Department for
Business, Energy
& Industrial Strategy

ELECTRICITY GENERATION COSTS

November 2016

ELECTRICITY GENERATION COSTS

November 2016

Any enquiries regarding this publication should be sent to us at generationcosts@beis.gsi.gov.uk

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.

The Department for Business, Energy and Industrial Strategy (BEIS) regularly updates estimates of the costs and technical specifications for different generation technologies used in its analysis (these were previously published by the Department of Energy and Climate Change (DECC)). 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 carbon costs.

During 2015, DECC undertook several major updates to the assumptions that underlie its levelised cost analysis.

- NERA Economic Consulting provided DECC with a report on the hurdle rates that could be applied to electricity generation technologies.[2]
- Arup provided a report that updated DECC's cost and technical assumptions for renewable technologies.[3] [4]
- The Impact Assessment for the Periodic Review of FITS (2015) provided data for Small-scale Feed in Tarff (FITs) technologies (solar PV, wind, and hydro).[5]
- Parsons Brinkerhoff (PB) provided data for Small-scale Feed in Tarff (FITs) AD technologies.[6]
- Leigh Fisher (with Jacobs), who provided a report that updated DECC's cost and technical assumptions for non-renewable technologies[7].

These updated detailed data are used by BEIS 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. It reflects the cost of building, operating and

[1] Including pre-development, construction, operation and de-commissioning costs.
[2] NERA Economic Consulting, 2016, *Electricity Generation Costs and Hurdle Rates: Lot 1: Hurdle Rates for Generation Technologies.*
[3] Arup 2016, *Review of Renewable Electricity Generation Cost and Technical Assumptions*.
[4] The one exception was AD, where BEIS used data based on the biomethane review (DECC 2014, *Renewable Heat Incentive – Biomethane Tariff Review (Impact Assessment)*).
[5] DECC 2015, *Periodic Review of FITs 2015 (Impact Assessment)*.
[6] Parsons Brinckerhoff 2015 (for DECC), *Small Scale Cost Generation Costs Update.*
[7] Leigh Fisher & Jacobs, 2016, *Electricity Generation Costs and Hurdle Rates: Lot 3: Non-Renewable Technologies.*

decommissioning a generic plant for each technology. Potential revenue streams are not considered[8].

It is important to note that there a number of reasons why administrative strike prices for Contracts for Difference (CfD) introduced as part of Electricity Market Reform are likely to be different to the estimates of levelised costs in this report. While levelised cost assumptions, such as those summarised in this report, form an input to the calculation of administrative strike prices, levelised costs are not the same as strike prices. Administrative strike prices are set using levelised cost evidence, but also take into account other factors such as market conditions and policy considerations. For further details, please see 'How we use data in modelling' section below.

This report is structured as follows:

- The first section details the methodology, data and assumptions used to generate the levelised cost estimates. This section also includes a discussion of how we use the data in modelling, including some of the limitations of these estimates.

- The second section presents selected 'levelised cost' estimates generated using BEIS's Levelised Cost Model and technology-specific hurdle rates for investors.

- The third section provides information around the sensitivity of the levelised cost results to different cost and technical assumptions.

- The fourth section presents an alternative metric to levelised costs for peaking technologies (£/kW).

- 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 also provides comparable information to previous editions of this report, including levelised cost estimates at more generic hurdle rates (10%, 7% and 3.5%) and for projects starting at a particular date (2015).

It is important to note there is a large amount of uncertainty when estimating current and future costs of electricity generation. For example:

- uncertainty over costs will be greater for more immature technologies;

- variation in capital and operating costs across sites;

[8] With the exception of heat revenues for CHP technologies.

- differences and uncertainty over load factors and hurdle rates.

- uncertainty over the fuel and carbon price trajectory for relevant technologies; and

This report has attempted to capture some of the above uncertainty by portraying ranges and in the new sensitivity analysis section. However, not all sensitivities and sources of uncertainty are captured.

While we consider that the ranges of levelised cost estimates presented in this report are robust for BEIS analysis, these estimates should also be used with a level of care given the above uncertainties and further considerations, listed below.

- The analysis by contractors was largely undertaken in 2015.

- Further to the above, the section in the report comparing levelised cost estimates for renewable technologies to the previous equivalent BEIS (rom DECC) report illustrates that based on previous experience, there is a risk that some of the projected cost reductions assumed going forward may be conservative for some technologies, especially renewables. In the future, there may also be unanticipated cost reductions and technological improvements, reductions in hurdle rates, and/or technological progress occurring faster than previously estimated.

- While BEIS has used updated fossil fuel prices and carbon values in this report[9], fossil fuel prices and carbon values are subject to considerable uncertainty. Implications of different assumptions are illustrated in the sensitivity analysis contained in this report.

- The levelised costs presented in this report are based on load factor assumptions that generally reflect the maximum potential (net of availability) of a plant (except for OCGTs and reciprocating engines).[10] Where flexible technologies such as CCGT and CCS plants operate at lower load factors, their levelised costs will be higher than those presented here.

All estimates are in 2014 real values.

[9] Refer to relevant section in this report.

[10] The load factors for wind, solar photovoltaic (PV) and marine technologies reflect that they operate as intermittent electricity generation 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.[11]

For further information on how levelised costs are calculated and BEIS’s Levelised Cost Model please refer to section 4.2 Mott MacDonald (2010). [12]

[11] Note that in this table, net electricity generation refers to gross generation minus any internal plant losses/use before electricity is exported to the electricity network.
[12] Mott MacDonald, 2010, *UK Generation Costs Update*.

Chart 1: Levelised costs

Step 1: Gather Plant Data and Assumptions

Capex Costs:	Opex Costs:	Expected Generation Data:
-Pre-development costs -Construction costs* -Infrastructure cost* (*adjusted over time for learning)	-Fixed opex* -Variable opex -Insurance -Connection costs -Carbon transport and storage costs -Decommissioning fund costs -Heat revenues -Fuel Prices -Carbon Costs	-Capacity of plant -Expected Availability -Expected Efficiency -Expected Load Factor (all assumed baseload)

Step 2: Sum the net present value of total expected costs for each year

$$\text{NPV of Total Costs} = \sum_n \frac{\text{total capex and opex costs}_n}{(1 + \text{discount rate})^n}$$

n = time period

Step 3: Sum the net present value of expected generation for each year

$$\text{NPV of Electricity Generation} = \sum_n \frac{\text{net electricity generation}_n}{(1 + \text{discount rate})^n}$$

n = time period

Step 4: Divide total costs by net generation

$$\text{Levelised Cost of Electricity Generation Estimate} = \frac{\text{NPV of Total Costs}}{\text{NPV of Electricity Generation}}$$

£/kW estimates for Gas and Diesel technologies

As an alternative to Levelised Costs, a £/kW measure covering the fixed costs from the pre-development period to the end of operation (including construction, pre-development, and fixed operating costs) is presented for peaking technologies (Open Cycle Gas Turbines (OCGT) and reciprocating engines), as well as Combined Cycle Gas Turbines (CCGT) for comparison purposes. [13]

Unlike levelised costs, this measure ignores generation, and so excludes fuel costs, carbon costs, and other variable costs. This measure is arguably more suitable for comparing technologies where generation is more likely to vary with demand (i.e. for peaking technologies).[14]

Data Sources and Assumptions

Data Sources

The following data sources and assumptions were used to calculate the levelised costs estimates presented in this report.

Annex 3 provides further explanation on the data used to inform BEIS's electricity generation cost estimates, and the full list of capital costs and operating costs used in BEIS electricity market modelling. This Annex also lists gross load factors[15], plant availability, build and operating period durations, hurdle rate and effective tax rate assumptions.

All costs in this report are expressed in 2014 values.[16]

Hurdle rates

NERA Economic Consulting provided DECC with a report on hurdle rates for projects starting development from 2015. This informed the hurdle rates that BEIS has applied across all technologies.[17] [18]

[13] This metric is not meant to illustrate likely capacity market outcomes, which will reflect a range of other factors, including different contract lengths, load factor and wholesale price expectations and other sources of revenue.

[14] The IEA/NEA have produced a similar $/kW metric to measure what they call the 'levelised cost of capacity' in order to provide a reference point of costs for plants built to meet reliability standards in the system and which only generate very rarely. IEA and NEA, *Projected Cost of Generating Electricity 2015*.

[15] This is the proportion of generated electricity as a percentage of installed capacity when the plant is available for operation (gross load factors). The Appendix presents information on net load factors, which combine plant availability and gross load factors.

[16] The previous DECC Electricity Generation Costs Report (Dec 2013) used 2012 values for costs.

[17] NERA Economic Consulting, 2016, *Electricity Generation Costs and Hurdle Rates: Lot 1: Hurdle Rates for Generation Technologies.*

For Feed-in Tariffs (FITs) technologies, BEIS has drawn on evidence presented in the Impact Assessment for the Periodic Review of FITS (2015), which provided data for small-scale Feed in Tarff (FITs) technologies.[19]

Further information is provided on both of the above evidence bases in the 'Financing and Hurdle Rate' section below.

Renewable Technologies:

Arup provided a report that updated BEIS's cost and technical assumptions for larger-scale renewable technologies for projects reaching FID between 2015 and 2030.[20]

It should be noted that for some technologies Arup provided results that BEIS has decided not to use. This is further outlined in Annex 3.

For FITS technologies (except AD) we have used the evidence presented in the above Government response to the recent consultation exercise. This covers PV, wind, and hydro. For Anaerobic Digestion (AD) we have used the recent Parsons Brinkerhoff report.[21]

Non – Renewable Technologies:

Leigh Fisher provided a report that updated BEIS's cost and technical assumptions for non-renewable technologies for projects reaching Final Investment Decision (FID) between 2015 and 2030. It should be noted that for some technologies Leigh Fisher provided results that BEIS has decided not to use. This is further outlined in Annex 3.

Fuel and decommissioning costs, and carbon prices were provided by BEIS. Note that the levelised cost results in Leigh Fisher's publication are based on DECC 2016 fossil fuel prices and updated carbon prices (both forthcoming). These have been updated for revised fossil fuel prices and carbon values (further information below) in this publication.

Further Assumptions

The following key assumptions have also been used for the baseline analysis:

- **Fuel and Carbon Prices**: BEIS's updated projected fossil fuel prices, and BEIS's pre-existing uranium fuel prices are used. For gas and coal plants, the total carbon price up until 2020/21 is given by the sum of the 2016 EU-ETS carbon price projections and the rate of Carbon Price Support (CPS). This

---

[18] With the exception of pumped storage technologies (not originally covered by the NERA work).
[19] DECC 2015, *Periodic Review of FITs 2015 (Impact Assessment)*.
[20] Note that in several cases, Arup needed to use pre-existing data (with this noted in the Arup report). Arup also provide fuel prices and gate fees for relevant renewable technologies.
[21] Parsons Brinckerhoff 2015 (for DECC), *Small Scale Cost Generation Costs Update.*

latter is set at £18/tCO2 until 2019/20 and at £18/tCO2 uprated with inflation in 2020/21 in line with recent government announcements. For the purposes of modelling we have assumed that the total carbon price after 2020/21 remains constant in real terms. However, the projected EU ETS price exceeds the total carbon price from the mid-2020s, and reaches around £35/tCO2 in 2030 (in 2012 prices).[22] As a result we assume that from the point where the EU ETS price exceeds the total carbon price and till 2030, the carbon price faced by the gas and coal sectors coincides with the EU ETS price. Beyond 2030, the total carbon price increases linearly to reach around £200/t in 2050 (in 2012 prices).[23] [24] [25]

- **Nuclear decommissioning and waste costs**: pre-existing BEIS assumptions.

- **Heat revenues**: pre-existing BEIS methodology based on the avoided boiler cost approach.[26]

All cost estimates are in 2014 real values.

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. For key cost categories, these reports provide information on how capital costs are expected to develop between 2015 and 2030.[27]

[22] HMG continues to consider the future direction of CPS policy. Budget 2016 announced CPS rates out to 2020/21; rates beyond this provide an illustrative assumption.

[23] The rising carbon price scenario to from £35/t in 2030 to £200/t in 2050 assumes there is a global deal on climate change mitigation and a global carbon market emerges. As cheaper greenhouse gas abatement opportunities are progressively used up, the carbon price is expected to rise. The flat carbon price scenario is an illustrative alternative scenario.

[24] *For more information on carbon values please see* https://www.gov.uk/government/collections/carbon-valuation--2

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

[26] Mott MacDonald, 2010, *UK Generation Costs Update*.

[27] Arup 2015 also provides information for some technologies on how operating costs are expected to develop over time.

All estimates presented are for established plants – referred to as 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 within the UK, not including demonstration projects. For these technologies, FOAK costs assume experience has been gained from international and demonstration projects[28] [29]. CCS in particular is a new technology and costs are therefore inherently more uncertain than established technologies with a proven track record in the UK. In addition, CCS costs depend not only on the characteristics of individual plants, but also the extent to which transport and storage infrastructure is shared between them. Some FOAK plants may be able to adapt existing oil and gas facilities, but others may have to build new infrastructure for transport and storage. The CCS FOAK transport and storage costs provided by Leigh Fisher therefore reflect this uncertainty, with the low case assuming access to shared infrastructure, whilst the central and high cases assume instead new infrastructure has to be built. NOAK CCS costs assume access to shared infrastructure, although Leigh Fisher provides a range to reflect uncertainty.

Transport and storage costs will therefore in general be dependent on future government policy and private sector actions to develop infrastructure, and charging for third party access. In this context, it is worth noting that in order to enable lower cost CCS in the long-term, early projects may feature intentionally over-sized transport and storage infrastructure that future projects would be able to utilise. This would increase the costs of initial projects.

All levelised costs for marine technologies (wave and tidal stream) in this report illustrate the costs of commercial projects commissioning from 2025 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.

---

[28] 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.

[29] 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 [commissioning from 2030 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.

The load factors for wind, solar photovoltaic (PV) and marine technologies reflect that they operate as intermittent electricity generation technologies.

For the purposes of reporting non-renewable technologies, with the exception of OCGTs and reciprocating engines, plants are assumed to operate at baseload with high load factors (i.e. according to availability). The actual load factors of plants will vary, depending on a range of factors including their age, the generation mix, and the impact of any subsidy. OCGTs and reciprocating engines are assumed to operate as peaking plants (operating at times of higher system stress).

Assumed load factors for key technologies are listed in Annex 3.

Financing and Hurdle Rates

Current hurdle rates

As noted above, DECC contracted NERA Economic Consulting to provide a report to update the BEIS evidence base on hurdle rates across all electricity generation technologies.

BEIS defines hurdle rates in pre-tax real terms. These rates are defined as the minimum project return that a plant owner would require over a project's lifetime on a pre-tax real basis.[30]

This NERA report provided a suggested range of hurdle rates that BEIS could use for each technology for projects starting pre-development in 2015. NERA provided a range for hurdle rates rather than a point estimate to reflect the uncertainty arising from their analysis. This reflected the relatively low survey response rates, potential bias in survey responses, differences in the way investors may price risk and set hurdle rates, and difficulty in comparing these required rates of return to published benchmarks.

Responses to the NERA surveys used to develop their recommendations indicated an increased perception of risk by project investors arising from the Government's introduction of a competitive contract allocation process for support (e.g. for CfDs) which added to perceived risks. Reflecting this factor, NERA provided DECC with hurdle rates that assume different 'success' rates in a competitive contract allocation environment, where the success rate refers to a probability of success in a competitive auction for government support according to NERA.[31]

[30] i.e. a pre-tax uninflated basis.
[31] NERA explain that the higher success rates could reflect business models adjusting so that only the most competitive projects are developed.

BEIS, however, considers it difficult to reconcile the suggested impact of allocation risk with the competitive nature of the contract for difference allocation process. NERA's suggestion would imply that if the allocation process became more competitive[32], the hurdle rates would edge higher and bidders would seek higher support levels in the auction. To the contrary, we would expect competitive pressures to drive down the support levels sought. Also, it may be reasonable to expect that the most cost effective projects have greater chances of success in the auction. Notwithstanding this, BEIS do recognise that the size of the Levy Control Framework budget is a policy risk particular to technologies that can access CfD auctions.

Considering the above arguments in conjunction with the guidance from peer reviewers[33] we have adopted the following approach:

- For most renewable technologies, FOAK CCS and nuclear, BEIS has used the '75% success rate hurdle rates' from the NERA report in order to account for some uncertainty that investors may face related to the budget for upcoming CfD auctions. For nuclear, we have in addition adjusted the NERA 75% success rate hurdle rate by applying a lower effective tax rate to that used by NERA (see Annex 3), which is consistent with the evidence from KPMG for technologies where the upfront capital costs represent a large proportion of the costs of a project.[34] For NOAK CCS, dedicated biomass/co-firing, geothermal, wave and tidal stream technologies we have also departed from the NERA assumptions. Refer to Annex 3 for further information on the basis of these changes.

- For all other technologies covered by the NERA report (conventional thermal generation and dedicated biomass/co-firing), BEIS considers it most appropriate to use the 100% success rate hurdle rates from the NERA report. The use of 100% success hurdle rates for these technologies reflects BEIS's view that the Capacity Market, the aim of which is to address the "missing money" problem currently inherent in the GB wholesale market, is unlikely to

[32] This may result from a range of issues, including extent of support, or larger number of bidders in the market.

[33] Two independent peer reviews were undertaken of NERA's work by Professor Derek Bunn (London Business School) and Professor Ania Zalewska (University of Bath). These are available on the BEIS website with the NERA 2015 report. Both recognised the difficultly in determining appropriate hurdle rates, but on balance supported taking hurdle rates towards the lower end of the NERA ranges. Professor Bunn suggested "taking values towards the lower end of the NERA range" for a range of reasons, and Professor Zalewska suggested a "slight shading of the Report's figures across all ranges". Professor Bunn also noted that "if industry thought that DECC would add an allocation risk premium to hurdle rates according to the probability of success, there may be a moral hazard as it might encourage a larger number of uncompetitive tenders."

