

Electricity Generation Costs

October 2012

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 or MWh for the lifetime of a plant, from planning costs right through construction and operating costs to eventual decommissioning costs.

These detailed costs 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. These reflect the cost of building a generic plant for each technology, potential revenue streams are not considered¹.

For the purposes of this report data on the cost of electricity generation has been drawn from Parsons Brinkerhoff (2012) for non-renewables technologies and evidence underpinning the Renewables Obligation and Feed in Tariff scheme for renewable technologies. Based on this detailed cost data, this report presents selected 'levelised costs of electricity generation' estimates generated using DECC's Levelised Cost Model.

This report firstly details the methodology and assumptions used in these estimates and discusses some of the limitations of levelised costs estimates. The report then presents selected 'levelised cost' estimates generated using DECC's Levelised Cost Model. The final section of this report also adds a brief explanation of how cost information is used in DECC modelling.

It is important to note there is a large amount of uncertainty when estimating the future costs of electricity generation.

The levelised costs in this report are not intended to provide any indication of potential future strike prices for the Feed-in Tariff with Contracts for Difference (CfD) being introduced as part of Electricity Market Reform.

¹ With the exception of heat revenues for CHP technologies

Explanatory Notes

Methodology

The levelised cost of electricity generation (LCOE) is defined as the ratio of the net present value of total capital and operating costs of a generic plant to the net present value of the net electricity generated by that plant over its operating life.

For further information on how levelised costs are calculated and DECC's Levelised Cost Model please refer to section 4.2 Mott MacDonald (2010)² or see Annex 2: Calculating Levelised Costs

Data Sources and Assumptions

The following data sources and assumptions have been used to calculate the levelised costs estimates presented in this report :

- Non-Renewables Data: Underlying data on non-renewable technologies has been provided by Parsons Brinckerhoff. The underlying data and assumptions can be found in the PB (2012) report³.
- Renewables Data (over 5MW): Renewable technology estimates (for plant size over 5MW) reflect 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 technologies⁴. Please note that the estimates for renewables over 5MW have been inflated from 2010 to 2012 prices and heat revenues have been updated to reflect new fuel, carbon, and electricity prices when compared to those published as part of the Government Response to Renewables Obligation.⁵
- Renewables Data (up to 5MW): Renewable technology estimates (for plant size up to 5MW) reflect data and evidence from PB (2012) published as part of the government response to Phase 2A and 2B comprehensive review of feed in tariffs⁶⁷.

² http://www.decc.gov.uk/en/content/cms/about/ec_social_res/analytic_projs/gen_costs/gen_costs.aspx

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

⁴ <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 RO' throughout this report.

⁵ Please note that the data used to produce these levelised costs is consistent with the data underpinning the Renewables Obligation and figures presented in the Call for Evidence on Onshore Wind

⁶ <http://www.decc.gov.uk/assets/decc/11/meeting-energy-demand/renewable-energy/5381-solar-pv-cost-update.pdf>.

- Fuel and Carbon Prices: DECC's projected fossil fuel prices and Carbon Price Support.
- Deployment Scenarios: Future cost estimates are driven by a combination of assumptions of learning rates and global and UK deployment. Please see data sources referenced above for detailed information about deployment scenarios used. In general IEA Bluemap scenarios were the main source for global deployment. Four notable exceptions are; offshore wind, ACT, marine and estimates for renewables technologies under 5MW which are driven by technical potential for UK deployment⁸

All estimates are in 2012 real prices. This is in contrast to previously published estimates which were in 2010 real prices.

Technology Notes

This report will not discuss changes to individual technology estimates from previously published figures. For more information on individual changes please refer to the source material referenced in the Data Sources and Assumptions section above.

Estimates for Carbon Capture and Storage (CCS) technologies and Nuclear are shown on 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 within the UK, not including demonstration projects. For these technologies, FOAK costs assume experience has been gained from international and demonstration projects⁹.

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.

Unless indicated all other estimates presented are NOAK.

⁷ <http://www.decc.gov.uk/assets/decc/Consultations/fits-review/5900-update-of-nonpv-data-for-feed-in-tariff-.pdf>

⁸ Please see Arup 2011 and PB 2012 for FITs for more details. Please note that reductions in costs for offshore wind are based on technical potential for deployment, if these levels of deployment do not materialise cost reductions would be less pronounced..

⁹ 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 to be successfully demonstrated first. In order to avoid confusion, we have not included estimates for CCS in the near future to illustrate the need for an initial 'demonstration' project

Limitations of 'Levelised Costs'

Levelised costs estimates are highly sensitive to the underlying data and assumptions used including those on capital costs, fuel and carbon costs, operating costs, operating profile, load factor and discount rates. Future levelised costs estimates are heavily driven by assumptions of global and UK deployment and assumed learning rates (and to a limited extent market effects¹⁰).

This report captures some of these uncertainties through ranges presented around key estimates (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.

Given these uncertainties, the levelised cost estimates in this report are not intended to provide any 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. Strike prices will vary according to the length and design of the FiT CfD contract, technology, financing costs and in a few limited cases specific project characteristics. To the extent that project specific cost discovery processes are undertaken, these will form the starting point of any process of setting a strike price, rather than relying on levelised cost data.

The levelised cost is a standardised measure of the net present value of lifetime costs divided by generation for a generic plant under each technology. This measure makes no assumptions about how particular generating stations would be financed, or the allocation of risk between parties. A CfD stabilises revenues for a particular generating station at a fixed price level known as the 'strike price' over a specified term, at a rate of return which reflects contract duration and design, financing costs, and risk allocation between parties.

The levelised cost measure does not explicitly include the financing costs attached to new generating stations¹¹. In most cases this report includes estimates using a standard 10% discount rate (in line with the 'tradition' used in reports produced by other organisations) across all technologies. These estimates may be viewed as neutral in terms of financing and risk when comparing 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.

Annex 4 includes levelised cost estimates for renewable technologies using technology specific hurdle rates as was done in previous reports on renewables. Currently uncertainties around the cost of financing nuclear and CCS technologies means technology specific hurdle rate estimates are only provided for renewables in this report.

¹⁰ Market effects can include short term imbalances between the demand and supply for component costs.

¹¹ While financing costs are included implicitly through the choice of discount rate used to produce the levelised cost this is an approximation.

Generation Cost Estimates

This section outlines the main results of the analysis of the levelised cost of electricity generation. It focuses primarily on the main technologies likely to be deployed in the UK over the next decade and a half.

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

A full set of estimates for renewable technologies not covered in the main report can be found in Annex 3.

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.

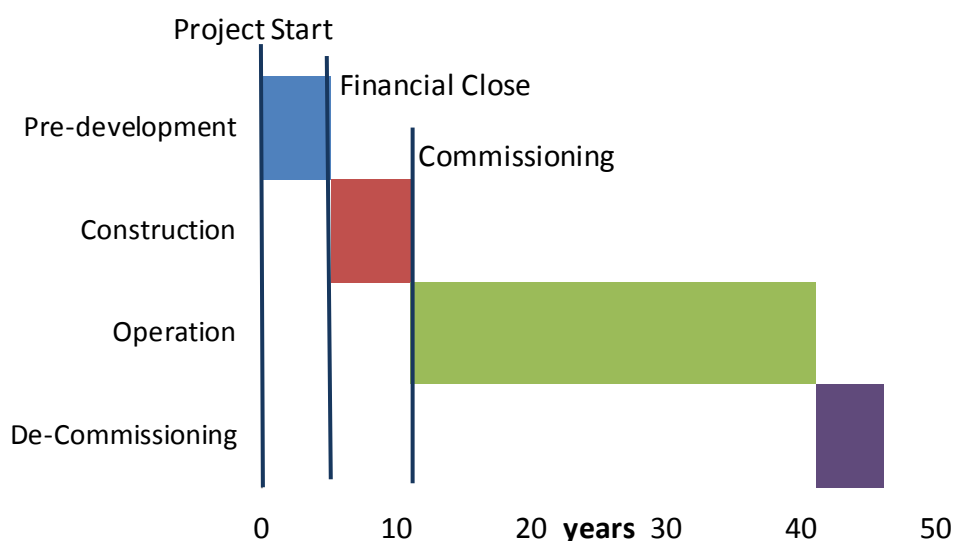
Timing

Levelised cost estimates can be reported for different time points associated with a project including 'Project Start', 'Financial Close' and 'Commissioning'. These are illustrated in Chart 1 below for an illustrative technology. A levelised cost estimate could be reported for 'project start', 'financial close' or 'commissioning' basis and represent the same information but be associated with different years.

