M*		

Hydro Large Storage				
		Commissioning		
		2016	2017	2020
Pre-development	High			
£/kW	Medium	55	55	55
	Low			
Construction costs	High			
£/kW	Medium	3400	3400	3600
	Low			
Fixed O+M				
£/MW/yr	Medium	24800	24800	24900
Variable O+M				
£/MWh	Medium	6	7	8
Insurance				
£/MW/yr	Medium	900	900	900
Connection and Use of System charges				
£/MW/yr	Medium	7300	7300	7400

Sewage Gas				
		Commissioning		
		2016	2017	2020
Pre-development	High			
£/kW	Medium	*Included in construction costs*		
	Low			
Construction costs	High	5900	5900	5800
£/kW	Medium	3600	3600	3500
	Low	2300	2300	2200
Fixed O+M				
£/MW/yr	Medium	101000	101000	101000
Variable O+M				
£/MWh	Medium	*Included in fixed O+M*		
Insurance				
£/MW/yr	Medium	*Included in fixed O+M*		
Connection and Use of System charges				
£/MW/yr	Medium	8700	8700	8700

Landfill				
		Commissioning		
		2016	2017	2020
Pre-development	High	210	210	210
£/kW	Medium	130	130	130
	Low	30	30	30
Construction costs	High	3400	3400	3300
£/kW	Medium	2000	2000	2000
	Low	1000	1000	1000
Fixed O+M				
£/MW/yr	Medium	59600	59600	59700
Variable O+M				
£/MWh	Medium	10	11	12
Insurance				
£/MW/yr	Medium	1300	1300	1300
Connection and Use of System charges				
£/MW/yr	Medium	5100	5100	5100

Energy from Waste

		Commissioning		
		2016	2017	2020
Pre-development £/kW	High / Medium / Low	*Included in construction costs*		
Construction costs £/kW	High	5200	5200	5100
	Medium	4900	4900	4800
	Low	4500	4500	4500
Fixed O+M £/MW/yr	Medium	222000	222000	222000
Variable O+M £/MWh	Medium	25	25	25
Insurance £/MW/yr	Medium	*Included in fixed O+M*		
Connection and Use of System charges £/MW/yr	Medium	*Included in fixed O+M*		

Energy from Waste CHP

		Commissioning		
		2016	2017	2020
Pre-development £/kW	High / Medium / Low	*Included in construction costs*		
Construction costs £/kW	High	6900	6900	6800
	Medium	6200	6200	6100
	Low	5500	5500	5400
Fixed O+M £/MW/yr	Medium	269000	269200	269600
Variable O+M £/MWh	Medium	30	30	30
Insurance £/MW/yr	Medium	*Included in fixed O+M*		
Connection and Use of System charges £/MW/yr	Medium	*Included in fixed O+M*		

Geothermal

		Commissioning		
		2016	2017	2020
Pre-development £/kW	High	300	300	300
	Medium	140	140	140
	Low	50	50	50
Construction costs £/kW	High	6700	6300	5900
	Medium	4600	4400	4100
	Low	2300	2200	2000
Fixed O+M £/MW/yr	Medium	35800	35800	35800
Variable O+M £/MWh	Medium	10	10	10
Insurance £/MW/yr	Medium	71500	71500	71700
Connection and Use of System charges £/MW/yr	Medium	2000	2000	2000

Geothermal CHP

		Commissioning		
		2016	2017	2020
Pre-development £/kW	High	240	240	240
	Medium	140	140	140
	Low	50	50	50
Construction costs £/kW	High	7300	6800	6400
	Medium	5100	4800	4500
	Low	2600	2500	2300
Fixed O+M £/MW/yr	Medium	34200	34200	34200
Variable O+M £/MWh	Medium	10	11	12
Insurance £/MW/yr	Medium	77100	77100	77200
Connection and Use of System charges £/MW/yr	Medium	1900	1900	1900

Biomass CHP		Commissioning		
		2016	2017	2020
Pre-development	High			
£/kW	Medium	*Included in construction costs*		
	Low			
Construction costs	High	5000	5000	4900
£/kW	Medium	3900	3800	3800
	Low	2700	2700	2700
Fixed O+M				
£/MW/yr	Medium	149900	149100	146700
Variable O+M				
£/MWh	Medium	10	11	12
Insurance				
£/MW/yr	Medium	25400	25300	24900
Connection and Use of System charges				
£/MW/yr	Medium	1400	1400	1400

AD		Commissioning		
		2016	2017	2020
Pre-development	High	580	580	580
£/kW	Medium	180	180	180
	Low	50	50	50
Construction costs	High	7200	7200	7000
£/kW	Medium	4000	3900	3900
	Low	1700	1700	1700
Fixed O+M				
£/MW/yr	Medium	301000	301000	301000
Variable O+M				
£/MWh	Medium	30	30	30
Insurance				
£/MW/yr	Medium	58000	58100	58200
Connection and Use of System charges				
£/MW/yr	Medium	8700	8700	8700

AD CHP		Commissioning		
		2016	2017	2020
Pre-development	High			
£/kW	Medium	*Included in construction costs*		
	Low			
Construction costs	High	7200	7200	7000
£/kW	Medium	4200	4200	4100
	Low	1800	1800	1800
Fixed O+M				
£/MW/yr	Medium	364000	364000	365000
Variable O+M				
£/MWh	Medium	20	20	20
Insurance				
£/MW/yr	Medium	58000	58100	58200
Connection and Use of System charges				
£/MW/yr	Medium	8700	8700	8700