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

add to project risks (even in the absence of any government intervention there would still be a proportion of failed projects). In contrast, the CfD auction process exists to address externalities which cannot be provided by the GB wholesale market, even when functioning correctly – namely higher cost, low carbon generation.

- Pumped storage was not covered by the NERA report, and BEIS has used other published evidence. This hurdle rate will be kept under review in the short to medium term. Further information is available in Annex 3.

BEIS's assumptions for hurdle rates are presented in Annex 3.

Hurdle rate projections

Reflecting the additional uncertainty in making projections of hurdle rates, NERA provided BEIS with three possible trajectories for hurdle rates out to 2030 based on different policy scenarios in the future. Both peer reviews[35] highlighted the difficulty of accurately projecting hurdle rates out to 2030.

As noted by NERA, there may be factors that work in opposite directions in considering the direction of future hurdle rates. The possible increases in the risk-free rate over time as shown by NERA in their report could be offset by risk improvements elsewhere (e.g. from learning), with the net effect being very difficult to project.

On this basis, BEIS assumes hurdle rates stay flat between now and 2030.[36]

FITs technologies

The hurdle rate assumptions used for FIT technologies were based on the evidence gathered throughout 2015 as part of the FIT Review [37] – first through a survey run by independent consultants WSP Parsons Brinckerhoff ("PB"), and then through consultation responses.[38] The evidence for the FIT hurdle rate assumptions was gathered across three main investor categories: domestic, commercial and utility, where the "commercial" investor category refers to small and medium businesses that are not energy professionals (e.g. businesses which own offices or factories and which choose to develop renewable electricity installations on their sites), while the

[35] See footnote 3, above.

[36] Professor Zalewska, in her peer review, commented that "it is not clear why the 2030 rates would be higher than those estimated for 2015". Professor Bunn, in his peer review, also noted that he would "lean towards the Low scenario for a trajectory to 2030".

[37] This is the review that BEIS have undertaken to carry out every three years under our State Aid approval with a view to reassess the costs of FITs technologies, electricity price forecasts and whether the target rate of return is still appropriate.

[38] More information about the whole range of FIT hurdle rates is available in Annex A of the Impact Assessment accompanying the Government Response to the consultation on a review of the Feed-in-Tariff scheme.

"utility" category refers to energy professionals and includes both utilities and independent renewable energy developers.

For the purpose of this report, average domestic hurdle rates were used to calculate the levelised cost of solar PV <10kW, however domestic data points were excluded for calculations regarding other FIT technologies and project sizes as they only apply to very small-scale installations. The average of the dataset resulting from combining all the commercial and utility data points was therefore used to calculate levelised costs for every other FIT technology apart from solar PV <10kW.

Further background

In past editions of this report, DECC presented levelised cost estimates using a standard 10% discount rate across all technologies, in line with the precedent set in reports produced by other organisations.[39]

In practice, the hurdle rates of individual projects are likely to vary depending on a range of factors, including financing type, project developer, conditions in financial markets, maturity of technology, and risk. As a result, in this report we have focused on levelised cost estimates using technology-specific hurdle rates.[40] [41]

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 2015, this would not be the same as saying £50/MWh for a project reaching financial close in 2020, or £50/MWh for a project commissioning in 2025. This is illustrated in Chart 1 below.

---

[39] For example, IEA 2015, *Projected Costs of Generating Electricity*

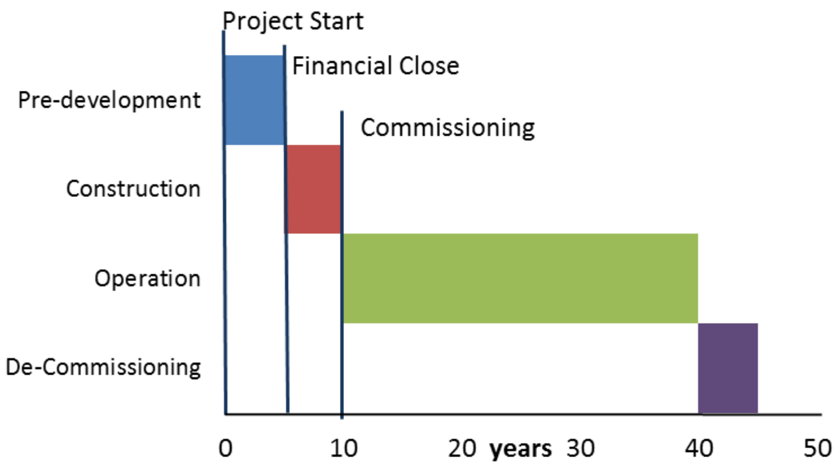
[40] These technology specific hurdle rate estimates were also presented in earlier editions of this report.

41 As a comparator to previous reports, BEIS is once again presenting these 10% hurdle rate estimates for selected technologies in Annex 2 of this Report. We have also presented estimates at 7% and 3.5% hurdle rates as a comparator to estimates produced in other reports (e.g. IEA 2015 above).

Pre-development and construction timings will vary by technology and therefore estimates reported for 'project start' or 'financial close'[42] 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.

In this report, BEIS has shifted the focus to reporting levelised cost estimates for projects commissioning in the same year. Levelised cost estimates for projects starting in 2015 are reported in Annex 2.

Chart 2: Illustrative Timings



Sensitivity Analysis

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.

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. In addition, for

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

non-renewable technologies, Leigh Fisher also provided a cost trajectory for the high and low capital cost estimates, which has been used for these technologies.[43]

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 renewables, there is considerable uncertainty over the actual supply curve range (for example from also varying operating costs, hurdle rates, and load factors). For non-renewable technologies, the capital cost range represents uncertainty for any given project. It should also be noted that all the estimates for non-renewable technologies do not reflect site-specific considerations which may become apparent through a detailed cost discovery process.

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, sensitivities which explore uncertainty over both fuel costs and capex costs are provided.

Tornado graphs

As noted, levelised cost results are highly sensitive to changes in the underlying components and assumptions. To illustrate the magnitude of the these sensitivities, tornado graphs are presented which show the change in levelised costs resulting both from a 10% upward or downward movement in the central estimates of its core components, or by using the high and low ranges of these core components provided by Arup and Leigh Fisher (whilst holding all other assumptions constant).

[43] For gas and reciprocating engine technologies this will impact the high and low levelised cost trajectories over time (for example, case 3 in the main report). For CCS and nuclear, it will impact the central, high and low estimates for projects commissioning in 2030 (the 2025 projects reflect the base assumptions of Leigh Fisher).

How we use the data in modelling

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

In practice, BEIS's electricity market modelling, including BEIS'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 capital expenditure (capex) and operating expenditure (opex) assumptions incorporated in the levelised cost estimates reported above; assumptions on investors' expectations over fossil fuel, carbon and wholesale electricity prices; and the financial incentives from policies e.g. the Renewables Obligation 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. As noted above, this edition of this report now focuses on these technology-specific hurdle rates. The technology-specific hurdle rates reflect different financing costs for different technologies.

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.

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. Within this, different technologies are sensitive to different input assumptions. Future levelised cost estimates are driven significantly by assumptions of different electricity generating technologies and assumptions of technology-specific 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, and the tornado graphs illustrate sensitivity to other assumptions. 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. For instance land costs are not included in our estimation and although use of system charges are included, they are calculated on an average basis.

Levelised Costs are not Strike Prices

The levelised cost estimates in this report do not provide an indication of potential future administrative strike prices for a particular technology or plant under Contracts for Difference (CfD) 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, such as that summarised here in the form of levelised costs, is one input into setting administrative strike prices – the maximum strike price applicable to a particular technology. Other inputs, including market conditions and policy considerations, may include:

- Revenue assumptions;
- Other costs not included in BEIS's definition of levelised cost (for example land costs);
- CfD contract terms including length and risk allocation;
- Financing costs (reflected in the levelised costs calculated at technology-specific hurdle rates);
- Other relevant information such as studies or data published by industry.
- Developments within industry; and
- Wider policy considerations.

The generation costs data used here may be different from that used as part of the administrative 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 administrative strike prices that are set for CfDs and therefore should not be seen as a guide to potential future strike prices.

Load factors

The levelised costs presented in this report are based on load factor assumptions that generally reflect the maximum potential (net of availability) of a plant (except for OCGT and reciprocating engines). Where flexible technologies such as CCGTs operate at lower load factors, their levelised costs will be higher than those presented here.

It should be noted that in the BEIS Dynamic Dispatch Model (DDM), load factors are determined endogenously based on dispatch modelling of the merit curve according to short-run marginal costs adjusted for support mechanisms.

Carbon price

As noted above, BEIS has used updated projections for CPS following Budget 2016, and after 2030 BEIS analysis assumes that the world is on a path to a global carbon market that is fully operational in 2050 under the auspices of a global deal on climate change action. This leads to a rising globally traded carbon market price after 2030 (as cheaper abatement options are used up) and demand for global abatement is sufficient to reach a global target of temperature increase of not higher than 2 degrees Centigrade on preindustrial levels. [44]

Whole System Impacts

The levelised costs estimates presented in this report do not take into account all of the wider positive or negative impacts that an electricity generation plant may impose on the electricity system. BEIS has undertaken a separate project to further systematise BEIS's understanding of the whole system impacts of electricity generation technologies. This will be published in due course.

[44] The carbon price values for this scenario are sourced from modelling by BEIS 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.

Generation Cost Estimates

This section summarises the analysis of the levelised cost of electricity generation at technology-specific hurdle rates.

Estimates that compare levelised costs across technologies at generic discount rates are presented in Annex 2. This latter approach 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.

This section focuses primarily on the main technologies likely to be deployed in the UK over the next few decades[45]. A full set of estimates for those technologies not covered in the main report can be found in Annex 1.

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

Table 1: Levelised cost cases

Case No.		
1	Projects commissioning in 2020 (NOAK)	Technology-specific hurdle rates
2	Projects commissioning in 2025 (FOAK)	
3	Projects Commissioning in 2016, 2018, 2020, 2025, 2030 (NOAK AND FOAK)	

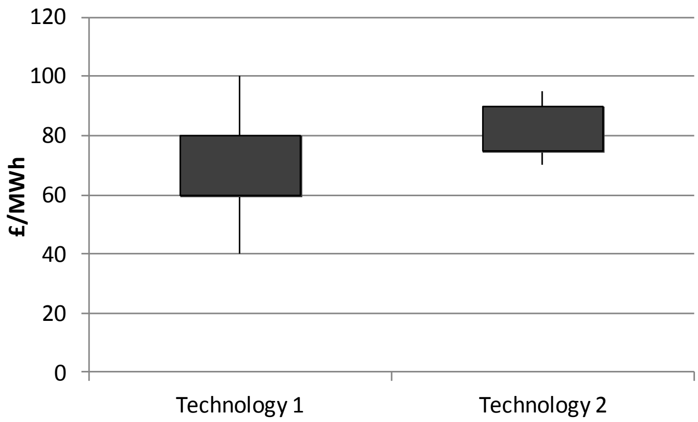
Cases 1 and 2 below show the levelised costs for NOAK and FOAK projects commissioning in 2020 and 2025 respectively (at technology-specific hurdle rates).

[45] 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 could come from.

FOAK technologies are only shown in the 2025 case given these are only expected to commission from these dates (at the earliest).

Charts 4 and 6 show the breakdown of central cost estimates, while Charts 5 and 7 shows the sensitivities of these estimates to capital costs[46], and to capital and fuel costs. In the latter case (illustration below) 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 3: Illustrative Sensitivities



For renewable technologies, as multiple costs and technical assumptions vary across projects, there is considerable uncertainty over the actual supply curve range (for example from also varying operating costs, hurdle rates, and load factors). For non-renewable technologies, the capital cost range represents uncertainty for any given project.

It should also be noted that all the estimates for non-renewable technologies reflect generic cost data and do not reflect site-specific considerations which may become apparent through a detailed cost discovery process.

Furthermore, as explained above, these levelised costs are not the sole determinant of strike prices and therefore should not be seen as a guide to potential future strike prices.

The figures used in these charts can be found in Tables 1 and 2 and Tables 3 and 4 for 2020 and 2025 commissioning respectively. The assumptions used to calculate these levelised cost assumptions are summarised in Annex 3.

---

[46] Including pre-development costs.

Case 1: NOAK Projects commissioning in 2020, technology-specific hurdle rates[47]

Chart 4: Levelised Cost Estimates for Projects Commissioning in 2020, Technology-specific Hurdle Rates, £/MWh

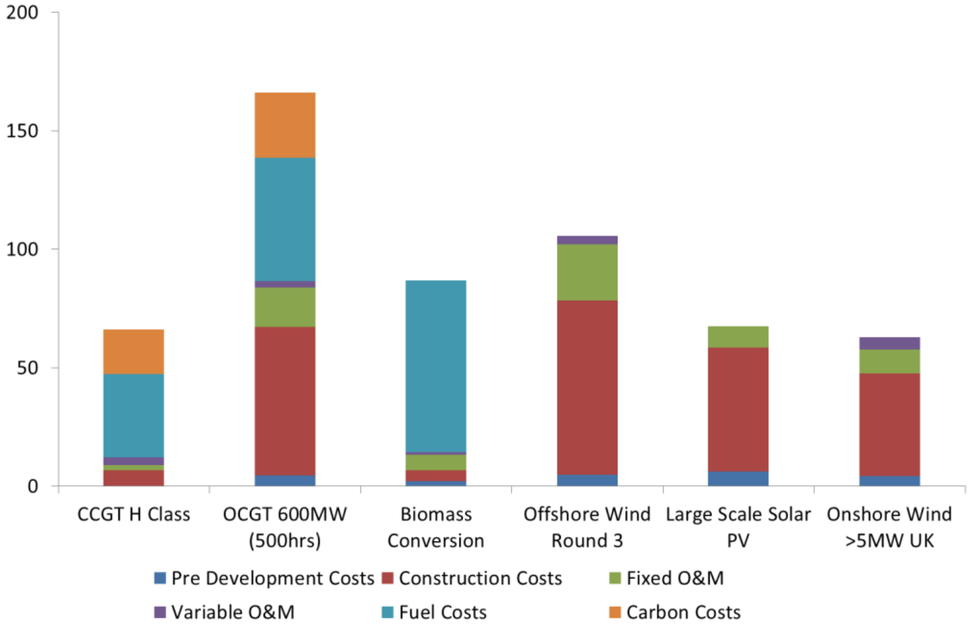
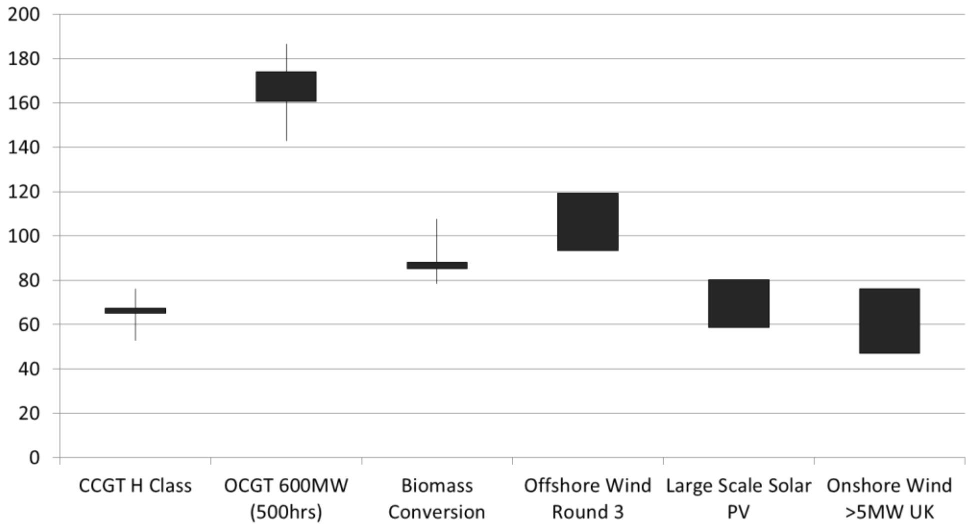


Chart 5: Levelised Cost Estimates for NOAK Projects Commissioning in 2020, Technology-specific Hurdle Rates, Sensitivities, £/MWh



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

Table 2: Levelised Cost Estimates for NOAK Projects Commissioning in 2020, Technology-specific Hurdle Rates, £/MWh

	CCGT H Class	OCGT 600MW (500hrs)	Biomass Conversion	Offshore Wind Round 3	Large Scale Solar PV	Onshore Wind >5MW UK
Pre Development Costs	0	5	2	5	6	4
Construction Costs	7	63	5	73	52	44
Fixed O&M	2	17	6	24	9	10
Variable O&M	3	3	1	3	0	5
Fuel Costs	35	52	72	0	0	0
Carbon Costs	19	28	0	0	0	0
Total	66	166	87	106	67	63

Table 3: Levelised Cost Estimates for NOAK Projects Commissioning in 2020, Technology-specific Hurdle Rates, Sensitivities, £/MWh

	CCGT H Class	OCGT 600MW (500hrs)	Biomass Conversion	Offshore Wind Round 3	Large Scale Solar PV	Onshore Wind >5MW UK
High capex	68	174	88	119	80	76
Central	66	166	87	106	67	63
Low capex	65	161	85	93	59	47
High capex, high fuel	76	187	108			
Low capex, low fuel	53	143	78			

Case 2: NOAK/FOAK Projects commissioning in 2025, technology-specific hurdle rates[48]

Chart 6: Levelised Cost Estimates for Projects Commissioning in 2025, Technology-specific Hurdle Rates, £/MWh