For example, using the illustrative timings below for 'Technology 1'. 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 (2012 plus the 5 year pre-development period), or £50/MWh for a project commissioning in 2023 (2017 plus the 6 year construction period).

It is important to consider this when comparing across technologies. Pre-development and construction timings will vary by technology and therefore estimates reported for 'project start' or 'financial close' may not represent technologies commissioning in the same year as each other, and vice versa. Please see Annex 1 for key timings for selected technologies.

Chart 1: Illustrative Timings



Sensitivities

Levelised costs estimates are highly sensitive to the underlying data and assumptions used including those on capital costs, fuel and 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.

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 reported incorporate 'high' and 'low' capital costs including 'high' and 'low' pre-development costs.

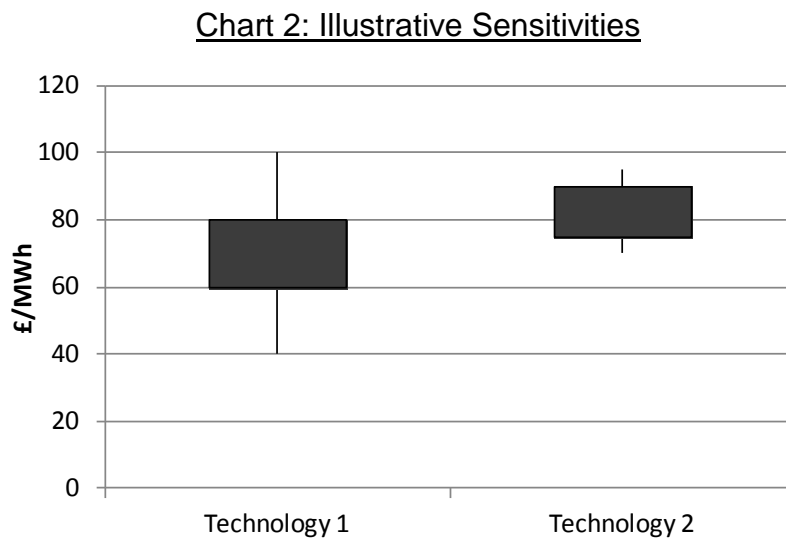
For non-renewable technologies this is a small change from previously reported estimates which used 'central' estimates for pre-development costs throughout. For non-renewables technologies 'high' and 'low' capital costs include the full range from PB (2012) i.e. both site-specific variation and uncertainty over future costs¹².

High and Low fuel and capital costs

In some cases, 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

¹² For more details on 'uncertainties' please see PB (2012). Please note for nuclear technologies there was no basis to distinguish between variation and uncertainty. Non-renewable technologies also include an adjustment for market effects. These do not have a large impact on the cost estimates.

lines represent 'high/low' sensitivities around fuel prices on top of the uncertainty around capex (including pre-development) costs.



Estimates

Levelised cost estimates for three cases have been calculated using the DECC Levelised Cost Model.

Case 1: projects starting in 2012, FOAK/ NOAK, 10% discount rate¹³

Case 1 shows the levelised costs for projects starting in 2012 with technologies which have not been deployed in the UK in their current form considered 'first of a kind' (FOAK), and those that have been deployed in the UK in their current form considered 'Nth of a kind' (NOAK). A 10% discount rate has been used in this case.

Table 1 and Chart 3 show the detailed breakdown of the central levelised cost estimates for projects starting in 2012.

Table 2 and Chart 4 show the sensitivities around capex and capex and fuel prices for projects starting in 2012.

¹³ Please note these estimates should be viewed in the context of the sensitivities and uncertainties highlighted in the text of this report.

Table 1: Levelised Cost Estimates for Projects Starting in 2012, 10% discount rate

Central Levelised Costs, £/MWh	Gas - CCGT	Coal - ASC with FGD	Coal - IGCC	Nuclear - FOAK	Offshore R2	Offshore R3	Solar250-5000kW
Pre-Development Costs	0	0	1	5	4	6	-
Capital Costs	9	22	26	55	81	91	143
Fixed O&M	3	5	7	11	32	37	26
Variable O&M	0	1	1	3	1	-	-
Fuel Costs	48	28	30	5	-	-	-
Carbon Costs	19	45	56	-	-	-	-
CO2 transport and storage	-	-	-	-	-	-	-
Decomm and waste fund	-	-	-	2	-	-	-
Heat Revenues	-	-	-	-	-	-	-
TOTAL LEVELISED COST	80	102	122	81	118	134	169

Central Levelised Costs, £/MWh	Onshore >5 MW E&W ¹⁴	Onshore >5 MW UK	Dedicated biomass >50MW	Dedicated biomass <50MW	Co-firing Conventional	Biomass Conversion
Pre-Development Costs	2	2	1	2	-	2
Capital Costs	79	71	38	52	5	11
Fixed O&M	19	17	14	16	5	13
Variable O&M	3	3	4	5	1	1
Fuel Costs	-	-	65	41	81	83
Carbon Costs	-	-	-	-	-	-
CO2 transport and storage	-	-	-	-	-	-
Decomm and waste fund	-	-	-	-	-	-
Heat Revenues	-	-	-	-	-	-
TOTAL LEVELISED COST	104	93	122	117	92	110

Table 2: Levelised Cost Estimates for Projects Starting in 2012, 10% discount rate, sensitivities

Levelised Costs, £/MWh	Gas - CCGT	Coal - ASC with FGD	Coal - IGCC	Nuclear - FOAK	Offshore R2	Offshore R3	Solar250-5000kW
Central	80	102	122	81	118	134	169
High Capex	81	105	125	92	134	156	203
High Capex and High Fuel	100	118	140	93	-	-	-
Low Capex and Low Fuel	58	90	108	72	-	-	-
Low Capex	78	99	118	73	104	117	145

Levelised Costs, £/MWh	Onshore >5 MW E&W	Onshore >5 MW UK	Dedicated biomass >50MW	Dedicated biomass <50MW	Co-firing Conventional
Central	104	93	122	117	92
High Capex	125	111	155	139	94
High Capex and High Fuel	-	-	165	160	108
Low Capex and Low Fuel	-	-	106	82	78
Low Capex	85	76	115	100	88

¹⁴ Estimates for onshore wind are shown using average load factors for UK and England and Wales 'E&W'

Chart 3: Levelised Cost Estimates for Projects Starting in 2012, 10% discount rate