ACT CHP		Commissioning		
		2016	2017	2020
Pre-development	High	90	90	90
£/kW	Medium	90	90	90
	Low	90	90	90
Construction costs	High	10600	10500	10300
£/kW	Medium	5900	5800	5700
	Low	1000	1000	900
Fixed O+M				
£/MW/yr	Medium	425800	421800	410000
Variable O+M				
£/MWh	Medium	10	11	12
Insurance				
£/MW/yr	Medium	21900	21700	21100
Connection and Use of System charges				
£/MW/yr	Medium	5600	5500	5400

Large scale solar PV

Commissioning

		2016	2017	2020
Pre-development £/kW	High / Medium / Low	*Included in construction costs*		
Construction costs £/kW	High	1100	1100	900
	Medium	1000	1000	900
	Low	900	900	800
Fixed O+M £/MW/yr	Medium	22600	22400	21900
Variable O+M £/MWh	Medium	*Included in fixed O+M*		
Insurance £/MW/yr	Medium	*Included in fixed O+M*		
Connection and Use of System charges £/MW/yr	Medium	*Included in fixed O+M*		

Solar <4kW

Commissioning

		2016	2017	2020
Pre-development £/kW	High / Medium / Low	*Included in construction costs*		
Construction costs £/kW	High	2500	2400	2100
	Medium	1900	1800	1600
	Low	1500	1400	1300
Fixed O+M £/MW/yr	Medium	23700	23600	23500
Variable O+M £/MWh	Medium	*Included in fixed O+M*		
Insurance £/MW/yr	Medium	*Included in fixed O+M*		
Connection and Use of System charges £/MW/yr	Medium	*Included in fixed O+M*		

Onshore 1MW<5MW

Commissioning

		2016	2017	2020
Pre-development £/kW	High / Medium / Low	*Included in construction costs*		
Construction costs £/kW	High	2300	2300	2300
	Medium	2000	2000	2000
	Low	1600	1600	1600
Fixed O+M £/MW/yr	Medium	29600	29400	29000
Variable O+M £/MWh	Medium	*Included in fixed O+M*		
Insurance £/MW/yr	Medium	*Included in fixed O+M*		
Connection and Use of System charges £/MW/yr	Medium	*Included in fixed O+M*		

Onshore <15kW

Commissioning

		2016	2017	2020
Pre-development £/kW	High / Medium / Low	*Included in construction costs*		
Construction costs £/kW	High	6100	6100	6100
	Medium	5500	5500	5500
	Low	5000	5000	5000
Fixed O+M £/MW/yr	Medium	73000	73000	73000
Variable O+M £/MWh	Medium	*Included in fixed O+M*		
Insurance £/MW/yr	Medium	*Included in fixed O+M*		
Connection and Use of System charges £/MW/yr	Medium	*Included in fixed O+M*		

AD < 250kW				
		Commissioning		
		2016	2017	2020
Pre-development £/kW	High / Medium / Low	*Included in construction costs*		
Construction costs £/kW	High	8000	8000	8000
	Medium	6000	6000	6000
	Low	4000	4000	4000
Fixed O+M £/MW/yr	Medium	924000	924000	924000
Variable O+M £/MWh	Medium	*Included in fixed O+M*		
Insurance £/MW/yr	Medium	*Included in fixed O+M*		
Connection and Use of System charges £/MW/yr	Medium	*Included in fixed O+M*		

AD > 500kW				
		Commissioning		
		2016	2017	2020
Pre-development £/kW	High / Medium / Low	*Included in construction costs*		
Construction costs £/kW	High	6000	6000	6000
	Medium	4500	4500	4500
	Low	3000	3000	3000
Fixed O+M £/MW/yr	Medium	714800	714800	714800
Variable O+M £/MWh	Medium	*Included in fixed O+M*		
Insurance £/MW/yr	Medium	*Included in fixed O+M*		
Connection and Use of System charges £/MW/yr	Medium	*Included in fixed O+M*		

Hydropower 100kW-1000kW				
		Commissioning		
		2016	2017	2020
Pre-development £/kW	High / Medium / Low	*Included in construction costs*		
Construction costs £/kW	High	10000	10000	10000
	Medium	4500	4500	4500
	Low	2000	2000	2000
Fixed O+M £/MW/yr	Medium	104000	104000	104000
Variable O+M £/MWh	Medium	*Included in fixed O+M*		
Insurance £/MW/yr	Medium	*Included in fixed O+M*		
Connection and Use of System charges £/MW/yr	Medium	*Included in fixed O+M*		

Hydropower <15kW				
		Commissioning		
		2016	2017	2020
Pre-development £/kW	High / Medium / Low	*Included in construction costs*		
Construction costs £/kW	High	21400	21400	21400
	Medium	9500	9500	9500
	Low	4200	4200	4200
Fixed O+M £/MW/yr	Medium	110000	110000	110000
Variable O+M £/MWh	Medium	*Included in fixed O+M*		
Insurance £/MW/yr	Medium	*Included in fixed O+M*		
Connection and Use of System charges £/MW/yr	Medium	*Included in fixed O+M*		

Department of Energy & Climate Change
3 Whitehall Place
London SW1A 2AW
www.gov.uk/decc

13D/185