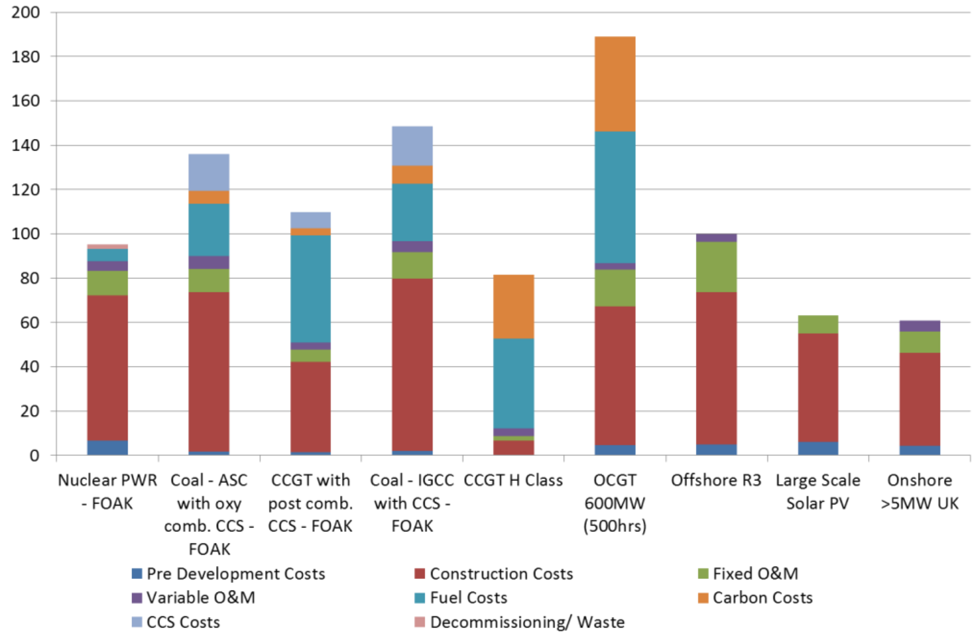
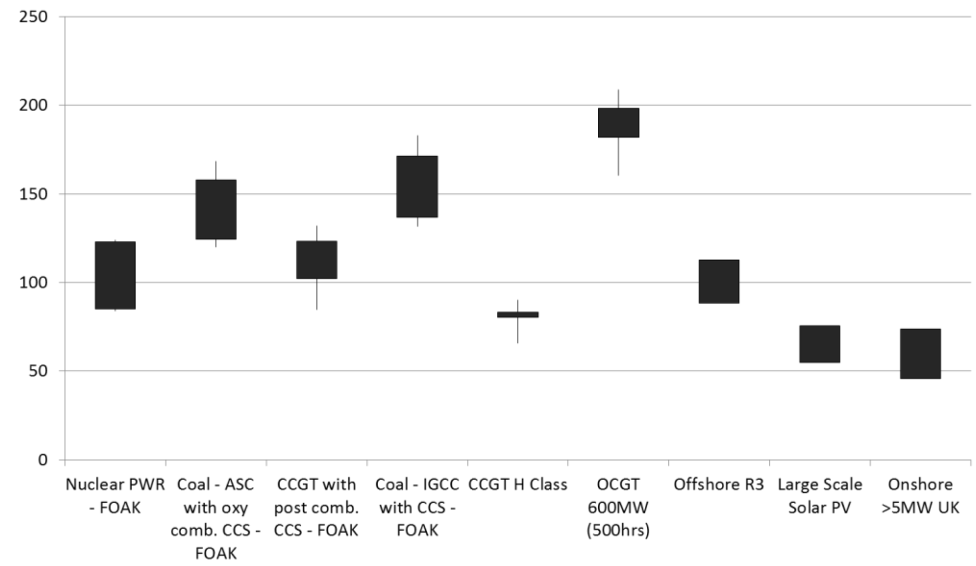


Chart 7: Levelised Cost Estimates for Projects Commissioning in 2025, Technology-specific Hurdle Rates, Sensitivities, £/MWh



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

Table 4: Levelised Cost Estimates for Projects Commissioning in 2025, Technology-specific Hurdle Rates, £/MWh

	Nuclear PWR - FOAK	Coal - ASC with oxy comb. CCS - FOAK	CCGT with post comb. CCS - FOAK	Coal - IGCC with CCS - FOAK	CCGT H Class	OCGT 600MW (500hrs)	Offshore R3	Large Scale Solar PV	Onshore >5MW UK
Pre Development Costs	7	2	2	2	0	5	5	6	4
Construction Costs	66	72	41	78	7	63	69	49	42
Fixed O&M	11	11	5	12	2	17	23	8	10
Variable O&M	5	6	3	5	3	3	3	0	5
Fuel Costs	5	24	48	26	40	60	0	0	0
Carbon Costs	0	6	3	8	29	43	0	0	0
CCS Costs	0	17	7	18	0	0	0	0	0
Decommissioning/ Waste	2	0	0	0	0	0	0	0	0
Total	95	136	110	148	82	189	100	63	61

Table 5: Levelised Cost Estimates for Projects Commissioning in 2025, Technology-specific Hurdle Rates, Sensitivities, £/MWh

	Nuclear PWR - FOAK	Coal - ASC with oxy comb. CCS - FOAK	CCGT with post comb. CCS - FOAK	Coal - IGCC with CCS - FOAK	CCGT H Class	OCGT 600MW (500hrs)	Offshore R3	Large Scale Solar PV	Onshore >5MW UK
High capex	123	158	123	171	83	198	113	76	74
Central	95	136	110	148	82	189	100	63	61
Low capex	85	125	102	137	80	182	88	55	46
High capex, high fuel	124	169	132	183	90	209			
Low capex, low fuel	84	120	85	132	66	160			

Case 3: Commissioning in 2016, 2018, 2020, 2025, 2030, FOAK/ NOAK, technology-specific hurdle rates[49]

In order to allow the comparison of the costs across different energy technologies commissioning, or starting operation, in the same year Case 3 (Table 5) illustrates the levelised costs for projects commissioning in 2016, 2018, 2020, 2025 and 2030. Technology-specific hurdle rates have been applied. 'High' and 'Low' estimates represent sensitivities around capex costs only.

As explained above, these levelised costs are not the sole determinant of strike prices and therefore should not be seen as a guide to potential future strike prices.

It should also be noted that all the estimates for non-renewable technologies do not reflect site-specific considerations which may become apparent through a detailed cost discovery process.

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

Table 6: Levelised Cost Estimates for Projects Commissioning in 2016, 2018, 2020, 2025 and 2030, technology-specific hurdle rates, £/MWh, highs and lows reflect high and low capital and pre-development cost estimates

Commissioning		2016	2018	2020	2025	2030
CCGT H Class	High	58	62	68	83	100
	Central	57	61	66	82	99
	Low	56	60	65	80	97
OCGT 600MW (500hrs)	High	159	166	174	198	224
	Central	152	159	166	189	214
	Low	148	154	161	182	207
Biomass Conversion	High	88	88	88	N/A	N/A
	Central	87	87	87	N/A	N/A
	Low	85	85	85	N/A	N/A
Offshore Wind Round 3	High	136	129	119	113	109
	Central	121	114	106	100	96
	Low	107	101	93	88	85
Large Scale Solar PV	High	94	84	80	76	73
	Central	80	71	67	63	60
	Low	71	62	59	55	52
Onshore Wind >5MW UK	High	81	79	76	74	72
	Central	67	65	63	61	60
	Low	50	49	47	46	45
Nuclear PWR - FOAK 2025 NOAK 2030	High	N/A	N/A	N/A	123	99
	Central	N/A	N/A	N/A	95	78
	Low	N/A	N/A	N/A	85	69
Coal - ASC with oxy comb. CCS - FOAK	High	N/A	N/A	N/A	158	146
	Central	N/A	N/A	N/A	136	131
	Low	N/A	N/A	N/A	125	123
CCGT with post comb. CCS - FOAK	High	N/A	N/A	N/A	123	120
	Central	N/A	N/A	N/A	110	111
	Low	N/A	N/A	N/A	102	105
Coal - IGCC with CCS - FOAK	High	N/A	N/A	N/A	171	159
	Central	N/A	N/A	N/A	148	144
	Low	N/A	N/A	N/A	137	135

Comparison to previous DECC Levelised Cost estimates

As noted earlier, the Levelised Cost estimates contained in this report are uncertain. Based on previous experience, there is a risk that some of the projected cost reductions assumed going forward may be conservative for some technologies, especially renewables.

For example, for solar PV, and offshore and onshore wind, the below table compares the previous DECC estimates (DECC 2013) [50] with the revised BEIS estimates in 'this report' for 2016, 2020 and 2030 commissioning (2014 values).

It can be seen that there have been large reductions in projected costs versus our previous estimates for all commissioning years. This reflects unanticipated cost reductions and technological improvements for these technologies, reduction in hurdle rates, and/or this progress occurring faster than previously estimated (for example due to accelerated global and domestic deployment).

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

Commissioning		2016		2020		2030	
		DECC 2013	This report	DECC 2013	This report	DECC 2013	This report
Large scale solar PV	High	116	94	98	80	73	73
	Central	108	80	92	67	69	60
	Low	101	71	86	59	65	52
Onshore wind >5MW UK	High	108	78	104	76	100	72
	Central	88	64	85	63	82	60
	Low	72	48	69	47	67	45
Offshore Wind Round 3	High	179	123	158	119	140	109
	Central	155	109	136	106	120	96
	Low	137	96	119	93	104	85

50 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/269888/131217_Electricity_Generation_costs_report_December_2013_Final.pdf

Sensitivity Analysis

Tornado graphs are presented below for selected technologies to show the change in Levelised Costs which would result from:

- The range of parameters provided by Leigh Fisher and Arup, and for BEIS data on fuel price sensitivity.
- A 10% upward or downward movement in the central estimates of its core components whilst holding all others constant. This shows which underlying assumptions are most 'important' for each technology.

The sensitivities examined are; Hurdle Rate, Net Load Factor[51] (or in the case of CCGT, CCS and nuclear, availability)[52], Capital Expenditure (Capex), Operations and Maintenance Expenditure (Total O+M), Fuel Price and Carbon Price. The blue bars show the impact of a reduction in assumptions, and the orange bars show the impact of an increase in assumptions. Some of the key findings are shown below.

High/low data range:

- Capital costs (including pre-development and infrastructure): the Arup or Leigh Fisher ranges for this assumption are the most important swing assumption for nuclear, onshore wind, offshore wind, and solar PV (high costs only for solar PV and offshore wind).
- Load factor: for offshore wind, onshore wind and solar PV, the range given by this assumption is almost as wide or wider than for capital costs.
- Fuel and carbon costs: these are the most important for CCGT and CCS technologies, with high (low) BEIS gas prices leading to around a £9/MWh (£12-£17/MWh) increase (decrease) in levelised costs from the central point.

10% change in assumptions: most material factors per technology are:

- Nuclear: a 10% change in capex, load factor and hurdle rate has a similar impact on levelised cost (£7/MWh-£10/MWh).

[51] This is the product of availability and gross load factor (both are reduced by 10%)
[52] It should be noted that this load factor variation is not meant to represent all the uncertainty related to load factors. For example, for CCGTs and OCGTs, load factors may vary to greater or lesser extent due to market conditions.

- CCGT: a 10% change in fuel costs and carbon costs changes levelised costs by around £3/MWh-£4/MWh.
- Solar PV: a 10% change in capex and load factor has around a £5/MWh - £7/MWh impact on levelised cost.
- Offshore and onshore wind: a 10% change in capex and load factor respectively have around a £8/MWh - £11/MWh impact or on £5/MWh - £6/MWh impact on levelised costs.

Chart 8: Nuclear FOAK, Commissioning 2025 LCOE Tornado Chart, £/MWh

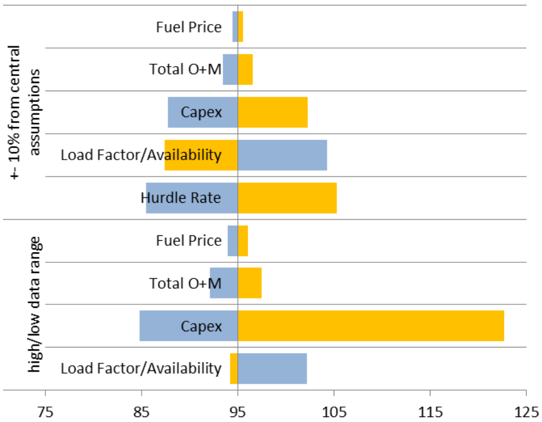


Chart 9: Offshore R3, Commissioning 2020 LCOE Tornado Chart, £/MWh

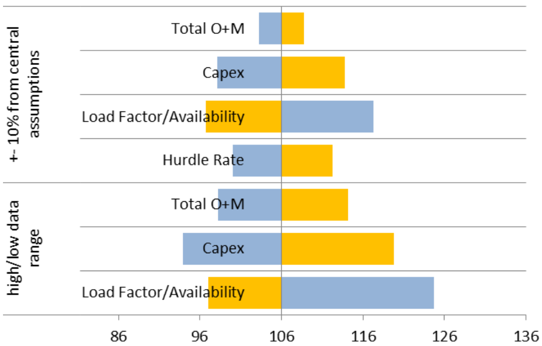


Chart 10: CCGT H Class, Commissioning 2020 LCOE Tornado Chart, £/MWh

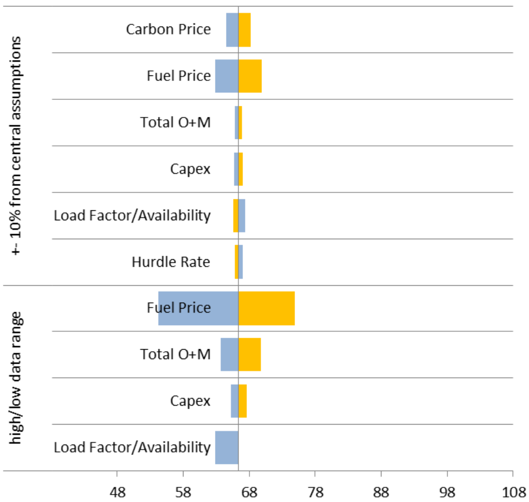


Chart 11: Large Scale Solar PV, Commissioning 2020 LCOE Tornado Chart, £/MWh

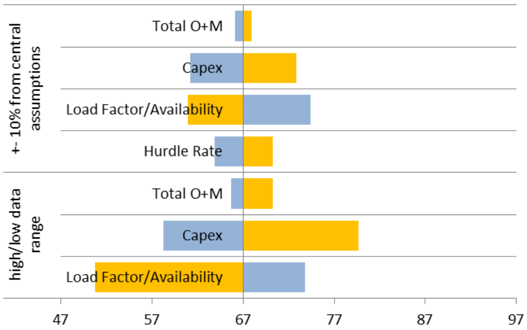


Chart 12: Onshore Wind > 5MW, Commissioning 2020 LCOE Tornado Chart, £/MWh

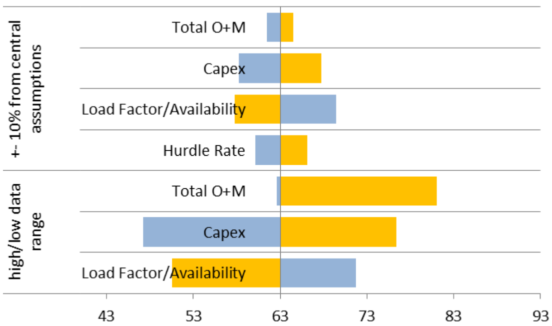
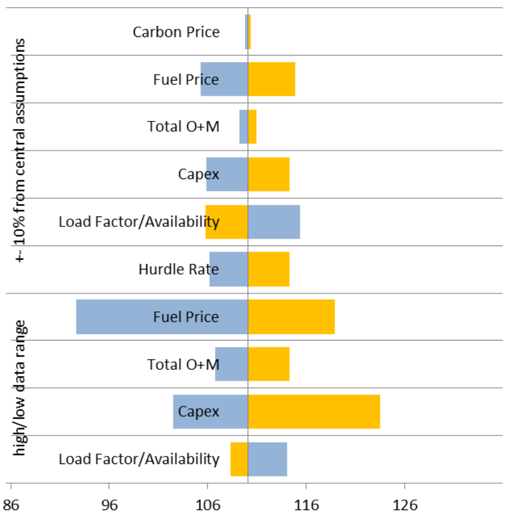


Chart 13: Gas CCS Post Comb., Commissioning 2025 LCOE Tornado Chart, £/MWh



Peaking Technologies

The previously presented Levelised Cost results show that there is considerable variation around the Levelised Costs for OCGTs (similar variation also applies to reciprocating engine plants, refer to Annex 1). This variation primarily relates to potential variation in load factor and fuel costs.

As mentioned above, this report also presents a £/kW measure for peaking technologies (OCGT and reciprocating engines), as well as a CCGT H Class for comparison. Unlike levelised costs, this measure ignores generation, and so excludes fuel costs, carbon costs, and other variable costs. This measure is arguably more suitable for comparing technologies where generation is more likely to vary with demand (i.e. for peaking technologies).[53]

This metric is not meant to illustrate likely capacity market outcomes, which will reflect a range of other factors, including different contract lengths, load factor and wholesale price expectations and other sources of revenue.