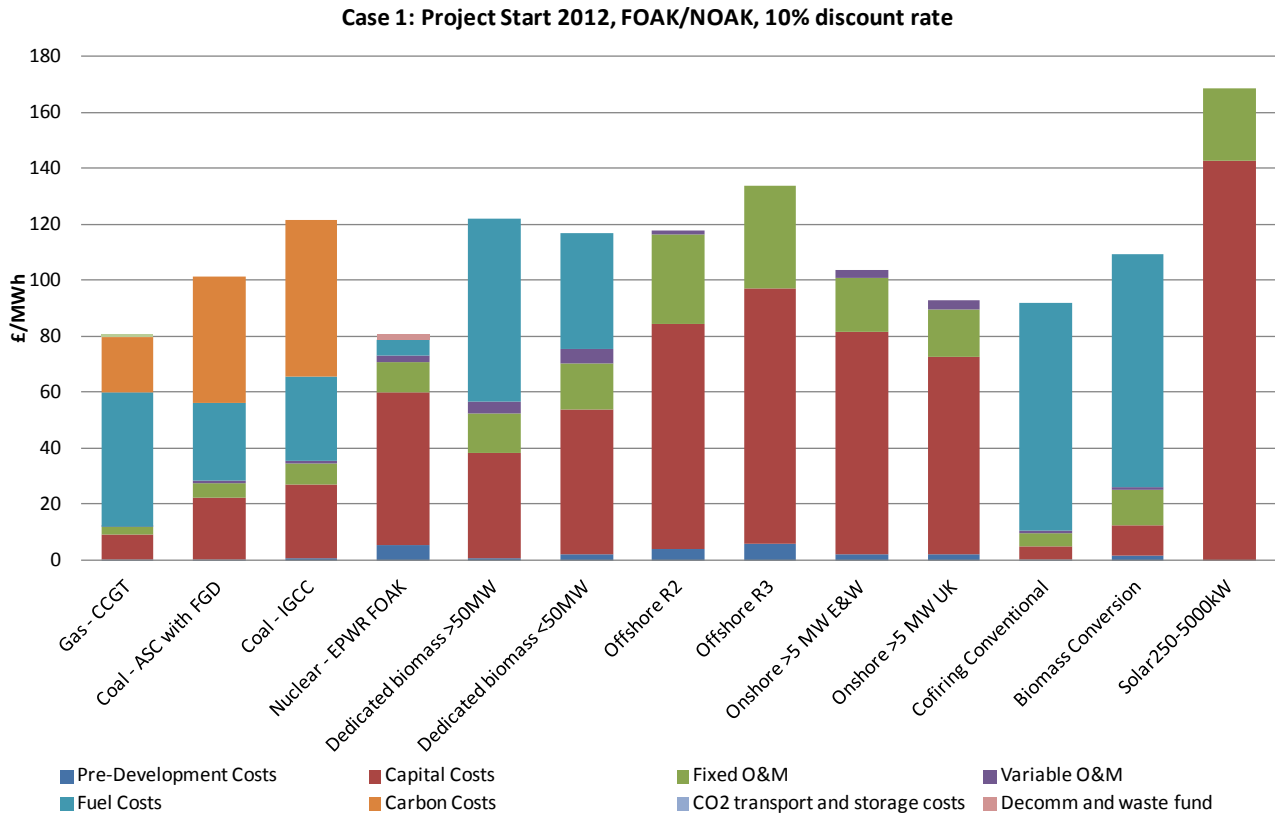
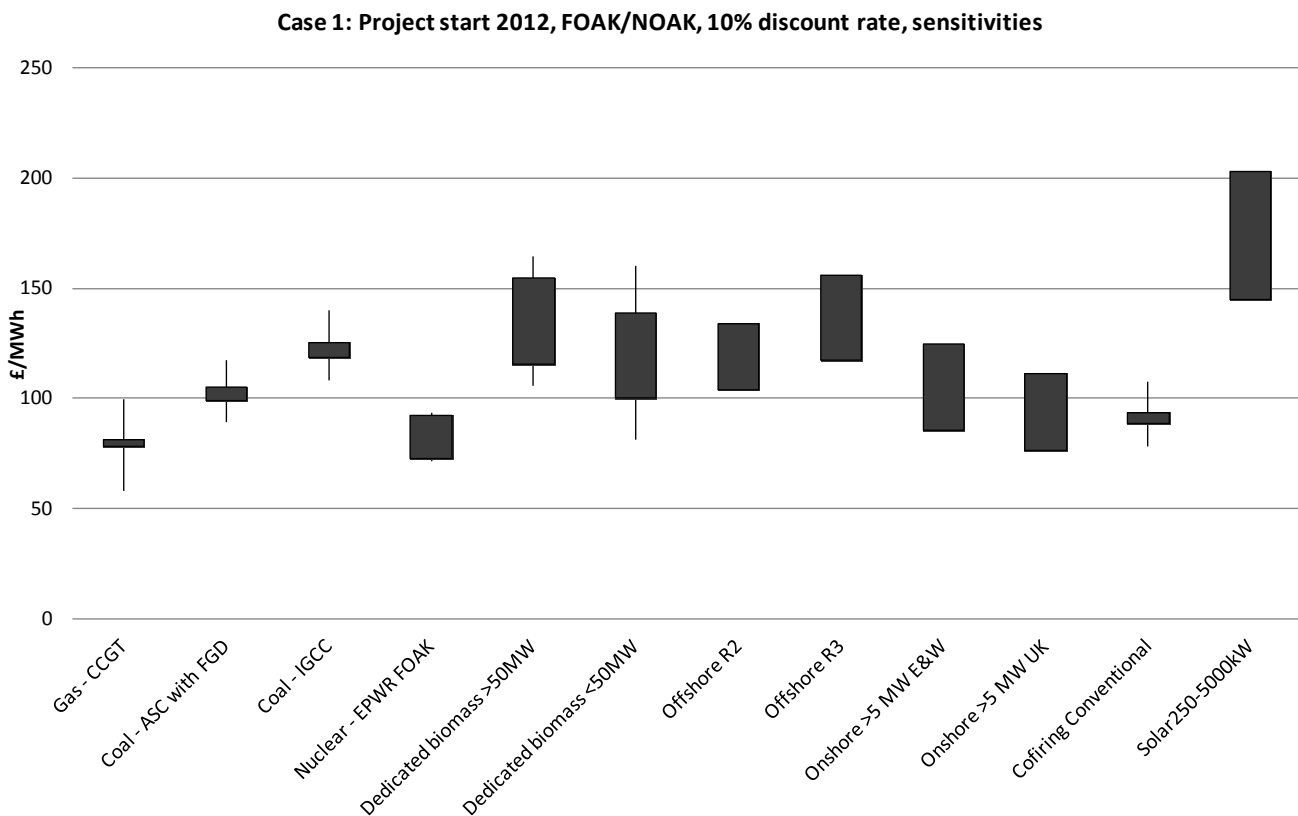


Chart 4: Levelised Cost Estimates for Projects Starting in 2012, 10% discount rate, sensitivities



Case 2: projects starting in 2018, FOAK/ NOAK, 10% discount rate¹⁵

Case 2 shows the levelised costs for projects starting in 2018 assuming that NOAK has been reached for all technologies (with the exception of CCS). A 10% discount rate has been used in this case.

Table 3 and Chart 5 show the detailed breakdown of the central levelised cost estimates for projects starting in 2018.

Table 4 and Chart 6 show the sensitivities around capex and capex and fuel prices for projects starting in 2018.