The below chart (Chart 13) covers 'peaking' technologies. The 500 hours of generation per year setting has been presented for the £/kW analysis of these plants, as the load factor will only have a marginal impact on this fixed-cost analysis of peaking technologies.[54]

Based on capital cost variability, the below graphs represents the range of the equivalent annual cashflows required to finance the upfront pre-development and construction costs, and ongoing fixed costs[55] for a generic plant resulting from capital cost variability. These annual cash flows are assumed to be paid from the start of operation over the plant lifetime to cover the fixed costs of the project. This calculation uses the technology-specific discount rates contained in this report.[56]

---

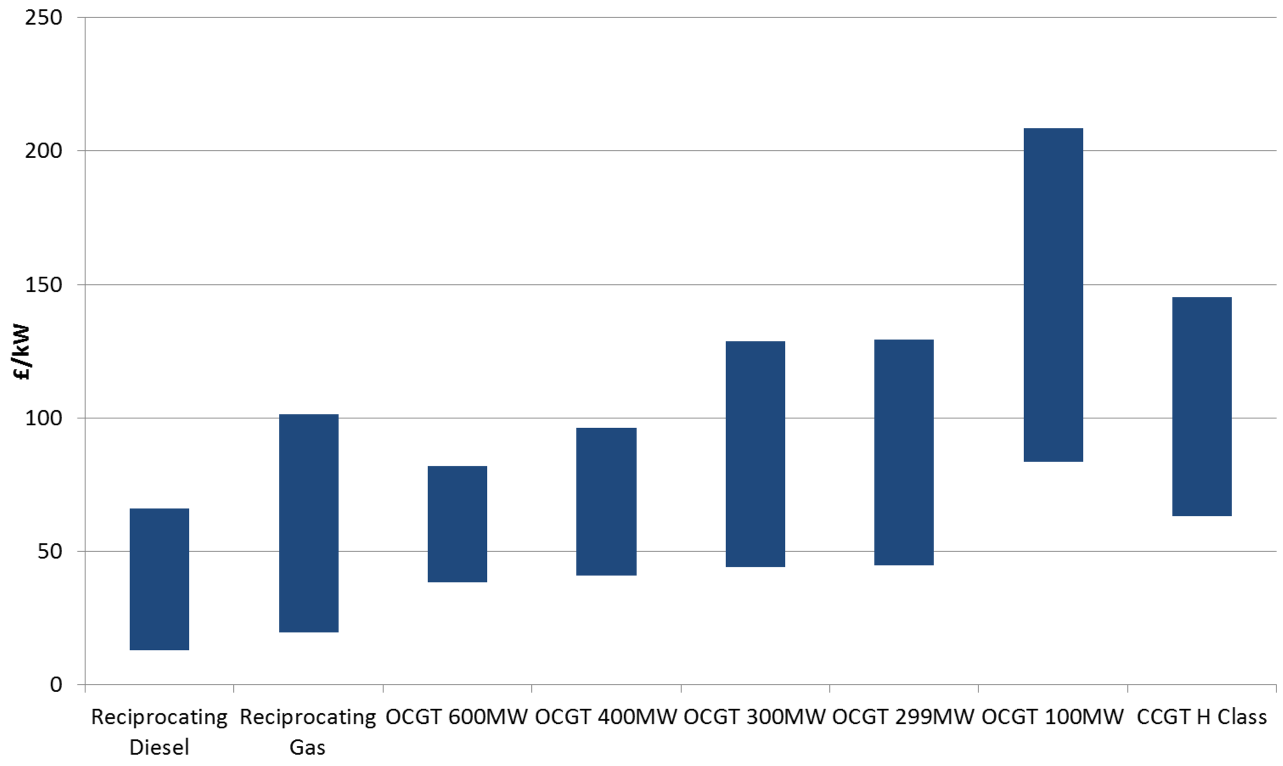
[53] The IEA/NEA have produced a similar $/kW metric to measure what they call the 'levelised cost of capacity' in order to provide a reference point of costs for plants built to meet reliability standards in the system and which only generate very rarely. IEA and NEA, *Projected Cost of Generating Electricity 2015*.

[54] For the CCGT H Class plant, we have maintained the normal load factors rather than use 500/2000 hours.

[55] These include fixed operations and maintenance costs, insurance and Use of system (UoS)/connection costs.

[56] The OCGT, CCGT, and reciprocating engine plants in the scenarios used here have a 25, 25 and 15 year life respectively. The 7.8% technology specific hurdle rate for these technologies has been applied. It should be noted that some of the fixed operating costs include a small variable cost component related to Use of system charges. Removing this from the analysis does not materially change these results.

Chart 14: Peaking technologies (reciprocating diesel and gas and OCGT at 500 hours per year) and CCGT (at normal load factors), £/kW per annum for construction and fixed operating costs, technology-specific discount rates



Annex 1: Additional Estimates

Case 1: Projects commissioning in 2020, technology-specific hurdle rates

Table 8: Levelised Cost Estimates for Projects Commissioning in 2020, Technology-specific Hurdle Rates, £/MWh

	CCGT F Class	CCGT H Class	CCGT CHP mode	OCGT 600MW 500hrs	OCGT 400MW 500hrs	OCGT 300MW 500hrs	OCGT 299MW 500hrs	OCGT 100MW 500hrs
Pre Development	0	0	1	5	6	7	7	18
Construction	6	7	12	63	73	88	92	150
Fixed O&M	2	2	4	17	18	21	21	31
Variable O&M	3	3	5	3	3	3	3	4
Fuel Costs	36	35	54	52	53	53	53	52
Carbon Costs	19	19	27	28	28	28	28	28
CCS Costs	0	0	0	0	0	0	0	0
Decommissioning/Waste	0	0	0	0	0	0	0	0
Steam Revenue	0	0	-25	0	0	0	0	0
Total	66	66	78	166	182	200	204	281

	OCGT 600MW 2000hrs	OCGT 400MW 2000hrs	OCGT 300MW 2000hrs	OCGT 299MW 2000hrs	OCGT 100MW 2000hrs	Reciprocating engines (diesel) 2000hrs	Reciprocating engines (diesel) 500hrs	Reciprocating engines (diesel) 90hrs
Pre Development	1	2	2	2	4	1	4	20
Construction	16	19	22	23	38	22	87	498
Fixed O&M	6	6	7	7	10	-11	-37	-205
Variable O&M	3	3	3	3	4	2	2	2
Fuel Costs	52	53	53	53	52	119	119	119
Carbon Costs	28	28	28	28	28	24	24	24
CCS Costs	0	0	0	0	0	0	0	0
Decommissioning/Waste	0	0	0	0	0	0	0	0
Steam Revenue	0	0	0	0	0	0	0	0
Total	105	111	115	116	136	156	198	458

	Reciprocating engines (gas) 2000hrs	Reciprocating engines (gas) 500hrs	Dedicat-ed biomass <50MW	Biomass Convers-ion	Biomass CHP	Onshore Wind >5MW UK	Offshore Wind Round 2	Offshore Wind Round 3
Pre Development	1	4	2	2	7	4	3	5
Construction	29	115	41	5	93	44	69	73
Fixed O&M	-11	-37	12	6	41	10	17	24
Variable O&M	2	2	8	1	11	5	3	3
Fuel Costs	53	53	33	72	41	0	0	0
Carbon Costs	18	18	0	0	0	0	0	0
CCS Costs	0	0	0	0	0	0	0	0
Decommissioning/Waste	0	0	0	0	0	0	0	0
Steam Revenue	0	0	0	0	-24	0	0	0
Total	92	155	96	87	170	63	92	106

	Large Scale Solar PV	PV 1-5MW ground	PV 1-5MW building	EfW	EfW CHP	AD	AD CHP	ACT standard
Pre Development	6	5	1	4	4	7	8	3
Construction	52	60	59	101	204	70	91	90
Fixed O&M	9	11	11	26	35	21	29	41
Variable O&M	0	0	3	25	55	81	81	21
Fuel Costs	0	0	0	-110	-140	-8	-10	-58
Carbon Costs	0	0	0	0	0	0	0	0
CCS Costs	0	0	0	0	0	0	0	0
Decommissioning/Waste	0	0	0	0	0	0	0	0
Steam Revenue	0	0	0	0	-25	0	-26	0
Total	67	76	73	45	133	172	174	98

	ACT Advanced	ACT CHP	Landfill	Sewage gas	Geother-mal CHP	Hydro large storage	Hydro 5-16MW	Hydro Pumped storage
Pre Development	8	9	1	13	6	1	2	5
Construction	114	194	40	141	264	64	75	85
Fixed O&M	34	34	17	24	12	9	15	17
Variable O&M	39	39	10	12	12	6	6	42
Fuel Costs	-48	-51	0	0	0	0	0	0
Carbon Costs	0	0	0	0	0	0	0	0
CCS Costs	0	0	0	0	0	0	0	0
Decommissioning/Waste	0	0	0	0	0	0	0	0
Steam Revenue	0	-12	0	0	-79	0	0	0
Total	148	214	67	191	215	80	97	148

	Solar<10kW	Solar 250-1000kW	Onshore Wind <50kW	Onshore Wind 100-1500kW	AD < 250kW	Hydro <100kW	Hydro 500kW-2000kW
Pre Development	0	0	0	0	0	0	0
Construction	103	99	203	100	118	110	90
Fixed O&M	25	10	16	25	133	16	5
Variable O&M	0	0	0	0	0	0	0
Fuel Costs	0	0	0	0	0	0	0
Carbon Costs	0	0	0	0	0	0	0
CCS Costs	0	0	0	0	0	0	0
Decommissioning/Waste	0	0	0	0	0	0	0
Steam Revenue	0	0	0	0	0	0	0
Total	128	109	220	124	252	126	95

Table 9: Levelised Cost Estimates for Projects Commissioning in 2020, Technology-specific Hurdle Rates, Sensitivities, £/MWh

	CCGT F Class	CCGT H Class	CCGT CHP mode	OCGT 600MW 500hrs	OCGT 400MW 500hrs	OCGT 300MW 500hrs	OCGT 299MW 500hrs	OCGT 100MW 500hrs
High capex	68	68	82	174	201	261	262	345
Central	66	66	78	166	182	200	204	281
Low capex	65	65	76	161	169	174	175	254
High capex, high fuel	76	76	89	187	214	274	275	358
Low capex, low fuel	53	53	65	143	150	156	157	237

	OCGT 600MW 2000hrs	OCGT 400MW 2000hrs	OCGT 300MW 2000hrs	OCGT 299MW 2000hrs	OCGT 100MW 2000hrs	Reciprocating engines (diesel) 2000hrs	Reciprocating engines (diesel) 500hrs	Reciprocating engines (diesel) 90hrs
High capex	107	116	131	131	153	171	259	803
Central	105	111	115	116	136	156	198	458
Low capex	104	108	108	109	129	149	170	297
High capex, high fuel	120	129	143	144	165	262	350	894
Low capex, low fuel	86	89	90	91	112	122	143	271

	Reciprocating engines (gas) 2000hrs	Reciprocating engines (gas) 500hrs	Dedicat-ed biomass <50MW	Biomass Convers-ion	Biomass CHP	Onshore Wind >5MW UK	Offshore Wind Round 2	Offshore Wind Round 3
High capex	115	247	104	88	196	76	124	119
Central	92	155	96	87	170	63	92	106
Low capex	81	113	88	85	141	47	74	93
High capex, high fuel	130	262	177	108	282			
Low capex, low fuel	63	95	67	78	122			

	Large Scale Solar PV	PV 1-5MW ground	PV 1-5MW building	EfW*	EfW CHP	AD	AD CHP	ACT standard
High capex	80	86	82	83	175	196	205	115
Central	67	76	73	45	133	172	174	98
Low capex	59	67	68	24	85	153	150	67
High capex, high fuel					217	196	199	123
Low capex, low fuel					65	153	158	60

***EfW – due to potential issues with the reliability of the range of Arup capital cost estimates, no capex sensitivity is shown for EfW. These figures only reflect fuel sensitivity.**

	ACT Advanced	ACT CHP	Landfill	Sewage gas	Geother-mal CHP	Hydro large storage	Hydro 5-16MW	Hydro Pumped storage
High capex	242	363	91	244	311	0	107	192
Central	148	214	67	191	215	80	97	148
Low capex	97	124	43	100	65	0	61	122
High capex, high fuel	249	367						
Low capex, low fuel	91	122						

	Solar<10kW	Solar 250-1000kW	Onshore Wind <50kW	Onshore Wind 100-1500kW	AD < 250kW	Hydro <100kW	Hydro 500kW-2000kW
High capex	153	127	264	145	292	151	115
Central	128	109	220	124	252	126	95
Low capex	103	92	176	104	211	101	76
High capex, high fuel					N/A		
Low capex, low fuel					N/A		

Case 2: Projects commissioning in 2025, technology-specific hurdle rates

Table 10: Levelised Cost Estimates for Projects Commissioning in 2025, Technology-specific Hurdle Rates, £/MWh

	CCGT F Class	CCGT H Class	CCGT CHP mode	OCGT 600MW 500hrs	OCGT 400MW 500hrs	OCGT 300MW 500hrs	OCGT 299MW 500hrs	OCGT 100MW 500hrs
Pre Development	0	0	1	5	6	7	7	18
Construction	6	7	12	63	73	88	92	150
Fixed O&M	2	2	4	17	18	21	21	31
Variable O&M	3	3	5	3	3	3	3	4
Fuel Costs	41	40	63	60	61	60	60	59
Carbon Costs	30	29	42	43	44	43	43	43
CCS Costs	0	0	0	0	0	0	0	0
Decommissioning/Waste	0	0	0	0	0	0	0	0
Steam Revenue	0	0	-31	0	0	0	0	0
Total	82	82	96	189	206	223	227	304

	OCGT 600MW 2000hrs	OCGT 400MW 2000hrs	OCGT 300MW 2000hrs	OCGT 299MW 2000hrs	OCGT 100MW 2000hrs	Reciprocating engines (diesel) 2000hrs	Reciprocating engines (diesel) 500hrs	Reciprocating engines (diesel) 90hrs
Pre Development	1	2	2	2	4	1	4	20
Construction	16	19	22	23	38	22	87	498
Fixed O&M	6	6	7	7	10	-11	-37	-205
Variable O&M	3	3	3	3	4	2	2	2
Fuel Costs	60	61	60	60	59	131	131	131
Carbon Costs	43	44	43	43	43	42	42	42
CCS Costs	0	0	0	0	0	0	0	0
Decommissioning/Waste	0	0	0	0	0	0	0	0
Steam Revenue	0	0	0	0	0	0	0	0
Total	128	134	138	139	159	187	229	488

	Reciprocating engines (gas) 2000hrs	Reciprocating engines (gas) 500hrs	Nuclear PWR - FOAK	CCGT with post comb. CCS - FOAK	CCGT with retro post comb. CCS - FOAK	CCGT with pre comb. CCS - FOAK	CCGT with oxy comb. CCS - FOAK	OCGT with post comb. CCS - FOAK
Pre Development	1	4	7	2	1	2	2	3
Construction	29	115	66	41	26	40	41	49
Fixed O&M	-11	-37	11	5	5	5	12	6
Variable O&M	2	2	5	3	3	4	4	3
Fuel Costs	63	64	5	48	48	56	51	87
Carbon Costs	32	32	0	3	3	2	0	6
CCS Costs	0	0	0	7	7	9	9	13
Decommissioning/Waste	0	0	2	0	0	0	0	0
Steam Revenue	0	0	0	0	0	0	0	0
Total	116	179	95	110	94	118	118	166

	Coal - ASC with ret post comb. CCS - FOAK	Coal - ASC with oxy comb. CCS - FOAK	Coal - ASC with ammonia - FOAK	Coal - ASC partial CCS - FOAK	Coal - IGCC with CCS - FOAK	Coal - IGCC with retro CCS - FOAK	Coal - IGCC partial CCS - FOAK	Coal - ASC with post comb. CCS - FOAK
Pre Development	1	2	2	2	2	2	1	2
Construction	50	72	81	49	78	79	56	81
Fixed O&M	12	11	13	9	12	15	9	12
Variable O&M	3	6	3	3	5	6	5	3
Fuel Costs	25	24	24	21	26	29	22	24
Carbon Costs	6	6	7	41	8	9	44	8
CCS Costs	17	17	16	5	18	20	5	17
Decommissioning/Waste	0	0	0	0	0	0	0	0
Steam Revenue	0	0	0	0	0	0	0	0
Total	114	136	147	130	148	160	143	147

	Dedicat-ed biomass <50MW	Biomass CHP	Onshore Wind >5MW UK	Offshore Wind Round 2	Offshore Wind Round 3	Large Scale Solar PV	PV 1-5MW ground	PV 1-5MW building
Pre Development	2	7	4	3	5	6	5	1
Construction	41	98	42	65	69	49	56	55
Fixed O&M	12	43	10	16	23	8	10	10
Variable O&M	8	11	5	3	3	0	0	3
Fuel Costs	33	41	0	0	0	0	0	0
Carbon Costs	0	0	0	0	0	0	0	0
CCS Costs	0	0	0	0	0	0	0	0
Decommissioning/Waste	0	0	0	0	0	0	0	0
Steam Revenue	0	-30	0	0	0	0	0	0
Total	96	171	61	86	100	63	72	69

	EfW	EfW CHP	AD	AD CHP	ACT standard	ACT Advanced	ACT CHP	Landfill
Pre Development	4	4	7	8	3	8	9	1
Construction	100	201	70	91	86	108	185	40
Fixed O&M	25	35	21	29	40	33	33	17
Variable O&M	24	53	81	81	20	38	38	10
Fuel Costs	-110	-140	-8	-10	-58	-48	-51	0
Carbon Costs	0	0	0	0	0	0	0	0
CCS Costs	0	0	0	0	0	0	0	0
Decommissioning/Waste	0	0	0	0	0	0	0	0
Steam Revenue	0	-31	0	-33	0	0	-15	0
Total	43	122	172	167	91	140	201	67

	Sewage gas	Geother-mal CHP	Hydro large storage	Hydro 5-16MW	Hydro Pumped storage	Wave	Tidal stream	Solar<10kW FiTs
Pre Development	13	6	1	2	5	8	10	0
Construction	141	258	64	75	85	256	254	96
Fixed O&M	24	12	9	15	17	32	57	24
Variable O&M	12	12	6	6	42	24	7	0
Fuel Costs	0	0	0	0	0	0	0	0
Carbon Costs	0	0	0	0	0	0	0	0
CCS Costs	0	0	0	0	0	0	0	0
Decommissioning/Waste	0	0	0	0	0	0	0	0
Steam Revenue	0	-108	0	0	0	0	0	0
Total	191	180	80	97	148	320	328	121

	Solar 250-1000kW	Onshore Wind <50kW	Onshore Wind 100-1500kW	AD < 250kW	Hydro <100kW	Hydro 500kW-2000kW
Pre Development	0	0	0	0	0	0
Construction	95	194	95	113	110	90
Fixed O&M	10	16	25	133	16	5
Variable O&M	0	0	0	0	0	0
Fuel Costs	0	0	0	0	0	0
Carbon Costs	0	0	0	0	0	0
CCS Costs	0	0	0	0	0	0
Decommissioning/Waste	0	0	0	0	0	0
Steam Revenue	0	0	0	0	0	0
Total	104	211	120	246	126	95

Table 11: Levelised Cost Estimates for Projects Commissioning in 2025, Technology-specific Hurdle Rates, Sensitivities, £/MWh

	CCGT F Class	CCGT H Class	CCGT CHP mode	OCGT 600MW (500hrs)	OCGT 400MW (500hrs)	OCGT 300MW (500hrs)	OCGT 299MW (500hrs)	OCGT 100MW (500hrs)
High capex	84	83	100	198	226	287	288	372
Central	82	82	96	189	206	223	227	304
Low capex	81	80	93	182	191	196	197	274
High capex, high fuel	91	90	106	209	237	298	299	382
Low capex, low fuel	66	66	80	160	168	174	175	253

	OCGT 600MW (2000hrs)	OCGT 400MW (2000hrs)	OCGT 300MW (2000hrs)	OCGT 299MW (2000hrs)	OCGT 100MW (2000hrs)	Reciprocating engines (diesel) 2000hrs	Reciprocating engines (diesel) 500hrs	Reciprocating engines (diesel) 90hrs
High capex	130	140	154	154	176	202	291	843
Central	128	134	138	139	159	187	229	488
Low capex	126	131	131	131	151	179	199	320
High capex, high fuel	141	150	165	165	187	313	402	953
Low capex, low fuel	104	108	109	109	130	158	178	299

	Reciprocating engines (gas) 2000hrs	Reciprocating engines (gas) 500hrs	Nuclear PWR - FOAK	CCGT with post comb. CCS - FOAK	CCGT with retro post comb. CCS - FOAK	CCGT with pre comb. CCS - FOAK	CCGT with oxy comb. CCS - FOAK	OCGT with post comb. CCS - FOAK
High capex	140	274	123	123	102	131	132	181
Central	116	179	95	110	94	118	118	166
Low capex	105	135	85	102	90	110	110	156
High capex, high fuel	152	286	124	132	111	141	141	197
Low capex, low fuel	82	113	84	85	72	90	92	125

	Coal - ASC with ret post comb. CCS - FOAK	Coal - ASC with oxy comb. CCS - FOAK	Coal - ASC with ammonia - FOAK	Coal - ASC partial CCS - FOAK	Coal - IGCC with CCS - FOAK	Coal - IGCC with retro CCS - FOAK	Coal - IGCC partial CCS - FOAK	Coal - ASC with post comb. CCS - FOAK
High capex	128	158	174	147	171	184	160	173
Central	114	136	147	130	148	160	143	147
Low capex	104	125	131	119	137	148	135	131
High capex, high fuel	139	169	184	156	183	197	170	184
Low capex, low fuel	99	120	126	116	132	143	131	126

	Dedicat-ed biomass <50MW	Biomass CHP	Onshore Wind >5MW UK	Offshore Wind Round 2	Offshore Wind Round 3	Large Scale Solar PV	PV 1-5MW ground	PV 1-5MW building
High capex	103	198	74	116	113	76	81	77
Central	96	171	61	86	100	63	72	69
Low capex	88	141	46	69	88	55	63	63
High capex, high fuel	177	286						
Low capex, low fuel	67	124						

	EfW*	EfW CHP	AD	AD CHP	ACT standard	ACT Advanced	ACT CHP	Landfill
High capex	80	164	196	198	107	229	342	91
Central	43	122	172	167	91	140	201	67
Low capex	22	75	153	143	62	91	115	43
High capex, high fuel	0	206	196	193	115	236	347	
Low capex, low fuel	0	57	153	153	55	85	113	

***EfW – due to potential issues with the reliability of the range of Arup capital cost estimates, no capex sensitivity is shown for EfW. These figures only reflect fuel sensitivity.**

	Sewage gas	Geother-mal CHP	Hydro large storage	Hydro 5-16MW	Hydro Pumped storage	Wave	Tidal stream	Solar<10kW FiTs
High capex	244	273	0	107	195	427	446	144
Central	191	180	80	97	148	320	328	121
Low capex	100	33	0	61	120	207	213	98
High capex, high fuel								
Low capex, low fuel								

	Solar 250-1000kW	Onshore Wind <50kW	Onshore Wind 100-1500kW	AD < 250kW	Hydro <100kW	Hydro 500kW-2000kW
High capex	120	252	140	285	151	115
Central	104	211	120	246	126	95
Low capex	88	169	101	208	101	76
High capex, high fuel				N/A		
Low capex, low fuel				N/A		

Case 3: Commissioning in 2016, 2018, 2020, 2025, 2030, FOAK/ NOAK, technology-specific hurdle rates[57]

Table 12: Levelised Cost Estimates for Projects Commissioning in 2016, 2018, 2020, 2025 and 2030, technology-specific hurdle rates, £/MWh, highs and lows reflect high and low capital and pre-development cost estimates

Commissioning		2016	2018	2020	2025	2030
CCGT H Class	High	58	62	68	83	100
	Central	57	61	66	82	99
	Low	56	60	65	80	97
CCGT F Class	High	58	62	68	84	101
	Central	57	61	66	82	100
	Low	56	60	65	81	98
CCGT CHP mode	High	72	76	82	100	124
	Central	68	73	78	96	120
	Low	66	70	76	93	117
OCGT 600MW (500hrs)	High	159	166	174	198	224
	Central	152	159	166	189	214
	Low	148	154	161	182	207
OCGT 400MW (500hrs)	High	185	192	201	226	252
	Central	168	174	182	206	231
	Low	155	162	169	191	216
OCGT 300MW (500hrs)	High	244	252	261	287	313
	Central	186	193	200	223	249
	Low	161	167	174	196	221
OCGT 299MW (500hrs)	High	245	253	262	288	314
	Central	190	197	204	227	253
	Low	162	168	175	197	222
OCGT 100MW (500hrs)	High	328	336	345	372	398
	Central	267	274	281	304	329
	Low	243	248	254	274	299
OCGT 600MW (2000hrs)	High	93	99	107	130	155
	Central	91	97	105	128	153
	Low	90	96	104	126	151
OCGT 400MW (2000hrs)	High	101	108	116	140	166
	Central	97	103	111	134	160
	Low	93	100	108	131	156

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

Commissioning		2016	2018	2020	2025	2030
OCGT 300MW (2000hrs)	High	116	123	131	154	180
	Central	101	107	115	138	163
	Low	94	101	108	131	156
OCGT 299MW (2000hrs)	High	116	123	131	154	180
	Central	102	108	116	139	164
	Low	95	101	109	131	157
OCGT 100MW (2000hrs)	High	138	145	153	176	201
	Central	122	129	136	159	184
	Low	116	122	129	151	176
Reciprocating engines (diesel) 2000hrs	High	152	161	171	202	240
	Central	137	146	156	187	224
	Low	130	139	149	179	217
Reciprocating engines (diesel) 500hrs	High	238	248	259	291	328
	Central	179	188	198	229	266
	Low	152	160	170	199	237
Reciprocating engines (diesel) 90hrs	High	776	789	803	843	880
	Central	438	448	458	488	526
	Low	284	290	297	320	357
Reciprocating engines (gas) 2000hrs	High	102	108	115	140	169
	Central	79	84	92	116	145
	Low	69	74	81	105	134
Reciprocating engines (gas) 500hrs	High	233	239	247	274	303
	Central	142	147	155	179	208
	Low	101	106	113	135	164
Nuclear PWR - FOAK 2025 NOAK 2030	High	N/A	N/A	N/A	123	99
	Central	N/A	N/A	N/A	95	78
	Low	N/A	N/A	N/A	85	69
CCGT with post comb. CCS - FOAK	High	N/A	N/A	N/A	123	120
	Central	N/A	N/A	N/A	110	111
	Low	N/A	N/A	N/A	102	105
CCGT retro post comb. CCS - FOAK	High	N/A	N/A	N/A	102	100
	Central	N/A	N/A	N/A	94	96
	Low	N/A	N/A	N/A	90	92
CCGT with pre comb. CCS - FOAK	High	N/A	N/A	N/A	131	128
	Central	N/A	N/A	N/A	118	119
	Low	N/A	N/A	N/A	110	113
CCGT with oxy comb. CCS - FOAK	High	N/A	N/A	N/A	132	126
	Central	N/A	N/A	N/A	118	117
	Low	N/A	N/A	N/A	110	111
OCGT with post comb. CCS - FOAK	High	N/A	N/A	N/A	181	180
	Central	N/A	N/A	N/A	166	169
	Low	N/A	N/A	N/A	156	162

Commissioning		2016	2018	2020	2025	2030
Coal - ASC ret post comb. CCS - FOAK	High	N/A	N/A	N/A	128	121
	Central	N/A	N/A	N/A	114	113
	Low	N/A	N/A	N/A	104	106
Coal - ASC with oxy comb. CCS - FOAK	High	N/A	N/A	N/A	158	146
	Central	N/A	N/A	N/A	136	131
	Low	N/A	N/A	N/A	125	123
Coal ASC with ammonia - FOAK	High	N/A	N/A	N/A	174	165
	Central	N/A	N/A	N/A	147	146
	Low	N/A	N/A	N/A	131	133
Coal - ASC FGD with 300MW CCS - FOAK	High	N/A	N/A	N/A	147	165
	Central	N/A	N/A	N/A	130	152
	Low	N/A	N/A	N/A	119	144
Coal - IGCC with CCS - FOAK	High	N/A	N/A	N/A	171	159
	Central	N/A	N/A	N/A	148	144
	Low	N/A	N/A	N/A	137	135
Coal - IGCC with retro CCS - FOAK	High	N/A	N/A	N/A	184	169
	Central	N/A	N/A	N/A	160	155
	Low	N/A	N/A	N/A	148	147
Coal - IGCC with 300MW CCS - FOAK	High	N/A	N/A	N/A	160	173
	Central	N/A	N/A	N/A	143	162
	Low	N/A	N/A	N/A	135	157
Coal - ASC with post comb. CCS - FOAK	High	N/A	N/A	N/A	173	165
	Central	N/A	N/A	N/A	147	146
	Low	N/A	N/A	N/A	131	134
Dedicated biomass <50MW	High	105	104	104	103	103
	Central	97	96	96	96	95
	Low	88	88	88	88	87
Biomass Conversion	High	88	88	88	N/A	N/A
	Central	87	87	87	N/A	N/A
	Low	85	85	85	N/A	N/A
Biomass CHP	High	192	192	196	198	194
	Central	167	167	170	171	167
	Low	139	139	141	141	137
Onshore >5MW UK	High	81	79	76	74	72
	Central	67	65	63	61	60
	Low	50	49	47	46	45
Offshore Wind Round 2	High	133	130	124	116	110
	Central	99	97	92	86	82
	Low	79	78	74	69	66
Offshore Wind Round 3	High	136	129	119	113	109
	Central	121	114	106	100	96
	Low	107	101	93	88	85

***EfW – due to potential issues with reliability of estimates, no capex sensitivity is shown for EfW. These figures only reflect fuel sensitivity highs and lows.**

Commissioning		2016	2018	2020	2025	2030
Large Scale Solar PV	High	94	84	80	76	73
	Central	80	71	67	63	60
	Low	71	62	59	55	52
PV 1-5MW ground	High	102	90	86	81	77
	Central	90	80	76	72	68
	Low	80	71	67	63	60
PV 1-5MW building	High	98	87	82	77	73
	Central	88	77	73	69	65
	Low	81	71	68	63	60
EfW*	High	84	84	83	80	78
	Central	46	46	45	43	41
	Low	25	25	24	22	20
EfW CHP	High	182	180	175	164	157
	Central	139	137	133	122	116
	Low	91	89	85	75	69
AD	High	195	196	196	196	196
	Central	171	171	172	172	172
	Low	152	153	153	153	153
AD CHP	High	209	207	205	198	195
	Central	177	176	174	167	164
	Low	154	152	150	143	140
ACT standard	High	119	118	115	107	101
	Central	102	100	98	91	85
	Low	70	69	67	62	57
ACT advanced	High	250	247	242	229	218
	Central	154	152	148	140	133
	Low	100	99	97	91	86
ACT CHP	High	376	371	363	342	325
	Central	223	220	214	201	190
	Low	131	128	124	115	108
Landfill	High	91	91	91	91	91
	Central	67	67	67	67	67
	Low	43	43	43	43	43
Sewage gas	High	244	244	244	244	244
	Central	191	191	191	191	191
	Low	100	100	100	100	100
Geothermal CHP	High	329	322	311	273	249
	Central	233	226	215	180	158
	Low	81	74	65	33	15
Hydro large storage	High	N/A	N/A	N/A	N/A	N/A
	Central	80	80	80	80	80
	Low	N/A	N/A	N/A	N/A	N/A

Commissioning		2016	2018	2020	2025	2030
Hydropower 5-16MW	High	107	107	107	107	107
	Central	97	97	97	97	97
	Low	61	61	61	61	61
Pumped storage	High	192	192	192	195	198
	Central	148	148	148	148	148
	Low	122	122	122	120	119
Wave	High	N/A	N/A	N/A	427	338
	Central	N/A	N/A	N/A	320	252
	Low	N/A	N/A	N/A	207	161
Tidal stream	High	N/A	N/A	N/A	446	365
	Central	N/A	N/A	N/A	328	267
	Low	N/A	N/A	N/A	213	171
Solar<10kW	High	160	157	153	144	135
	Central	134	131	128	121	114
	Low	108	106	103	98	92
Solar 250-1000kW	High	132	129	127	120	115
	Central	113	111	109	104	99
	Low	95	93	92	88	84
Onshore Wind <50kW	High	273	269	264	252	242
	Central	227	224	220	211	202
	Low	182	179	176	169	162
Onshore Wind 100-1500kW	High	149	147	145	140	134
	Central	128	126	124	120	116
	Low	107	105	104	101	98
AD < 250kW	High	298	295	292	285	278
	Central	256	254	252	246	241
	Low	214	213	211	208	204
Hydro <100kW	High	151	151	151	151	151
	Central	126	126	126	126	126
	Low	101	101	101	101	101
Hydro 500kW-2000kW	High	115	115	115	115	115
	Central	95	95	95	95	95
	Low	76	76	76	76	76

Annex 2: Alternative hurdle rates and 2015 project start estimates

This Annex presents the below cases for comparative purposes to previous reports:

- Case 4: Selected levelised cost estimates at the 10% hurdle rate in order to be consistent with the previous DECC publication from 2013.
- Case 5 and 6: Selected levelised cost estimates at the 3.5% and 7% hurdle rate for comparative purposes with international publications. The 3.5% rate is equivalent to the discount rate used in the HM Treasury Green Book, though we are not suggesting that this discount rate should be used as a basis for levelised costs analysis.[58]
- Case 7: Selected levelised cost for a 2015 project start date in order to be consistent with the previous DECC publication from 2013 (which also presented levelised cost estimates at project start (2013 and 2019).

[58] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/220541/green_book_complete.pdf.