Table 3: Levelised Cost Estimates for Projects Starting in 2018, 10% discount rate

Central Levelised Costs, £/MWh	Gas - CCGT	Gas - CCGT with post comb. CCS FOAK	Gas - CCGT retro post comb. CCS FOAK	Coal - ASC with FGD	Coal - ASC with post comb. CCS FOAK	Coal - IGCC	Coal - IGCC with CCS
Pre-Development Costs	0	1	1	0	1	1	1
Capital Costs	8	24	19	21	47	26	43
Fixed O&M	3	4	4	5	10	7	9
Variable O&M	0	2	2	1	3	1	2
Fuel Costs	48	55	56	28	37	30	36
Carbon Costs	26	4	4	57	9	66	9
CO2 transport and storage	-	5	5	-	11	-	11
Decomm and waste fund	-	-	-	-	-	-	-
Heat Revenues	-	-	-	-	-	-	-
TOTAL LEVELISED COST	85	94	89	113	116	131	111

Central Levelised Costs, £/MWh	Nuclear - NOAK	Dedicated biomass >50MW	Dedicated biomass <50MW	Offshore R2	Offshore R3	Onshore >5 MW E&W	Onshore >5 MW UK
Pre-Development Costs	4	1	2	4	6	2	2
Capital Costs	50	37	51	71	76	76	68
Fixed O&M	9	14	16	28	31	19	17
Variable O&M	3	4	5	1	-	3	3
Fuel Costs	5	65	41	-	-	-	-
Carbon Costs	-	-	-	-	-	-	-
CO2 transport and storage	-	-	-	-	-	-	-
Decomm and waste fund	2	-	-	-	-	-	-
Heat Revenues	-	-	-	-	-	-	-
TOTAL LEVELISED COST	73	121	115	103	113	101	90

¹⁵ Please note these estimates should be viewed in the context of the sensitivities and uncertainties highlighted in the text of this report.

Table 3: (continued)

Central Levelised Costs, £/MWh	Cofiring Conventional	Biomass Conversion	Solar250-5000kW
Pre-Development Costs	-	2	-
Capital Costs	5	10	104
Fixed O&M	5	13	25
Variable O&M	1	1	-
Fuel Costs	81	83	-
Carbon Costs	-	-	-
CO2 transport and storage	-	-	-
Decomm and waste fund	-	-	-
Heat Revenues	-	-	-
TOTAL LEVELISED COST	92	109	129

Table 4: Levelised Cost Estimates for Projects Starting in 2018, 10% discount rate, sensitivities

Levelised Costs, £/MWh	Gas - CCGT	Gas - CCGT with post comb. CCS	Gas - CCGT retro post comb. CCS ¹⁶	Coal - ASC with FGD	Coal - ASC with post comb. CCS	Coal - IGCC	Coal - IGCC with CCS
Central	85	94	89	113	116	131	111
High Capex	86	104	98	117	136	135	141
High Capex and High Fuel	106	127	121	131	155	151	160
Low Capex and Low Fuel	64	63	59	100	88	116	75
Low Capex	84	86	82	109	101	127	87

Levelised Costs, £/MWh	Nuclear - EPWR NOAK	Dedicated biomass >50MW	Dedicated biomass <50MW	Offshore R2	Offshore R3	Onshore >5 MW E&W	Onshore >5 MW UK
Central	73	121	115	103	113	101	90
High Capex	85	153	137	118	132	122	109
High Capex and High Fuel	86	163	158	-	-	-	-
Low Capex and Low Fuel	64	105	80	-	-	-	-
Low Capex	65	114	99	91	98	83	74

Levelised Costs, £/MWh	Cofiring Conventional	Solar250-5000kW
Central	92	129
High Capex	93	154
High Capex and High Fuel	107	-
Low Capex and Low Fuel	78	-
Low Capex	88	112

¹⁶ Please note all retrofit estimates are for the retrofit of CCS only and do not include the cost of the base plant.

Chart 5: Levelised Cost Estimates for Projects Starting in 2018, 10% discount rate

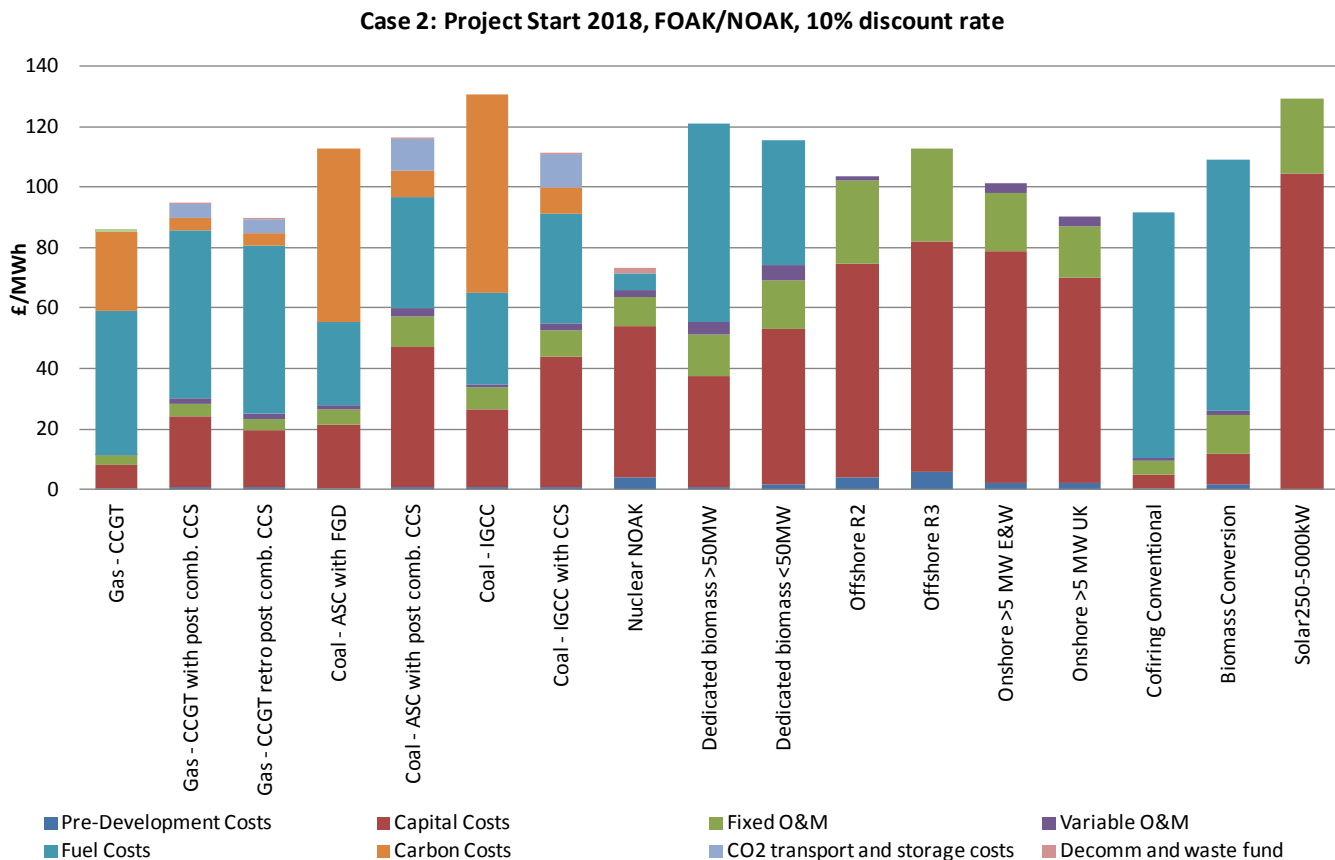
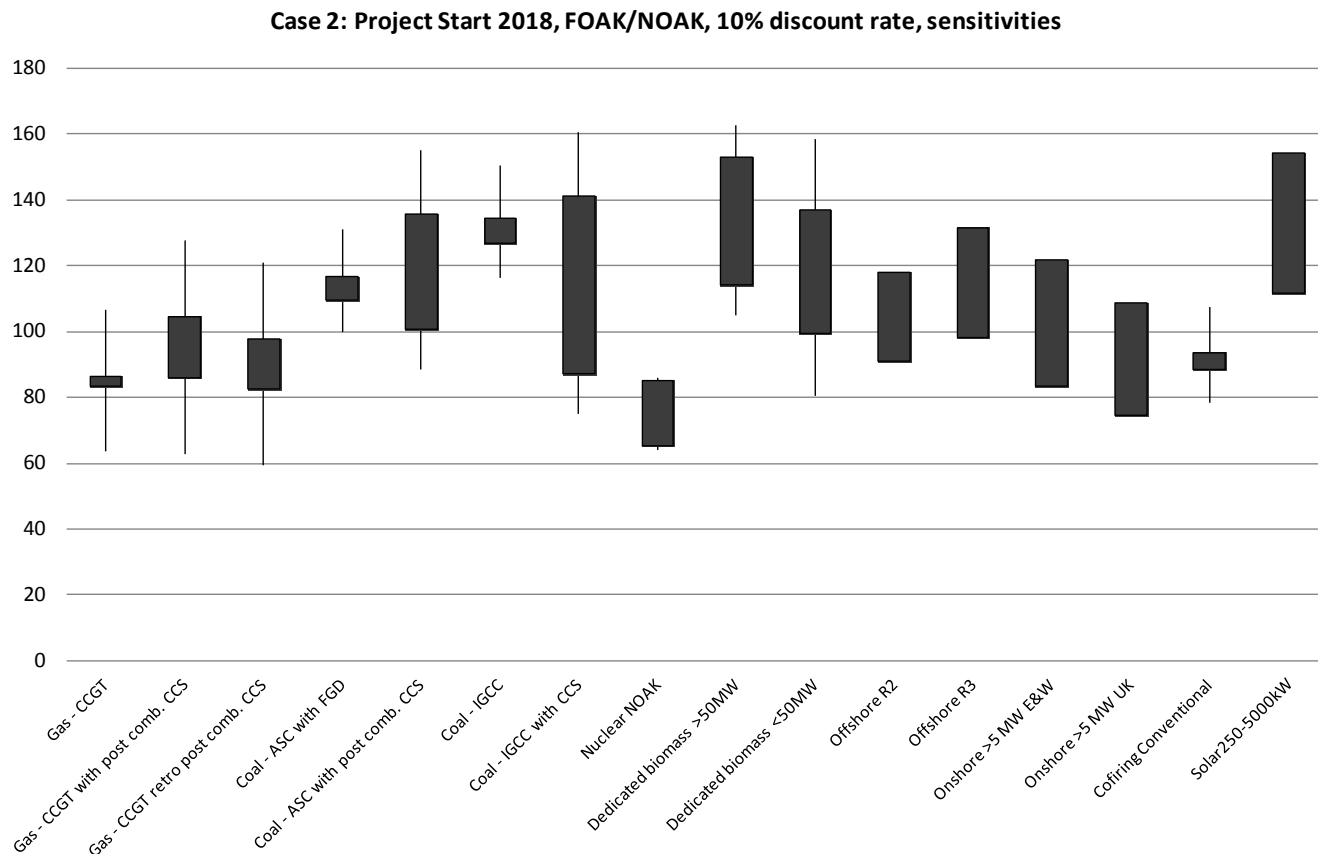