Case 4: 10% hurdle rate Levelised Cost estimates

Table 13: Levelised Cost Estimates for Projects Commissioning in 2016, 2018, 2020, 2025 and 2030, 10% discount rate, £/MWh, highs and lows reflect high and low capital and pre-development cost estimates

Commissioning		2016	2018	2020	2025	2030
CCGT H Class	High	57	61	66	82	99
	Central	56	60	65	80	97
	Low	54	59	63	78	95
OCGT 600MW (500hrs)	High	171	178	186	210	236
	Central	163	169	176	199	224
	Low	158	163	170	190	215
Biomass Conversion	High	88	88	88	N/A	N/A
	Central	87	87	87	N/A	N/A
	Low	85	85	85	N/A	N/A
Offshore Wind Round 3	High	147	139	129	122	117
	Central	129	123	113	107	103
	Low	114	108	100	94	91
Large Scale Solar PV	High	120	107	102	97	93
	Central	101	90	85	80	76
	Low	89	78	74	69	65
Onshore Wind >5MW UK	High	101	97	96	94	92
	Central	82	79	78	76	75
	Low	60	58	57	55	55
Nuclear PWR - FOAK 2025 NOAK 2030	High	N/A	N/A	N/A	141	112
	Central	N/A	N/A	N/A	108	86
	Low	N/A	N/A	N/A	96	76
Coal - ASC with oxy comb. CCS - FOAK	High	N/A	N/A	N/A	146	136
	Central	N/A	N/A	N/A	127	123
	Low	N/A	N/A	N/A	117	116
CCGT with post comb. CCS - FOAK	High	N/A	N/A	N/A	117	115
	Central	N/A	N/A	N/A	105	107
	Low	N/A	N/A	N/A	99	102
Coal - IGCC with CCS - FOAK	High	N/A	N/A	N/A	159	149
	Central	N/A	N/A	N/A	139	136
	Low	N/A	N/A	N/A	129	129

Case 5: 3.5% discount rate Levelised Cost estimates

Table 14: Levelised Cost Estimates for Projects Commissioning in 2016, 2018, 2020, 2025 and 2030, 3.5% discount rate, £/MWh, highs and lows reflect high and low capital and pre-development cost estimates

Commissioning		2016	2018	2020	2025	2030
CCGT H Class	High	60	65	71	87	104
	Central	60	65	70	86	103
	Low	59	64	70	85	102
OCGT 600MW (500hrs)	High	140	148	157	181	206
	Central	136	143	152	175	200
	Low	133	140	148	171	195
Biomass Conversion	High	85	85	85	N/A	N/A
	Central	84	84	84	N/A	N/A
	Low	83	83	83	N/A	N/A
Offshore Wind Round 3	High	93	88	81	77	74
	Central	84	79	73	69	67
	Low	76	72	66	63	61
Large Scale Solar PV	High	74	66	63	59	57
	Central	63	56	53	50	48
	Low	56	49	47	44	41
Onshore Wind >5MW UK	High	63	61	59	57	56
	Central	52	51	49	48	47
	Low	40	39	38	37	36
Nuclear PWR - FOAK 2025 NOAK 2030	High	N/A	N/A	N/A	57	51
	Central	N/A	N/A	N/A	48	44
	Low	N/A	N/A	N/A	45	40
Coal - ASC with oxy comb. CCS - FOAK	High	N/A	N/A	N/A	104	101
	Central	N/A	N/A	N/A	95	95
	Low	N/A	N/A	N/A	90	92
CCGT with post comb. CCS - FOAK	High	N/A	N/A	N/A	94	95
	Central	N/A	N/A	N/A	89	91
	Low	N/A	N/A	N/A	85	88
Coal - IGCC with CCS - FOAK	High	N/A	N/A	N/A	117	114
	Central	N/A	N/A	N/A	107	108
	Low	N/A	N/A	N/A	102	105

Case 6: 7% discount rate Levelised Cost estimates

Table 15: Levelised Cost Estimates for Projects Commissioning in 2016, 2018, 2020, 2025 and 2030, 7.0% discount rate, £/MWh, highs and lows reflect high and low capital and pre-development cost estimates

Commissioning		2016	2018	2020	2025	2030
CCGT H Class	High	58	63	68	84	101
	Central	57	62	67	82	99
	Low	56	61	66	81	98
OCGT 600MW (500hrs)	High	155	162	170	194	220
	Central	149	155	163	186	211
	Low	144	151	158	179	204
Biomass Conversion	High	87	87	87	N/A	N/A
	Central	86	86	86	N/A	N/A
	Low	84	84	84	N/A	N/A
Offshore Wind Round 3	High	119	113	105	99	95
	Central	106	101	93	88	85
	Low	95	90	83	78	76
Large Scale Solar PV	High	97	87	83	79	75
	Central	83	74	70	66	63
	Low	73	64	61	57	54
Onshore Wind >5MW UK	High	81	78	77	75	74
	Central	66	64	63	62	61
	Low	50	48	47	46	45
Nuclear PWR - FOAK 2025 NOAK 2030	High	N/A	N/A	N/A	95	80
	Central	N/A	N/A	N/A	76	64
	Low	N/A	N/A	N/A	69	58
Coal - ASC with oxy comb. CCS - FOAK	High	N/A	N/A	N/A	123	118
	Central	N/A	N/A	N/A	110	108
	Low	N/A	N/A	N/A	103	103
CCGT with post comb. CCS - FOAK	High	N/A	N/A	N/A	105	104
	Central	N/A	N/A	N/A	97	98
	Low	N/A	N/A	N/A	92	95
Coal - IGCC with CCS - FOAK	High	N/A	N/A	N/A	137	131
	Central	N/A	N/A	N/A	122	121
	Low	N/A	N/A	N/A	115	116

Case 7: Projects Starting in 2015, Levelised Cost estimates, technology-specific hurdle rates

Table 16: Levelised Cost Estimates for Projects Starting in 2015, technology-specific hurdle rate, £/MWh, highs and lows reflect high and low capital and pre-development cost estimates

Project start		**2015**
CCGT H Class	High	68
	Central	66
	Low	65
OCGT 600MW (500hrs)	High	170
	Central	162
	Low	157
Biomass Conversion	High	88
	Central	87
	Low	85
Offshore Wind Round 3	High	115
	Central	102
	Low	90
Large Scale Solar PV	High	94
	Central	80
	Low	71
Onshore Wind >5MW UK	High	76
	Central	62
	Low	47
Nuclear PWR - FOAK 2025 NOAK 2030	High	121
	Central	93
	Low	82
Coal - ASC with oxy comb. CCS - FOAK	High	153
	Central	134
	Low	124
CCGT with post comb. CCS - FOAK	High	123
	Central	110
	Low	102
Coal - IGCC with CCS - FOAK	High	171
	Central	148
	Low	137

Annex 3: Key Data and Assumptions

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.

Hurdle Rates from NERA Economic Consulting

NERA mainly collected post-tax nominal hurdle rates from industry through their research project. These post-tax nominal rates were adjusted using the following assumptions:

- To convert post-tax nominal to pre-tax real hurdle rates, a 2% inflation assumption, consistent with the Government's inflation target, has been applied.
- Assumptions on effective tax rates (ETRs) across technologies are the same as those made by DECC in 2013. This is based on advice for renewables from KPMG in July 2013.[59] ETRs take into account the effect of capital allowances. KPMG modelled project cash flows including the impact of capital allowance on corporation tax paid.

The one departure from the DECC 2013 assumptions on ETRs is the hurdle rates applied to nuclear technologies. In the case of nuclear, BEIS has applied the 12% ETR used for offshore wind from the above KPMG 2013 report instead of the 20% ETR assumed by NERA in their report for this cost update project. The KPMG report noted that "For the technologies where the upfront capital represents a large proportion of the costs of a project (i.e. where up-front capital expenditure is at least four times greater than the annual operating expenditure), the front-loading of corporation tax relief to earlier years of the project, through the capital allowances mechanism, is expected to reduce the discounted ETR to below the main UK corporation tax rate of 20%". The ratio of upfront capital costs to annual operating expenditures is greater for nuclear power than for offshore wind and so a 12% ETR is also considered appropriate for nuclear.

In the main section of this report it was noted that the below adjustments to the hurdle rates presented in the NERA report have also been made.

- For CCS (NOAK) technologies, we have reduced the equivalent FOAK hurdle rate by 2.1 percentage points on the basis of the expected reduction in the CCS Cost reduction task force report.[60]

---

[59] KPMG 2013, *Electricity Market Reform: Review of effective tax rates for renewable technologies*.
[60] Crown Estate 2013, *CCS Cost Reduction Task Force Final Report*, Derived from Annex A.

- For wave, tidal stream and geothermal technologies, NERA and/or we consider that the revised NERA range as not being based on sufficient evidence (NERA did not obtain any quantified hurdle rates from their survey for these technologies)[61], and therefore we continue to rely on the assumptions DECC published in December 2013.[62]

- For the pumped storage technology, this technology was added to this assumption update after NERA had started its survey work. In order to develop a hurdle rate for levelised cost purposes, BEIS has used evidence from Lazard that indicates a pre-tax real hurdle rate of 11.4%. [63]

Hurdle rates for FITs technologies

BEIS also uses pre-tax real hurdle rates in its FIT modelling, and returns are considered at a project level rather than an equity level. This definition was explicitly stated in the PB questionnaire, and in paragraph 4.12 of the Impact Assessment accompanying the FIT Review consultation published in August 2015, though some of the quantitative responses received assumed different definitions – with post-tax nominal equity returns most commonly featured. Post-tax nominal hurdle rates were converted into pre-tax real equivalents, and further information on this and other aspects of the methodology is available in the Impact Assessment.[64]

This report uses the average of the dataset resulting from combining all the commercial and utility data points gathered through the FIT Review process for each technology, except for solar PV <10kW where the average of the domestic data points was used. To avoid confusion it is worth pointing out that this leads to numbers that are different from the target rates of return used for the purpose of setting the revised FIT tariffs,[65] as these were selected at the lower end of the intersection between the domestic and commercial hurdle rate ranges for each technology.[66]

[61] In relation to geothermal, NERA argued that their evidence may not provide a strong reason for BEIS to consider changing its existing assumption. NERA also recognise that "hurdle rates where there are very few survey responses (or in some cases none) and where there is little other evidence should be used with caution".

[62] For wave and tidal stream, BEIS has used the commercial project rates from its 2013 report.

[63] Lazard 2015, *Lazard's Levelized Cost of Storage* Analysis, (https://www.lazard.com/media/2391/lazards-levelized-cost-of-storage-analysis-10.pdf. This publication provides an illustrative financing structure across storage technologies. We have applied the hydro effective tax rate of 20% and NERA inflation assumptions for converting this financing structure to a pre-tax real hurdle rate.

[64] More background and information on the terms outlined in this section is available in Annex A of the Impact Assessment accompanying the Government Response to the consultation on a review of the Feed-in-Tariff scheme, available here: https://www.gov.uk/government/consultations/consultation-on-a-review-of-the-feed-in-tariff-scheme".

[65] For more information please see Table 4, p11 of the Impact Assessment accompanying the Government Response to the consultation on a review of the Feed-in-Tariff scheme.

[66] For more information please see paragraphs A25 and A29 of Annex A to the Impact Assessment accompanying the Government Response to the consultation on a review of the Feed-in-Tariff scheme.

Hurdle rates and effective tax rates

The resulting pre-tax real hurdle rates and ETRs used for renewable and non-renewable technologies are shown in the Table below.

Table 17: Technology-specific hurdle rates and effective tax rates

Technology	Category	Hurdle rate (pre-tax real)	Effective tax rate
Solar		6.50%	12%
Onshore wind		6.70%	11%
Offshore wind		8.90%	12%
Hydro	>5MW	6.90%	20%
	Large Storage	6.90%	20%
	Pumped storage	11.40%	20%
Wave		11.00%	12%
Tidal stream		12.90%	20%
Geothermal	Geothermal	22.00%	20%
	Geothermal CHP	23.80%	20%
Biomass	Dedicated >100MW	9.20%	20%
	Dedicated 5-100MW	9.00%	20%
	Co-firing	9.60%	21%
	CHP	12.20%	20%
	Conversion	10.10%	21%
ACT	ACT standard	9.20%	12%
	ACT advanced	10.20%	12%
	ACT CHP	11.20%	12%
AD	AD	10.20%	12%*
	AD CHP	12.20%	12%
EfW	EfW CHP	9.40%	12%
	EfW	7.40%	12%
Landfill		7.40%	12%
Sewage Gas		8.50%	20%
Nuclear	FOAK and NOAK	8.90%	12%
CCS Gas	FOAK	11.30%	20%
	NOAK	9.20%	20%
CCS Coal	FOAK	11.40%	20%
	NOAK	9.30%	20%
CCS Biomass		11.40%	20%
Gas	CCGT & OCGT	7.80%	20%
	CCGT IED retrofit	7.70%	20%
	Reciprocating engine (incl. diesel)	7.80%	20%
Coal plants	All retrofits	8.20%	20%

FITs Technologies	Category	Hurdle rate (pre-tax real)
Solar PV	Solar<10kW FiTs	5.70%
	Solar 250-1000kW FITS	6.10%
Hydro	Hydro <100kW	8.90%
	Hydro 500kW-2000kW	8.90%
Onshore Wind	Onshore Wind <50kW FiTs	7.40%
	Onshore Wind 100-1500kW FiTs	7.40%
AD	AD < 250kW FiTs	10.80%

Data used from Arup cost update

It should be noted that Arup provided certain results for some technologies that BEIS have decided not to use. This is outlined below:

- **Offshore wind**: Arup provided assumptions and levelised cost estimates for Round 2 sites, Round 3 sites, Round 2 and 3 combined (as well as estimates for sites by water depth and distance from shore[67]). For the purposes of analysis using this report, BEIS have decided to use the Round 3 sites on the basis that these sites differ in terms of timing – generally, Rounds 1, 2 and their extensions are now largely under construction or operational. Most of the projects in the pipeline are Round 3 projects.

- **Anaerobic Digestion**: BEIS has decided to use the capex and opex data derived from the biomethane review for 100% food waste plants[68 69], combined with other data from Arup and BEIS (where necessary) on the basis that this review data is considered more robust. The biomethane review is based on a larger number of data points, and Arup recognised that the cost of digestate disposal was excluded from their analysis (an omission which made it unsuitable for the purposes of estimating levelised costs). Further information on these capex and opex assumptions is provided below.

- **Energy from Waste**: BEIS did not use the capital cost range provided by Arup around their central cost estimate given BEIS concerns over the reliability of this capital costs range. Instead, BEIS has shown the fuel price sensitivity only around the central levelised cost estimate.

- **Cofiring**, Arup data was based on its previous dataset for enhanced cofiring. However, BEIS did not present this data previously, so has decided once again not to publish this information.

- **Wave and Tidal**: BEIS have presented results for 2025 commissioning and beyond to reflect possible timing of plants moving past the demonstration stage.

- **Load factors**: for offshore wind and onshore wind technologies, Arup have provided different load factors to apply over the plant lifetime for projects that commission before 2020. These load factors have been applied for the 2016 and 2018 levelised cost results in this report for these technologies.

Arup also only provided data in their report for projects reaching Final Investment Decision (FID) from 2015 onwards. In order to generate the 2016 and 2018 Levelised Cost estimates in this

67 Round 2 and Round 3 refer to the leasing rounds undertaken by The Crown Estate so it does not divide sites into near shore/far from shore or shallow water / deep water.

68 DECC 2014, Renewable Heat Incentive – Biomethane Tariff Review (Impact Assessment).

report for renewable technologies, it is assumed that these 2015 FID estimates also apply for earlier years to 2015 (if these projects reach FID before 2015 for the 2016 and 2018 levelised cost estimates). [70]

Anaerobic Digestion

As noted above, BEIS has used the capex and opex assumptions from the biomethane review. This excludes 'infrastructure' or grid connection costs, use of system operating expenditures, and fuel costs (gate fees), which have been taken from Arup data. The reference plant size for an AD plant between the DECC biomethane report and DECC 2013 are consistent. . For AD CHP plants, BEIS has used a heat to power ratio of 1.1, i.e. for every 1KWh of electricity the plant produces it also produces 1.1KWh of heat. (corresponding to 2.2 MWth for the 2.0MW sized reference plant).

Data from the biomethane review was adjusted in order to fully and exclusively capture the costs of an AD electricity only plant and AD CHP plant. Any components related to the upgrade of biogas and its injection into the gas grid were excluded from the capital and operational expenditure. Capital and operation costs are specific to the use of 100% waste feedstock, and include the cost associated with digestate disposal as well as other elements such as waste treatment costs and landfill costs.

Table 18: Data used from DECC biomethane review, 2014 values

		AD	AD CHP
Capital costs			
Pre-development costs		300	300
Capital costs[71]	£/kW	3,700	4,300
Operating costs			
Fixed	£/MW/year	78,000	132,000
Insurance	£/MW/year	54,000	54,000
Variable[72]	£/MWh	£81	£81

70 For most technologies, this assumption will only have an impact for 2016 where there is more than one year of pre-development. BEIS uses FID data provided by contractors to work out the cost of a particular project that may start in an earlier year (i.e. when this project reaches the FID stage, this 'FID year' data from Arup is the cost that is applied to the construction costs of a project that started in an earlier year).

[71] For the purposes of generating a range around capital costs to derive Levelised Costs estimates, BEIS has applied the range around capital costs that Arup is inherent in the data that Arup has provided to BEIS.

[72] Includes £1.9/MWh for BSUoS costs that Arup has applied for all other technologies.

Data used from the Feed-in-Tariffs (FITs) Cost Update

For FITs technologies, BEIS has drawn on evidence presented in the Impact Assessment for the Periodic Review of FITS (2015), which provided data for Small-scale Feed in Tarff (FITs) technologies.[73] This covers the cost estimates for PV, wind, and hydro under 5MW presented in this report. For Anaerobic Digestion (AD) we have used the recent Parsons Brinkerhoff report for the AD <250kW estimates presented in this report.[74]

Data used from Leigh Fisher cost update

It should be noted that the base cost data provided in the Leigh Fisher report differs between NOAK and FOAK technologies. For NOAK technologies, costs do not change over time for the central scenario, and so the base central costs apply for every commissioning year in this report. For FOAK technologies, the base costs apply to the 2025 commissioning year - this will be a different FID and project start year for different technologies corresponding to the length of pre-development and construction periods.

Leigh Fisher also only provided data in their report for projects reaching FID from 2015 onwards. In order to generate the 2016 and 2018 Levelised Cost estimates in this report for non-renewable technologies, it is assumed that these 2015 FID estimates apply for earlier years to 2015 (if these projects reach FID before 2015 for the 2016 and 2018 estimates). [75]

Note that the levelised cost results in Leigh Fisher's publication are based on DECC 2015 fossil fuel prices and carbon prices. These have been updated for revised carbon values and fossil fuel prices in this DECC publication.

Leigh Fisher provided technical and cost assumptions for biomass CCS technologies. As noted by Leigh Fisher, this costing is subject to considerable uncertainty and should only be seen as indicative. Further, the costing is based on a costing for a relatively small-sized dedicated biomass plant (23MW) from the equivalent Arup study[76] compared to the much larger likely size of a biomass CCS plant.. Leigh Fisher also recognise that their costing may not reflect the most efficient or cost effective approach to biomass CCS. Given the above, BEIS has not included the biomass CCS information from the Leigh Fisher cost study at this stage.

[73] DECC 2015, *Periodic Review of FITs 2015 (Impact Assessment)*.
[74] Parsons Brinckerhoff 2015 (for DECC), *Small Scale Cost Generation Costs Update.*
[75] For most technologies, this assumption will only have an impact for 2016 where there is more than one year of pre-development.
[76] Arup 2016, *Review of Renewable Electricity Generation Cost and Technical Assumptions*.

Key data assumptions

The below tables summarise the key other assumptions used to calculate levelised costs for key technologies in this report. This includes data on:

- Reference plant sizes.
- Average load factor (net of availability) and plant efficiency (LHV basis for renewables, and HHV basis for non-renewables).
- Duration of pre-development, construction and operating periods.
- Main cost categories used in BEIS levelised cost modelling.

Tables 21 to 23 provide information on fuel prices/gate fees and carbon values used in this report.

Table 19: Capital and operating cost assumptions for all technologies[77]

		CCGT H Class			CCGT F Class			CCGT CHP mode			OCGT 600MW 500 hr		
Reference plant size	MW	1,200			1,471			168			625		
Average load factor (net of availability)	%	93%			93%			93%			6%		
Efficiency (HHV)	%	54%			53%			34%			35%		
Pre-development period	**Duration** and % spend per years 1 & 2	**2 years**	44%	44%	**2 years**	44%	44%	**2 years**	43.5%	43.5%	**2 years**	55.6%	44.4%
	% spend per years 3, 4, & 5	12%			12%			13%					
	% spend per years 6, 7, & 8												
Construction period	**Duration** and % spend per years 1 & 2	**3 years**	40%	40%	**3 years**	40%	40%	**3 years**	40%	40%	**2 years**	50%	50%
	% spend per years 3, 4, & 5	20%			20%			20%					
	% spend per years 6, 7, & 8												
Operating period	**Duration**	25 years			25 years			25 years			25 years		
		Commissioning year			**Commissioning year**			**Commissioning year**			**Commissioning year**		
		2018	**2020**	**2025**	**2018**	**2020**	**2025**	**2018**	**2020**	**2025**	**2018**	**2020**	**2025**
Pre-development £/kW	High	20	20	20	10	10	10	80	80	80	20	20	20
	Medium	10	10	10	10	10	10	60	60	60	20	20	20
	Low	10	10	10	10	10	10	30	30	30	20	20	20
Construction £/kW	High	600	600	600	500	600	600	800	800	900	300	300	300
	Medium	500	500	500	500	500	500	700	700	700	300	300	300
	Low	400	400	400	400	400	400	600	600	600	300	300	300
Infrastructure £'000s	High	30,200	30,200	30,200	30,200	30,200	30,200	27,100	27,100	27,100	30,200	30,200	30,200
	Medium	15,100	15,100	15,100	15,100	15,100	15,100	13,600	13,600	13,600	15,100	15,100	15,100
	Low	7,600	7,600	7,600	7,600	7,600	7,600	6,800	6,800	6,800	7,600	7,600	7,600
Fixed O&M £/MW/year	Medium	12,200	12,200	12,200	11,400	11,400	11,400	28,200	28,200	28,200	4,600	4,600	4,600
Variable O&M £/MWh	Medium	3	3	3	3	3	3	5	5	5	3	3	3
Insurance £/MWh/year	Medium	2,100	2,100	2,100	1,900	1,900	1,900	2,900	2,900	2,900	1,200	1,200	1,200
Connection and Use of System charges £/MW/year	Medium	3,300	3,300	3,300	3,300	3,300	3,300	3,300	3,300	3,300	2,400	2,400	2,400

[77] For the tables in this section (except for onshore and offshore wind) the load factor quoted is the same for all commissioning years. Refer to relevant table notes for exceptions related to onshore and offshore wind.

		OCGT 400MW 500 hr			OCGT 300MW 500 hr			OCGT 299MW 500 hr			OCGT 100MW 500 hr		
Reference plant size	MW	400			311			299			96		
Average load factor (net of availability)	%	6%			6%			6%			6%		
Efficiency (HHV)	%	34%			35%			35%			35%		
Pre-development period	**Duration** and % spend per years 1 & 2	**2 years**	55.6%	44.4%	**2 years**	55.6%	44.4%	**2 years**	55.6%	44.4%	**2 years**	55.6%	44.4%
	% spend per years 3, 4, & 5												
	% spend per years 6, 7, & 8												
Construction period	**Duration** and % spend per years 1 & 2	**2 years**	50%	50%	**2 years**	50%	50%	**2 years**	50%	50%	**2 years**	50%	50%
	% spend per years 3, 4, & 5												
	% spend per years 6, 7, & 8												
Operating period	**Duration**	25 years			25 years			25 years			25 years		
		Commissioning year			**Commissioning year**			**Commissioning year**			**Commissioning year**		
		2018	**2020**	**2025**	**2018**	**2020**	**2025**	**2018**	**2020**	**2025**	**2018**	**2020**	**2025**
Pre-development £/kW	High	30	30	30	40	40	40	40	40	40	90	90	90
	Medium	30	30	30	30	30	30	30	30	30	80	80	80
	Low	20	20	20	30	30	30	30	30	30	70	70	70
Construction £/kW	High	400	400	400	600	700	700	600	700	700	800	800	800
	Medium	300	300	300	400	400	400	400	400	400	600	600	600
	Low	300	300	300	300	300	300	300	300	300	600	600	600
Infrastructure £'000s	High	30,200	30,200	30,200	27,100	27,100	27,100	27,100	27,100	27,100	25,100	25,100	25,100
	Medium	15,100	15,100	15,100	13,600	13,600	13,600	13,600	13,600	13,600	12,600	12,600	12,600
	Low	7,600	7,600	7,600	6,800	6,800	6,800	6,800	6,800	6,800	6,300	6,300	6,300
Fixed O&M £/MW/year	Medium	5,200	5,200	5,200	6,300	6,300	6,300	6,400	6,400	6,400	9,900	9,900	9,900
Variable O&M £/MWh	Medium	3	3	3	3	3	3	3	3	3	4	4	4
Insurance £/MWh/year	Medium	1,300	1,300	1,300	1,600	1,600	1,600	1,600	1,600	1,600	2,500	2,500	2,500
Connection and Use of System charges £/MW/year	Medium	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400

		OCGT 600MW 2000 hr			OCGT 400MW 2000 hr			OCGT 300MW 2000 hr			OCGT 299MW 2000 hr		
Reference plant size	MW	625			400			311			299		
Average load factor (net of availability)	%	22%			22%			22%			22%		
Efficiency (HHV)	%	35%			34%			35%			35%		
Pre-development period	**Duration** and % spend per years 1 & 2	**2 years**	55.6%	44.4%	**2 years**	55.6%	44.4%	**2 years**	55.6%	44.4%	**2 years**	55.6%	44.4%
	% spend per years 3, 4, & 5												
	% spend per years 6, 7, & 8												
Construction period	**Duration** and % spend per years 1 & 2	**2 years**	50%	50%	**2 years**	50%	50%	**2 years**	50%	50%	**2 years**	50%	50%
	% spend per years 3, 4, & 5												
	% spend per years 6, 7, & 8												
Operating period	**Duration**	25 years			25 years			25 years			25 years		
		Commissioning year			**Commissioning year**			**Commissioning year**			**Commissioning year**		
		2018	**2020**	**2025**	**2018**	**2020**	**2025**	**2018**	**2020**	**2025**	**2018**	**2020**	**2025**
Pre-development £/kW	High	20	20	20	30	30	30	40	40	40	40	40	40
	Medium	20	20	20	30	30	30	30	30	30	30	30	30
	Low	20	20	20	20	20	20	30	30	30	30	30	30
Construction £/kW	High	300	300	300	400	400	400	600	700	700	600	700	700
	Medium	300	300	300	300	300	300	400	400	400	400	400	400
	Low	300	300	300	300	300	300	300	300	300	300	300	300
Infrastructure £'000s	High	30,200	30,200	30,200	30,200	30,200	30,200	27,100	27,100	27,100	27,100	27,100	27,100
	Medium	15,100	15,100	15,100	15,100	15,100	15,100	13,600	13,600	13,600	13,600	13,600	13,600
	Low	7,600	7,600	7,600	7,600	7,600	7,600	6,800	6,800	6,800	6,800	6,800	6,800
Fixed O&M £/MW/year	Medium	6,800	6,800	6,800	7,800	7,800	7,800	9,500	9,500	9,500	9,600	9,600	9,600
Variable O&M £/MWh	Medium	3	3	3	3	3	3	3	3	3	3	3	3
Insurance £/MWh/year	Medium	1,200	1,200	1,200	1,300	1,300	1,300	1,600	1,600	1,600	1,600	1,600	1,600
Connection and Use of System charges £/MW/year	Medium	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500

		OCGT 100MW 2000 hr			Recip Diesel 2000 hr			Recip Diesel 500 hrs			Recip Diesel 90 hrs		
Reference plant size	MW	96			20			20			20		
Average load factor (net of availability)	%	22%			22%			5%			1%		
Efficiency (HHV)	%	35%			34%			34%			34%		
Pre-development period	**Duration** and % spend per years 1 & 2	**2 years**	55.6%	44.4%	**2 years**	50%	50%	**2 years**	50%	50%	**2 years**	50%	50%
	% spend per years 3, 4, & 5												
	% spend per years 6, 7, & 8												
Construction period	**Duration** and % spend per years 1 & 2	**2 years**	50%	50%	**1 years**	100%		**1 years**	100%		**1 years**	100%	
	% spend per years 3, 4, & 5												
	% spend per years 6, 7, & 8												
Operating period	**Duration**	25 years			15 years			15 years			15 years		
		Commissioning year			**Commissioning year**			**Commissioning year**			**Commissioning year**		
		2018	**2020**	**2025**	**2018**	**2020**	**2025**	**2018**	**2020**	**2025**	**2018**	**2020**	**2025**
Pre-development £/kW	High	90	90	90	20	20	20	20	20	20	20	20	20
	Medium	80	80	80	10	10	10	10	10	10	10	10	10
	Low	70	70	70	10	10	10	10	10	10	10	10	10
Construction £/kW	High	800	800	800	300	300	300	300	300	300	300	300	300
	Medium	600	600	600	300	300	300	300	300	300	300	300	300
	Low	600	600	600	200	200	200	200	200	200	200	200	200
Infrastructure £'000s	High	25,100	25,100	25,100	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500	6,500
	Medium	12,600	12,600	12,600	2,200	2,200	2,200	2,200	2,200	2,200	2,200	2,200	2,200
	Low	6,300	6,300	6,300	400	400	400	400	400	400	400	400	400
Fixed O&M £/MW/year	Medium	14,800	14,800	14,800	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
Variable O&M £/MWh	Medium	4	4	4	2	2	2	2	2	2	2	2	2
Insurance £/MWh/year	Medium	2,500	2,500	2,500	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Connection and Use of System charges £/MW/year	Medium	2,500	2,500	2,500	- 31,900	- 31,900	- 31,900	- 28,500	- 28,500	- 28,500	- 28,000	- 28,000	- 28,000

		Recip Gas 2000 hr			RECIP GAS 500 hrs			Nuclear - PWR FOAK			Pumped storage		
Reference plant size	MW	20			20			3,300			600		
Average load factor (net of availability)	%	22%			5%			90%			21%		
Efficiency (HHV)	%	32%			32%			100%			77%		
Pre-development period	**Duration** and % spend per years 1 & 2	**2 years**	50%	50%	**2 years**	50%	50%	**5 years**	20%	20%	**5 years**	20%	20%
	% spend per years 3, 4, & 5							20%	20%	20%	20%	20%	20%
	% spend per years 6, 7, & 8												
Construction period	**Duration** and % spend per years 1 & 2	**1 years**	100%		**1 years**	100%		**8 years**	5%	5%	**5 years**	22.2%	22.2%
	% spend per years 3, 4, & 5							20%	20%	20%	22.2%	22.2%	11.1%
	% spend per years 6, 7, & 8							20%	5%	5%			
Operating period	**Duration**	15 years			15 years			60 years			50 years		
		Commissioning year			**Commissioning year**			**Commissioning year**			**Commissioning year**		
		2018	**2020**	**2025**	**2018**	**2020**	**2025**	**2018**	**2020**	**2025**	**2018**	**2020**	**2025**
Pre-development £/kW	High	20	20	20	20	20	20	-	-	640	50	50	50
	Medium	10	10	10	10	10	10	-	-	240	40	40	40
	Low	10	10	10	10	10	10	-	-	110	30	30	30
Construction £/kW	High	300	300	300	300	300	300	-	-	5,100	1,500	1,500	1,600
	Medium	300	300	300	300	300	300	-	-	4,100	1,000	1,000	1,000
	Low	300	300	300	300	300	300	-	-	3,700	700	700	700
Infrastructure £'000s	High	10,300	10,300	10,300	10,300	10,300	10,300	-	-	50,000	50,000	50,000	50,000
	Medium	3,400	3,400	3,400	3,400	3,400	3,400	-	-	11,500	25,000	25,000	25,000
	Low	700	700	700	700	700	700	-	-	-	10,000	10,000	10,000
Fixed O&M £/MW/year	Medium	10,000	10,000	10,000	10,000	10,000	10,000	-	-	72,900	11,200	11,200	11,200
Variable O&M £/MWh	Medium	2	2	2	2	2	2	-	-	5	42	42	42
Insurance £/MWh/year	Medium	1,000	1,000	1,000	1,000	1,000	1,000	-	-	10,000	4,100	4,100	4,100
Connection and Use of System charges £/MW/year	Medium	- 31,900	- 31,900	- 31,900	- 28,500	- 28,500	- 28,500	-	-	500	15,800	15,800	15,800

		Gas - CCS CCGT Post FOAK			Gas - CCS CCGT Retro Post FOAK			Gas - CCS CCGT Pre FOAK			Gas - CCS CCGT oxy FOAK		
Reference plant size	MW	963			618			1,084			1,038		
Average load factor (net of availability)	%	88%			88%			88%			88%		
Efficiency (HHV)	%	44%			44%			38%			42%		
Pre-development period	**Duration** and % spend per years 1 & 2	**5 years**	20%	20%	**4 years**	25%	25%	**5 years**	20%	20%	**6 years**	16.7%	16.7%
	% spend per years 3, 4, & 5	20%	20%	20%	25%	25%		20%	20%	20%	16.7%	16.7%	16.7%
	% spend per years 6, 7, & 8										16.7%		
Construction period	**Duration** and % spend per years 1 & 2	**5 years**	20%	20%	**4 years**	25%	25%	**5 years**	20%	20%	**5 years**	20%	20%
	% spend per years 3, 4, & 5	20%	20%	20%	25%	25%		20%	20%	20%	20%	20%	20%
	% spend per years 6, 7, & 8												
Operating period	**Duration**	25 years			25 years			25 years			25 years		
		Commissioning year			**Commissioning year**			**Commissioning year**			**Commissioning year**		
		2018	**2020**	**2025**	**2018**	**2020**	**2025**	**2018**	**2020**	**2025**	**2018**	**2020**	**2025**
Pre-development £/kW	High	-	-	80	-	-	50	-	-	80	-	-	80
	Medium	-	-	50	-	-	30	-	-	50	-	-	40
	Low	-	-	30	-	-	20	-	-	30	-	-	30
Construction £/kW	High	-	-	2,700	-	-	1,800	-	-	2,600	-	-	2,700
	Medium	-	-	2,100	-	-	1,400	-	-	2,000	-	-	2,100
	Low	-	-	1,700	-	-	1,200	-	-	1,700	-	-	1,700
Infrastructure £'000s	High	-	-	30,200	-	-	-	-	-	30,200	-	-	30,200
	Medium	-	-	15,100	-	-	-	-	-	15,100	-	-	15,100
	Low	-	-	7,600	-	-	-	-	-	7,600	-	-	7,600
Fixed O&M £/MW/year	Medium	-	-	31,000	-	-	30,900	-	-	30,500	-	-	83,800
Variable O&M £/MWh	Medium	-	-	3	-	-	3	-	-	4	-	-	4
Insurance £/MWh/year	Medium	-	-	7,300	-	-	7,400	-	-	7,500	-	-	7,500
Connection and Use of System charges £/MW/year	Medium	-	-	3,300	-	-	3,300	-	-	3,300	-	-	3,300

		Gas - CCS OCGT post FOAK			Coal - CCS ASC Partial FOAK			Coal - CCS ASC FOAK			Coal - CCS ASC retrofit FOAK		
Reference plant size	MW	290			734			624			390		
Average load factor (net of availability)	%	85%			91%			91%			91%		
Efficiency (HHV)	%	24%			38%			32%			31%		
Pre-development period	**Duration** and % spend per years 1 & 2	**5 years**	20%	20%	**5 years**	20%	20%	**5 years**	20%	20%	**5 years**	20%	20%
	% spend per years 3, 4, & 5	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
	% spend per years 6, 7, & 8												
Construction period	**Duration** and % spend per years 1 & 2	**5 years**	20%	20%	**5 years**	20%	20%	**5 years**	20%	20%	**4 years**	25%	25%
	% spend per years 3, 4, & 5	20%	20%	20%	20%	20%	20%	20%	20%	20%	25%	25%	
	% spend per years 6, 7, & 8												
Operating period	**Duration**	25 years			25 years			25 years			15 years		
		Commissioning year			**Commissioning year**			**Commissioning year**			**Commissioning year**		
		2018	**2020**	**2025**	**2018**	**2020**	**2025**	**2018**	**2020**	**2025**	**2018**	**2020**	**2025**
Pre-development £/kW	High	-	-	120	-	-	80	-	-	110	-	-	50
	Medium	-	-	80	-	-	60	-	-	70	-	-	30
	Low	-	-	60	-	-	40	-	-	60	-	-	20
Construction £/kW	High	-	-	3,000	-	-	3,400	-	-	5,500	-	-	3,000
	Medium	-	-	2,300	-	-	2,600	-	-	4,200	-	-	2,400
	Low	-	-	1,900	-	-	2,100	-	-	3,400	-	-	1,900
Infrastructure £'000s	High	-	-	30,200	-	-	15,000	-	-	15,000	-	-	-
	Medium	-	-	15,100	-	-	10,000	-	-	10,000	-	-	-
	Low	-	-	7,600	-	-	5,000	-	-	5,000	-	-	-
Fixed O&M £/MW/year	Medium	-	-	31,800	-	-	56,400	-	-	78,500	-	-	80,700
Variable O&M £/MWh	Medium	-	-	3	-	-	3	-	-	3	-	-	3
Insurance £/MWh/year	Medium	-	-	8,500	-	-	9,600	-	-	15,800	-	-	8,200
Connection and Use of System charges £/MW/year	Medium	-	-	2,500	-	-	3,800	-	-	3,800	-	-	3,800