Chart 6: Levelised Cost Estimates for Projects Starting in 2018, 10% discount rate, sensitivities



Case 3: Commissioning in 2013, 2015, 2020, 2025, 2030, FOAK/ NOAK, 10% discount rate¹⁷

In order to also show the costs of technologies commissioning in the same year Case 3 illustrates the levelised costs for projects commissioning in 2013, 2015, 2020, 2025 and 2030, using a 10% discount rate.

<u>Table 5: Projects Commissioning in 2013, 2015, 2020, 2025 and 2030, FOAK/NOAK, 10% discount rate, capex sensitivity</u> Levelised Costs, £/MWh Commissioning Year		Capex	2013	2015	2020	2025	2030
Gas - CCGT	High		77	79	84	88	91
	Central		76	78	82	87	89
	Low		75	77	81	85	87
Gas - CCGT with post comb. CCS FOAK	High					104	105
	Central					94	95
	Low					86	86
Gas - CCGT retro post comb. CCS FOAK	High					97	100
	Central					89	90
	Low					82	83
Coal - ASC with FGD	High		93	97	107	117	121
	Central		90	94	104	113	117
	Low		88	91	101	109	113
Coal - ASC with post comb. CCS	High					136	137
	Central					116	116
	Low					101	101
Coal - IGCC NOAK	High			108	121	131	136
	Central			106	117	127	132
	Low			103	114	123	128
Coal - IGCC with CCS FOAK	High					109	111
	Central					111	111
	Low					88	87
Nuclear - EPWR FOAK/NOAK ¹⁸	High				96	91	85
	Central				85	79	73
	Low				77	71	65
Dedicated biomass >50MW	High		157	156	154	153	152
	Central		124	123	122	121	120
	Low		117	116	115	114	114
Dedicated biomass <50MW	High		141	140	138	137	136
	Central		119	118	116	115	115
	Low		102	101	100	99	99
Offshore R2	High		174	159	134	120	110
	Central		153	140	118	105	96
	Low		135	124	104	93	85

¹⁷ Please note these estimates should be viewed in the context of the sensitivities and uncertainties highlighted in the text of this report.

¹⁸ We have assumed that Nuclear switches from FOAK to NOAK for projects commissioning in 2029 onwards.

Table 5: (continued)

Levelised Costs, £/MWh Commissioning Year	Capex	2013	2015	2020	2025	2030
Offshore R3	High		190	162	138	125
	Central		164	139	118	107
	Low		145	122	103	93
Onshore >5 MW E&W	High	129	127	123	121	119
	Central	107	106	103	101	99
	Low	88	87	84	83	81
Onshore >5 MW UK	High	115	114	110	108	106
	Central	96	95	92	90	88
	Low	79	78	76	74	73
Cofiring Conventional	High	94	94	93	93	93
	Central	92	92	92	92	91
	Low	88	88	88	88	88
Biomass Conversion	Central	110	110	109	109	109
Solar250-5000kW	High	203	178	149	131	118
	Central	169	149	125	110	100
	Low	145	128	109	96	87

DECC Modelling

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 for the Updated Energy & Emissions Projections (which uses DECC's Dynamic Dispatch model), 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.

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 starting point for these is Oxera 2011¹⁹ and other sources²⁰, but these are adjusted to allow for the estimated impact of policies on financing costs (e.g. the impact of CfDs). As these hurdle rates are understood to incorporate an allowance for a return on pre-development costs, pre-development costs are not separately included in the investment decision modelling to avoid double counting.

¹⁹

<http://hmccc.s3.amazonaws.com/Renewables%20Review/Oxera%20low%20carbon%20discount%20rates%20180411.pdf>

²⁰ See Annex 4 for further details

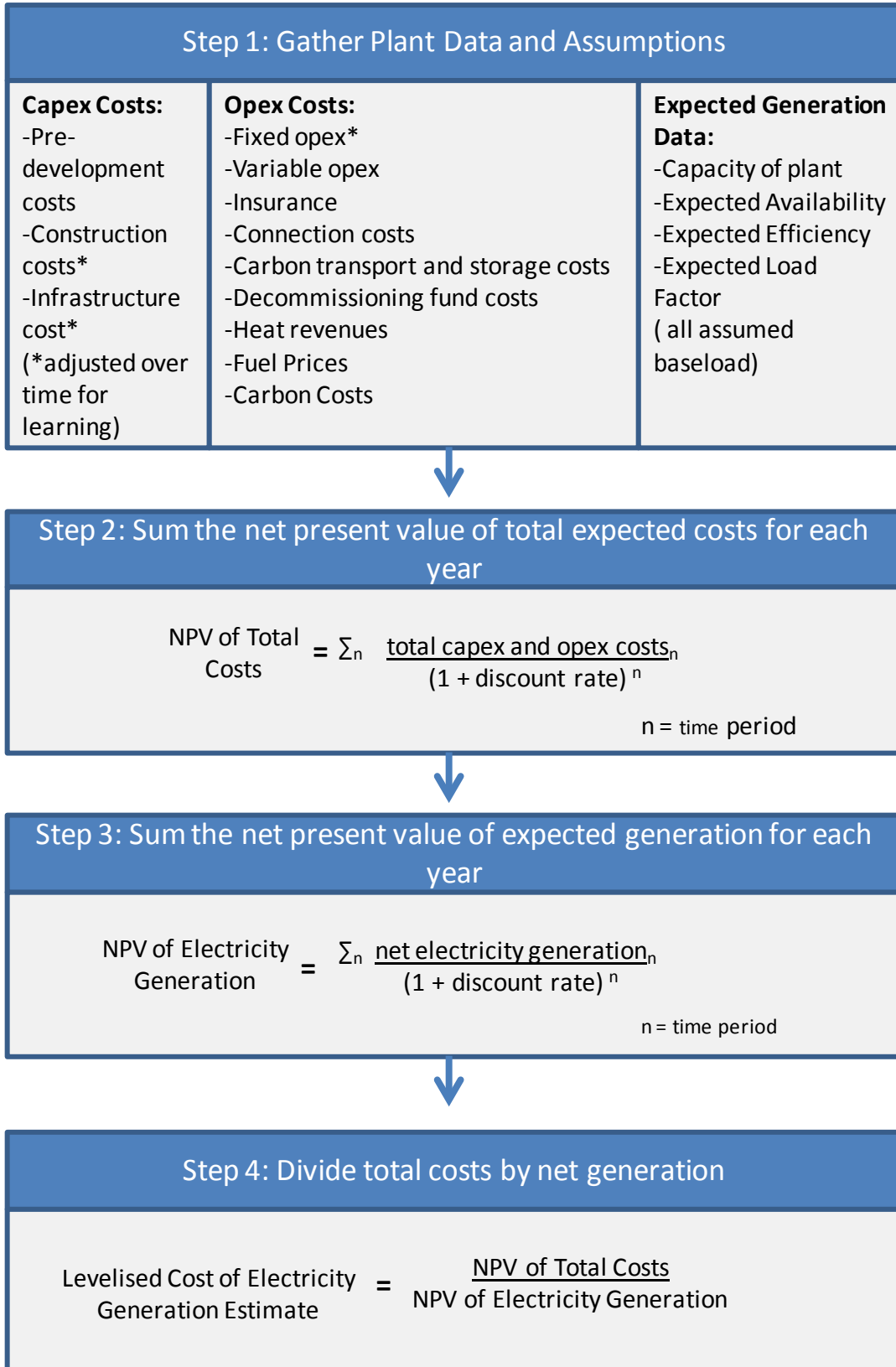
Annex 1: Key timings for selected technologies

<u>Table 6:Central Estimates for project timings for selected technologies</u>	Pre-development Period (years)	Construction Period (years)
Gas - CCGT	2	3
Gas - CCGT with post comb. CCS FOAK	5	5
Gas - CCGT retro post comb. CCS FOAK	4	4
Coal - ASC with FGD	4	3
Coal - ASC with post comb. CCS FOAK	5	5
Coal – IGCC	5	5
Coal - IGCC with CCS FOAK	5	6
Nuclear - NOAK	5	5
Nuclear - FOAK	5	6
Dedicated biomass >50MW	3	3
Dedicated biomass 5-50MW	4	2
Offshore R1/2	5	3
Offshore R3	6	3
Onshore >5 MW	4	2
Cofiring Conventional	1	1
Biomass Conversion	2	1

Please see assumptions section for details of sources

Annex 2: Calculating Levelised Cost Estimates

The below figure, demonstrates at a high level how Levelised Costs are calculated.



Annex 3: Additional Estimates for Renewables Technologies

This Annex presents estimates for the same Cases described in the main report for additional renewable technologies.

Case 1: projects starting in 2012, NOAK, 10% discount rate²¹

Table 7: Levelised Cost Estimates for Projects Starting in 2012, 10% discount rate

Levelised Costs, £/MWh	Co-firing Standard CHP	Hydro Large STORE	ACT standard	Bioliqids	Bioliqids CHP	EfW CHP	EfW
Pre-Development Costs	-	2	7	5	5	-	-
Capital Costs	62	90	84	21	21	95	75
Fixed O&M	32	8	58	22	22	42	36
Variable O&M	2	6	24	6	6	30	24
Fuel Cost	63	-	-27	272	272	-121	-100
Carbon Costs	-	-	-	-	-	-	-
Heat Revenues	-57	-	-	-	-14	-13	-
TOTAL LEVELISED COST	102	106	145	325	211	32	35

Levelised Costs, £/MWh	Geothermal	Geothermal CHP	Hydropower 5-16MW	ACT advanced	ACT CHP	Sewage Gas	Landfill
Pre-Development Costs	3	3	2	8	2	0	3
Capital Costs	66	72	110	104	101	69	41
Fixed O&M	14	14	17	58	67	18	9
Variable O&M	11	10	6	13	24	-	9
Fuel Costs	-	-	-	-23	-32	-	-
Carbon Costs	-	-	-	-	-	-	-
Heat Revenues	-	-55	-	-	-16	-	-
TOTAL LEVELISED COST	94	45	134	159	145	87	62

Levelised Costs, £/MWh	Biomass CHP	AD CHP	Solar<4kW	Energy crops (small)	Energy crops (large)	Onshore <15kW	Onshore 1MW<5MW
Pre-Development Costs	2	3	-	2	1	-	-
Capital Costs	63	67	281	52	38	414	107
Fixed O&M	24	58	29	16	14	49	14
Variable O&M	10	21	-	5	4	-	-
Fuel Costs	119	-56	-	96	82	-	-
Carbon Costs	-	-	-	-	-	-	-
Heat Revenues	-35	-15	-	-	-	-	-
TOTAL LEVELISED COST	182	78	310	172	139	463	121

²¹ Please note these estimates should be viewed in the context of the sensitivities and uncertainties highlighted in the text of this report

Table 7: (continued)

Levelised Costs, £/MWh	AD < 250kW	AD > 500kW	Hydropower <15kW	Hydropower 100kW-1000kW
Pre-Development Costs	-	-	-	-
Capital Costs	134	75	341	162
Fixed O&M	176	102	36	34
Variable O&M	-	-	-	-
Fuel Costs	-	-70	-	-
Carbon Costs	-	-	-	-
Heat Revenues	-	-	-	-
TOTAL LEVELISED COST	310	107	377	196

Table 8: Levelised Cost Estimates for Projects Starting in 2012, 10% discount rate, sensitivities

Levelised Costs, £/MWh	ACT standard	Bioliquids	Bioliquids CHP	EfW CHP	EfW	Geothermal	Geothermal CHP
Central	145	325	211	32	35	94	45
High Capex	225	378	365	43	40	125	77
High Capex and High Fuel	245	392	379	61	55	-	-
Low Capex and Low Fuel	58	225	210	3	15	-	-
Low Capex	72	313	298	21	30	59	7

Levelised Costs, £/MWh	Hydropower 5-16MW	ACT advanced	ACT CHP	Sewage Gas	Landfill	Biomass CHP	AD CHP
Central	134	159	145	87	62	182	78
High Capex	149	172	229	131	90	202	134
High Capex and High Fuel	-	190	253	-	-	219	164
Low Capex and Low Fuel	-	117	45	-	-	146	-53
Low Capex	82	129	61	62	40	163	38

Levelised Costs, £/MWh	Solar<4kW	Energy crops (small)	Energy crops (large)	Onshore <15kW	Onshore 1MW<5MW	AD < 250kW	AD > 500kW
Central	310	172	139	463	121	310	107
High Capex	400	194	172	503	137	358	134
High Capex and High Fuel	-	210	186	-	-	-	166
Low Capex and Low Fuel	-	138	117	-	-	-	-14
Low Capex	248	156	133	429	100	265	82

Levelised Costs, £/MWh	Hydropower <15kW	Hydropower 100kW-1000kW
Central	377	196
High Capex	805	393
Low Capex	187	106

Case 2: projects starting in 2018, NOAK, 10% discount rate²²

Table 7: Levelised Cost Estimates for Projects Starting in 2018, 10% discount rate

Levelised Costs, £/MWh	Co-firing Standard CHP	Hydro Large STORE	ACT standard	Bioliqids	Bioliqids CHP	EfW CHP	EfW
Pre-Development Costs	1	2	7	5	5	-	-
Capital Costs	62	102	80	20	20	93	74
Fixed O&M	32	9	55	21	21	42	36
Variable O&M	2	-	23	5	5	30	24
Fuel Cost	63	-	-24	264	264	-121	-100
Carbon Costs	-	-	-	-	-	-	-
Heat Revenues	-56	-	-	-	-14	-14	-
TOTAL LEVELISED COST	104	117	140	316	302	30	34

Levelised Costs, £/MWh	Geothermal	Geothermal CHP	Hydropower 5-16MW	ACT advanced	ACT CHP	Sewage Gas	Landfill
Pre-Development Costs	3	3	2	8	2	-	3
Capital Costs	64	70	123	100	96	66	40
Fixed O&M	14	14	17	55	63	18	10
Variable O&M	11	10	6	12	23	-	9
Fuel Costs	-	-	-	-21	-28	-	-
Carbon Costs	-	-	-	-	-	-	-
Heat Revenues	-	-55	-	-	-16	-	-
TOTAL LEVELISED COST	92	42	148	154	140	84	61

Levelised Costs, £/MWh	Biomass CHP	AD CHP	Solar<4kW	Energy crops (small)	Energy crops (large)	Onshore <15kW	Onshore 1MW<5MW
Pre-Development Costs	2	3	-	2	1	-	-
Capital Costs	62	64	204	51	37	414	107
Fixed O&M	23	59	28	16	14	49	14
Variable O&M	9	21	-	5	4	-	-
Fuel Costs	119	0	-	97	83	-	-
Carbon Costs	-	-	-	-	-	-	-
Heat Revenues	-35	-15	-	-	-	-	-
TOTAL LEVELISED COST	180	131	231	171	139	463	121

²² Please note these estimates should be viewed in the context of the sensitivities and uncertainties highlighted in the text of this report

Table 9: (continued)

Levelised Costs, £/MWh	AD < 250kW	AD > 500kW	Hydropower <15kW	Hydropower 100kW-1000kW
Pre-Development Costs	-	-	-	-
Capital Costs	134	75	341	162
Fixed O&M	176	102	36	36
Variable O&M	-	-	-	-
Fuel Costs	-	-3	-	-
Carbon Costs	-	-	-	-
Heat Revenues	-	-	-	-
TOTAL LEVELISED COST	310	174	377	196

Table 10: Levelised Cost Estimates for Projects Starting in 2018, 10% discount rate, sensitivities

Levelised Costs, £/MWh	ACT standard	Bioliqids	Bioliqids CHP	EfW CHP	EfW	Geothermal	Geothermal CHP
Central	140	316	302	30	34	92	42
High Capex	217	367	355	41	38	123	74
High Capex and High Fuel	237	387	371	19	53	-	-
Low Capex and Low Fuel	56	224	210	59	14	-	-
Low Capex	69	303	289	-1	29	58	5

Levelised Costs, £/MWh	Hydropower 5-16MW	ACT advanced	ACT CHP	Sewage Gas	Landfill	Biomass CHP	AD CHP
Central	148	154	140	84	61	180	131
High Capex	164	166	220	126	90	199	185
High Capex and High Fuel	-	184	244	-	-	217	215
Low Capex and Low Fuel	-	113	43	-	-	144	3
Low Capex	89	124	59	60	39	161	93

Levelised Costs, £/MWh	Solar<4kW	Energy crops (small)	Energy crops (large)	Onshore <15kW	Onshore 1MW<5MW	AD < 250kW	AD > 500kW
Central	231	171	139	463	121	310	174
High Capex	297	193	170	530	144	369	208
High Capex and High Fuel	-	209	184	-	-	-	240
Low Capex and Low Fuel	-	139	118	-	-	-	52
Low Capex	187	155	132	425	98	264	149

Levelised Costs, £/MWh	Hydropower <15kW	Hydropower 100kW-1000kW
Central	377	196
High Capex	852	415
Low Capex	185	105

Case 3: Commissioning in 2013, 2015, 2020, 2025, 2030, NOAK, 10% discount rate²³

Table 11: Projects Commissioning in 2013,2015, 2020, 2025 and 2030, NOAK, 10%discount rate, capex sensitivity, £/MWh

Commissioning, £/MWh	Capex	2013	2015	2020	2025	2030
Co-firing Standard CHP	Central	103	103	104	104	104
Hydro_LargeSTORE	Central	104	108	117	122	122
ACT standard	High	230	226	218	214	209
	Central	149	146	141	138	133
	Low	73	72	70	68	64
Bioliquids	High	380	375	367	366	365
	Central	327	323	316	314	314
	Low	315	310	303	302	301
Bioliquids CHP	High	368	363	355	353	351
	Central	314	309	302	300	299
	Low	301	296	289	288	286
EfW CHP	High	44	44	42	41	40
	Central	33	32	31	30	30
	Low	22	21	20	19	19
EfW	High	41	40	39	38	38
	Central	36	36	34	34	33
	Low	31	30	29	28	28
Geothermal	High	157	143	124	122	120
	Central	116	106	93	92	90
	Low	70	65	58	58	57
Geothermal CHP	High	111	96	76	73	70
	Central	69	58	44	42	40
	Low	19	13	6	5	4
Hydropower 5-16MW	High	142	147	159	164	164
	Central	128	132	144	149	149
	Low	79	81	87	89	90
ACT advanced	High	176	173	168	164	160
	Central	163	161	155	152	147
	Low	132	130	125	122	118
ACT CHP	High	235	231	222	217	211
	Central	149	147	141	138	132
	Low	62	61	59	57	53
Sewage Gas	High	132	131	127	125	124
	Central	88	87	85	84	83
	Low	62	62	60	60	59
Landfill	High	91	90	90	89	89
	Central	62	62	61	61	61
	Low	40	40	39	39	39

²³ Please note these estimates should be viewed in the context of the sensitivities and uncertainties highlighted in the text of this report

Table 11: (continued)

Commissioning, £/MWh	Capex	2013	2015	2020	2025	2030
Biomass CHP	High	206	204	201	199	198
	Central	185	184	182	180	179
	Low	165	164	162	161	160
AD CHP	High	118	148	185	183	182
	Central	62	92	93	93	93
	Low	22	53	93	93	93
Solar<4kW	High	400	346	287	252	230
	Central	310	269	224	198	181
	Low	248	216	181	160	147
Onshore <15kW	High	503	512	535	559	585
	Central	463	463	463	462	462
	Low	429	429	423	413	404
Onshore 1MW<5MW	High	137	139	146	152	159
	Central	121	121	121	121	121
	Low	100	99	98	96	94
AD < 250kW	High	358	362	371	381	392
	Central	310	310	310	310	310
	Low	265	265	263	261	259
AD > 500kW	High	134	167	212	218	223
	Central	107	137	177	177	177
	Low	82	112	151	150	149
Hydropower <15kW	High	805	820	860	902	947
	Central	377	377	377	377	377
	Low	187	187	185	181	177
Hydropower 100kW-1000kW	High	394	400	419	439	459
	Central	196	196	196	196	196
	Low	106	106	105	103	101
Energy crops (small)	High	196	195	193	193	192
	Central	174	173	171	171	170
	Low	157	156	155	155	154
Energy crops (large)	High	174	173	171	170	169
	Central	141	140	139	138	138
	Low	134	133	132	132	131
Amalgamated Wave	Central				194	160
Tidal stream shallow	High				168	144
	Central				163	146
	Low				133	120
Tidal stream deep	High				164	143
	Central				147	128
	Low				130	114
Tidal range	High				283	283
	Central				229	229
	Low				172	172

Annex 4: Estimates for Renewables Technologies using technology specific hurdle rates

This annex shows estimates using technology-specific ‘discount’ or ‘hurdle’ rates²⁴ for renewable technologies, in line with the approach used in reports on renewables levelised costs commissioned by DECC and its predecessor departments in recent years.

The starting point for these rates is Oxera 2011²⁵ along with other sources²⁶. These are adjusted to allow for the estimated impact of policies on financing costs (e.g. the impact of the Renewables Obligation, Feed in Tariffs and Energy Market Reforms).

Case 4: renewable projects commissioning in 2013-16, 2020, 2025, 2030, NOAK, technology specific hurdle rates²⁷

Table 12: Projects Commissioning in 2013,2015, 2020, 2025 and 2030, NOAK, technology specific hurdle rates, capex sensitivity

Commissioning, £/MWh	Capex	2013	2015	2020	2025	2030
Co-firing Standard CHP	Central	109	108	106	106	106
Hydro_LargeSTORE	Central	83	86	88	91	92
ACT standard	High	224	221	200	196	191
	Central	145	143	132	128	124
	Low	73	72	68	66	62

²⁴ Please note that hurdle rates are themselves uncertain and likely to vary between projects and financing structures/providers.

²⁵

<http://hmccc.s3.amazonaws.com/Renewables%20Review/Oxera%20low%20carbon%20discount%20rates%20180411.pdf>

²⁶ Please see Arup 2011, Government Response to the RO and the following Feed in Tariff Impact Assessment for more details:

2a: Impact Assessment: Government response to consultation on Feed-in Tariffs Comprehensive Review Phase

2A: Solar PV Tariffs and cost control:

http://www.decc.gov.uk/en/content/cms/consultations/fits_rev_ph2a/fits_rev_ph2a.aspx

2b: Impact Assessment: Government Response to Consultation on the Comprehensive Review Phase 2B - on

Feed-in Tariffs for anaerobic digestion, wind, hydro and micro-CHP installations:

http://www.decc.gov.uk/en/content/cms/consultations/fits_rev_ph2b/fits_rev_ph2b.aspx

²⁷ Please note these estimates should be viewed in the context of the sensitivities and uncertainties highlighted in the text of this report.

Table 12: (continued)

Commissioning, £/MWh	Capex	2013	2015	2020	2025	2030
Dedicated biomass >50MW	High	176	174	166	158	157
	Central	134	133	128	124	123
	Low	125	124	120	117	116
Dedicated biomass 5-50MW	High	160	158	150	142	141
	Central	132	131	125	119	118
	Low	111	110	106	102	101
Offshore R2	High	193	177	138	110	101
	Central	169	155	121	97	88
	Low	148	136	107	86	78
Offshore R3	High		231	188	146	116
	Central		198	161	125	100
	Low		172	139	108	87
Onshore >5 MW E&W	High	125	124	112	110	108
	Central	105	103	94	92	91
	Low	86	85	78	77	75
Onshore >5 MW UK	High	112	111	100	99	97
	Central	93	92	84	83	81
	Low	77	76	70	68	67
Bioliquids	High	391	386	374	369	368
	Central	331	326	318	315	315
	Low	317	312	305	303	302
Bioliquids CHP	High	383	378	366	360	358
	Central	319	314	305	302	301
	Low	304	299	291	289	287
Cofiring Conventional	High	94	94	93	93	93
	Central	92	92	92	92	91
	Low	88	88	88	88	88
Biomass Conversion	Central	111	111	110	110	110
EfW CHP	High	74	73	62	61	60
	Central	60	58	49	48	47
	Low	45	44	36	35	34
EfW	High	56	55	47	47	46
	Central	50	50	42	42	41
	Low	44	43	36	36	36
Geothermal	High	357	322	254	176	137
	Central	252	228	181	128	102
	Low	137	125	101	75	63
Geothermal CHP	High	328	288	213	132	94
	Central	216	187	135	80	55
	Low	84	69	44	20	9
Hydropower 5-16MW	High	114	117	120	124	124
	Central	103	106	109	113	113
	Low	65	67	69	71	71
ACT advanced	High	205	202	186	171	166
	Central	189	186	171	157	153
	Low	151	148	137	126	122
ACT CHP	High	301	296	270	247	240
	Central	185	181	167	154	148
	Low	67	65	63	59	55

Table 12: (continued)

Commissioning, £/MWh	Capex	2013	2015	2020	2025	2030
Sewage Gas	High	128	118	114	113	112
	Central	86	79	77	76	76
	Low	61	57	55	55	55
Landfill	High	89	89	85	84	84
	Central	61	61	58	58	58
	Low	39	39	38	38	38
Biomass CHP	High	233	231	221	211	210
	Central	206	204	196	189	188
	Low	179	177	172	167	166
AD CHP	High	143	170	213	201	199
	Central	69	101	146	140	139
	Low	16	52	99	96	96
Solar<4kW	High	305	288	271	253	238
	Central	238	208	174	154	142
	Low	192	151	126	114	107
Solar250-5000kW	High	165	150	138	127	117
	Central	138	117	100	88	80
	Low	119	92	79	71	65
Onshore <15kW	High	461	469	490	512	535
	Central	425	425	424	424	423
	Low	394	394	388	379	371
Onshore 1MW<5MW	High	126	128	134	140	146
	Central	111	111	111	111	111
	Low	92	92	90	88	86
AD < 250kW	High	399	392	403	397	409
	Central	340	332	332	320	320
	Low	285	280	278	268	266
AD > 500kW	High	148	179	230	227	233
	Central	115	145	190	183	183
	Low	84	116	159	154	153
Hydropower <15kW	High	635	647	678	711	746
	Central	302	302	302	302	302
	Low	153	153	152	149	146
Hydropower 100kW-1000kW	High	314	320	334	349	366
	Central	160	160	160	160	160
	Low	90	90	89	88	86
Energy crops (small)	High	215	213	205	198	197
	Central	187	186	180	175	174
	Low	166	165	161	158	157
Energy crops (large)	High	192	191	183	176	175
	Central	150	150	145	141	141
	Low	142	141	137	134	134
Amalgamated Wave	Central				216	166
Tidal stream shallow	High				202	167
	Central				185	153
	Low				150	126
Tidal stream deep	High				187	150
	Central				167	135
	Low				147	119

Table 12: (continued)

Commissioning, £/MWh	Capex	2013	2015	2020	2025	2030
Tidal range	High				218	218
	Central				165	165
	Low				126	126

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3 Whitehall Place
London SW1A 2AW
www.decc.gov.uk

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