		Coal - CCS ASC Oxy FOAK			Coal - CCS ASC NH3 FOAK			Coal - CCS IGCC FOAK			Coal - CCS IGCC partial FOAK		
Reference plant size	MW	552			624			652			760		
Average load factor (net of availability)	%	91%			91%			88%			88%		
Efficiency (HHV)	%	32%			32%			30%			35%		
Pre-development period	**Duration** and % spend per years 1 & 2	**6 years**	16.7%	16.7%	**5 years**	20%	20%	**5 years**	20%	20%	**5 years**	20%	20%
	% spend per years 3, 4, & 5	16.7%	16.7%	16.7%	20%	20%	20%	20%	20%	20%	20%	20%	20%
	% spend per years 6, 7, & 8	16.7%											
Construction period	**Duration** and % spend per years 1 & 2	**6 years**	18.2%	18.2%	**5 years**	20%	20%	**5 years**	20%	20%	**5 years**	20%	20%
	% spend per years 3, 4, & 5	18.2%	18.2%	18.2%	20%	20%	20%	20%	20%	20%	20%	20%	20%
	% spend per years 6, 7, & 8	9.1%											
Operating period	**Duration**	25 years			25 years			25 years			25 years		
		Commissioning year			**Commissioning year**			**Commissioning year**			**Commissioning year**		
		2018	**2020**	**2025**	**2018**	**2020**	**2025**	**2018**	**2020**	**2025**	**2018**	**2020**	**2025**
Pre-development £/kW	High	-	-	80	-	-	110	-	-	80	-	-	60
	Medium	-	-	40	-	-	70	-	-	60	-	-	40
	Low	-	-	30	-	-	60	-	-	50	-	-	40
Construction £/kW	High	-	-	4,400	-	-	5,500	-	-	5,000	-	-	3,600
	Medium	-	-	3,400	-	-	4,200	-	-	3,900	-	-	2,800
	Low	-	-	2,900	-	-	3,400	-	-	3,300	-	-	2,400
Infrastructure £'000s	High	-	-	15,000	-	-	15,000	-	-	15,000	-	-	15,000
	Medium	-	-	10,000	-	-	10,000	-	-	10,000	-	-	10,000
	Low	-	-	5,000	-	-	5,000	-	-	5,000	-	-	5,000
Fixed O&M £/MW/year	Medium	-	-	68,200	-	-	79,600	-	-	65,300	-	-	52,100
Variable O&M £/MWh	Medium	-	-	6	-	-	3	-	-	5	-	-	5
Insurance £/MWh/year	Medium	-	-	13,000	-	-	19,300	-	-	22,700	-	-	14,000
Connection and Use of System charges £/MW/year	Medium	-	-	3,800	-	-	3,800	-	-	3,800	-	-	3,800

		Coal - CCS IGCC retro FOAK		
Reference plant size	MW	622		
Average load factor (net of availability)	%	88%		
Efficiency (HHV)	%	27%		
Pre-development period	**Duration** and % spend per years 1 & 2	**5 years**	20%	20%
	% spend per years 3, 4, & 5	20%	20%	20%
	% spend per years 6, 7, & 8			
Construction period	**Duration** and % spend per years 1 & 2	**4 years**	25%	25%
	% spend per years 3, 4, & 5	25%	25%	
	% spend per years 6, 7, & 8			
Operating period	**Duration**	25 years		
		Commissioning year		
		2018	**2020**	**2025**
Pre-development £/kW	High	-	-	100
	Medium	-	-	60
	Low	-	-	60
Construction £/kW	High	-	-	5,400
	Medium	-	-	4,200
	Low	-	-	3,600
Infrastructure £'000s	High	-	-	-
	Medium	-	-	-
	Low	-	-	-
Fixed O&M £/MW/year	Medium	-	-	81,900
Variable O&M £/MWh	Medium	-	-	6
Insurance £/MWh/year	Medium	-	-	27,600
Connection and Use of System charges £/MW/year	Medium	-	-	3,800

		Dedicated Biomass			Conversions			Biomass CHP			Onshore UK>5MW		
Reference plant size	MW	23			349			14			20		
Average load factor (net of availability)	%	84%			79%			80%			32%		
Efficiency (LHV)	%	29%			40%			23%			0%		
Pre-development period	**Duration** and % spend per years 1 & 2	**3 years**	33.3%	33.3%	**2 years**	50%	50%	**3 years**	33.3%	33.3%	**4 years**	25%	25%
	% spend per years 3, 4, & 5	33.3%						33.3%			25%	25%	
	% spend per years 6, 7, & 8												
Construction period	**Duration** and % spend per years 1 & 2	**2 years**	50%	50%	**2 years**	43.5%	43.5%	**2 years**	50%	50%	**2 years**	50%	50%
	% spend per years 3, 4, & 5				13%								
	% spend per years 6, 7, & 8												
Operating period	**Duration**	25 years			15 years			24 years			24 years		
		Commissioning year			**Commissioning year**			**Commissioning year**			**Commissioning year**		
		2018	**2020**	**2025**	**2018**	**2020**	**2025**	**2018**	**2020**	**2025**	**2018**	**2020**	**2025**
Pre-development £/kW	High	160	160	160	120	120	-	580	580	580	190	190	190
	Medium	110	110	110	80	80	-	270	270	270	110	110	110
	Low	80	80	80	50	50	-	40	40	40	40	40	40
Construction £/kW	High	3,400	3,300	3,300	300	300	-	5,400	5,600	5,900	1,500	1,500	1,400
	Medium	2,900	2,900	2,800	200	200	-	4,500	4,700	4,900	1,200	1,200	1,200
	Low	2,400	2,300	2,300	200	200	-	3,400	3,500	3,700	900	800	800
Infrastructure £'000s	High	500	500	500	-	-	-	1,100	1,100	1,100	4,100	4,100	4,100
	Medium	400	400	400	-	-	-	900	900	900	3,300	3,300	3,300
	Low	200	200	200	-	-	-	700	700	700	2,300	2,300	2,300
Fixed O&M £/MW/year	Medium	65,500	65,500	65,500	22,800	22,800	-	223,500	230,000	240,600	23,200	23,000	22,400
Variable O&M £/MWh	Medium	8	8	8	1	1	-	11	11	11	5	5	5
Insurance £/MWh/year	Medium	11,500	11,500	11,500	11,500	11,500	-	44,000	45,300	47,400	1,400	1,400	1,400
Connection and Use of System charges £/MW/year	Medium	12,900	12,900	12,900	10,500	10,500	-	15,500	16,000	16,700	3,100	3,100	3,000

Note: The load factor provided above for onshore wind is for plants commissioning from 2020 comissioing onwards. Different load factors apply to the pre 2020 levelised costs results presented in this report (refer to the underlying Arup report for this information).

		Offshore R2			Offshore R3			PV>5MW			PV 1-5MW ground		
Reference plant size	MW	321			844			16			4		
Average load factor (net of availability)	%	43%			48%			11%			11%		
Efficiency (LHV)	%	0%			0%			0%			0%		
Pre-development period	**Duration** and % spend per years 1 & 2	**5 years**	22.2%	22.2%	**5 years**	22.2%	22.2%	**1 years**	100%		**1 years**	100%	
	% spend per years 3, 4, & 5	22.2%	22.2%	11.1%	22.2%	22.2%	11.1%						
	% spend per years 6, 7, & 8												
Construction period	**Duration** and % spend per years 1 & 2	**3 years**	33.3%	33.3%	**3 years**	33.3%	33.3%	**0 years**	100%		**0 years**	100%	
	% spend per years 3, 4, & 5	33.3%			33.3%								
	% spend per years 6, 7, & 8												
Operating period	**Duration**	23 years			22 years			25 years			25 years		
		Commissioning year			**Commissioning year**			**Commissioning year**			**Commissioning year**		
		2018	**2020**	**2025**	**2018**	**2020**	**2025**	**2018**	**2020**	**2025**	**2018**	**2020**	**2025**
Pre-development £/kW	High	150	150	150	190	190	190	170	170	170	60	60	60
	Medium	60	60	60	120	120	120	70	70	70	60	60	60
	Low	20	20	20	60	60	60	10	10	10	60	60	60
Construction £/kW	High	3,100	3,000	2,700	2,700	2,600	2,400	700	700	600	900	800	700
	Medium	2,200	2,100	1,900	2,400	2,300	2,100	700	600	600	700	700	600
	Low	1,700	1,600	1,500	2,100	2,000	1,800	600	600	500	600	600	500
Infrastructure £'000s	High	97,400	97,400	97,400	372,400	372,400	372,400	400	400	400	300	300	300
	Medium	69,300	69,300	69,300	323,000	323,000	323,000	400	400	400	200	200	200
	Low	53,000	53,000	53,000	281,400	281,400	281,400	400	400	400	200	200	200
Fixed O&M £/MW/year	Medium	30,900	30,000	28,600	48,600	47,300	45,400	5,600	5,400	5,100	8,300	8,000	7,500
Variable O&M £/MWh	Medium	3	3	3	4	3	3	-	-	-	-	-	-
Insurance £/MWh/year	Medium	1,400	1,400	1,300	3,300	3,300	3,100	2,000	1,900	1,800	1,200	1,100	1,100
Connection and Use of System charges £/MW/year	Medium	33,500	32,600	31,100	50,300	48,900	47,000	1,300	1,300	1,200	1,300	1,300	1,200

Note: The load factor provided above for offshore wind round 2 and 3 is for plants commissioning from 2020 comissioing onwards. Different load factors apply to the pre 2020 levelised costs results presented in this report (refer to the underlying Arup report for this information).

		PV 1-5MW building			EfW			EfW CHP			AD		
Reference plant size	MW	1			30			24			2		
Average load factor (net of availability)	%	11%			81%			81%			79%		
Efficiency (LHV)	%	0%			28%			22%			40%		
Pre-development period	**Duration** and % spend per years 1 & 2	**1 years**	100%		**4 years**	22.8%	22.8%	**4 years**	22.8%	22.8%	**2 years**	66.7%	33.3%
	% spend per years 3, 4, & 5				22.8%	22.8%	9%	22.8%	22.8%	9%			
	% spend per years 6, 7, & 8												
Construction period	**Duration** and % spend per years 1 & 2	**0 years**	100%		**3 years**	33.3%	33.3%	**3 years**	33.3%	33.3%	**1 years**	100%	
	% spend per years 3, 4, & 5				33.3%			33.3%					
	% spend per years 6, 7, & 8												
Operating period	**Duration**	25 years			35 years			35 years			20 years		
		Commissioning year			**Commissioning year**			**Commissioning year**			**Commissioning year**		
		2018	**2020**	**2025**	**2018**	**2020**	**2025**	**2018**	**2020**	**2025**	**2018**	**2020**	**2025**
Pre-development £/kW	High	20	20	20	390	390	390	300	300	300	440	440	440
	Medium	20	20	20	230	230	230	210	210	210	340	340	340
	Low	20	20	20	110	110	110	130	130	130	260	260	260
Construction £/kW	High	800	800	700	12,500	12,400	12,200	15,900	15,800	15,600	4,900	4,900	4,900
	Medium	700	700	600	8,200	8,100	8,000	13,300	13,200	13,000	3,700	3,700	3,700
	Low	700	600	600	4,600	4,600	4,500	10,300	10,300	10,100	2,900	2,900	2,900
Infrastructure £'000s	High	-	-	-	6,600	6,600	6,600	8,500	8,500	8,500	1,000	1,000	1,000
	Medium	-	-	-	4,600	4,600	4,600	5,900	5,900	5,900	700	700	700
	Low	-	-	-	2,500	2,500	2,500	3,000	3,000	3,000	500	500	500
Fixed O&M £/MW/year	Medium	6,600	6,300	5,900	139,500	137,900	134,800	153,000	151,300	147,900	78,100	78,100	78,100
Variable O&M £/MWh	Medium	3	3	3	25	25	24	55	55	53	81	81	81
Insurance £/MWh/year	Medium	2,600	2,600	2,400	30,500	30,100	29,500	85,200	84,300	82,400	54,200	54,200	54,200
Connection and Use of System charges £/MW/year	Medium	1,300	1,300	1,200	16,700	16,500	16,100	16,700	16,500	16,100	12,900	12,900	12,900

		AD CHP			ACT Standard			ACT Advanced			ACT CHP		
Reference plant size	MW	2			12			9			1		
Average load factor (net of availability)	%	79%			83%			83%			83%		
Efficiency (LHV)	%	32%			21%			25%			24%		
Pre-development period	**Duration** and % spend per years 1 & 2	**2 years**	66.7%	33.3%	**3 years**	36.4%	36.4%	**3 years**	36.4%	36.4%	**3 years**	36.4%	36.4%
	% spend per years 3, 4, & 5				27.3%			27.3%			27.3%		
	% spend per years 6, 7, & 8												
Construction period	**Duration** and % spend per years 1 & 2	**1 years**	100%		**2 years**	50%	50%	**2 years**	44.4%	44.4%	**2 years**	44.4%	44.4%
	% spend per years 3, 4, & 5							11.1%			11.1%		
	% spend per years 6, 7, & 8												
Operating period	**Duration**	20 years			25 years			25 years			25 years		
		Commissioning year			**Commissioning year**			**Commissioning year**			**Commissioning year**		
		2018	**2020**	**2025**	**2018**	**2020**	**2025**	**2018**	**2020**	**2025**	**2018**	**2020**	**2025**
Pre-development £/kW	High	440	440	440	300	300	300	980	980	980	980	980	980
	Medium	340	340	340	180	180	180	410	410	410	410	410	410
	Low	260	260	260	50	50	50	90	90	90	90	90	90
Construction £/kW	High	5,600	5,600	5,600	7,100	6,900	6,600	12,300	12,000	11,400	16,700	16,300	15,400
	Medium	4,300	4,300	4,300	6,100	6,000	5,600	7,100	7,000	6,600	9,000	8,800	8,300
	Low	3,300	3,300	3,300	4,200	4,100	3,900	4,300	4,200	4,000	4,900	4,800	4,500
Infrastructure £'000s	High	1,000	1,000	1,000	1,600	1,600	1,600	1,600	1,600	1,600	1,600	1,600	1,600
	Medium	700	700	700	1,400	1,400	1,400	1,400	1,400	1,400	1,400	1,400	1,400
	Low	500	500	500	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Fixed O&M £/MW/year	Medium	132,000	132,000	132,000	232,400	229,700	223,200	157,700	156,000	151,600	157,700	156,000	151,600
Variable O&M £/MWh	Medium	81	81	81	21	21	20	40	39	38	40	39	38
Insurance £/MWh/year	Medium	54,200	54,200	54,200	56,700	56,000	54,400	83,300	82,400	80,100	83,300	82,400	80,100
Connection and Use of System charges £/MW/year	Medium	12,900	12,900	12,900	12,700	12,600	12,200	12,700	12,600	12,200	12,700	12,600	12,200

		Landfill gas			Sewage gas			Geothermal CHP			Hydro Large Store		
Reference plant size	MW	2			3			3			11		
Average load factor (net of availability)	%	58%			46%			90%			45%		
Efficiency (LHV)	%	100%			100%			100%			100%		
Pre-development period	**Duration** and % spend per years 1 & 2	**1 years**	100%		**1 years**	100%		**1 years**	100%		**0 years**	70%	30%
	% spend per years 3, 4, & 5												
	% spend per years 6, 7, & 8												
Construction period	**Duration** and % spend per years 1 & 2	**0 years**	100%		**2 years**	56%	44%	**3 years**	33.3%	33.3%	**2 years**	70%	30%
	% spend per years 3, 4, & 5							33.3%					
	% spend per years 6, 7, & 8												
Operating period	**Duration**	27.8571428571429 years			20 years			25 years			41 years		
		Commissioning year			**Commissioning year**			**Commissioning year**			**Commissioning year**		
		2018	**2020**	**2025**	**2018**	**2020**	**2025**	**2018**	**2020**	**2025**	**2018**	**2020**	**2025**
Pre-development £/kW	High	60	60	60	420	420	420	130	130	130	-	-	-
	Medium	40	40	40	420	420	420	110	110	110	60	60	60
	Low	20	20	20	410	410	410	80	80	80	-	-	-
Construction £/kW	High	3,600	3,600	3,600	7,000	7,000	7,000	9,400	9,300	9,100	-	-	-
	Medium	2,200	2,200	2,200	5,100	5,100	5,100	6,900	6,800	6,700	3,200	3,200	3,200
	Low	800	800	800	1,800	1,800	1,800	3,000	3,000	2,900	-	-	-
Infrastructure £'000s	High	1,000	1,000	1,000	200	200	200	500	500	500	-	-	-
	Medium	700	700	700	200	200	200	300	300	300	-	-	-
	Low	500	500	500	100	100	100	200	200	200	-	-	-
Fixed O&M £/MW/year	Medium	81,000	81,000	81,000	48,600	48,600	48,600	81,000	81,000	81,000	25,700	25,700	25,700
Variable O&M £/MWh	Medium	9	9	9	12	12	12	12	12	12	6	6	6
Insurance £/MWh/year	Medium	1,600	1,600	1,600	36,600	36,600	36,600	1,600	1,600	1,600	1,000	1,000	1,000
Connection and Use of System charges £/MW/year	Medium	6,500	6,500	6,500	12,900	12,900	12,900	12,900	12,900	12,900	7,600	7,600	7,600

		Hydro 5-16MW			Wave			Tidal stream		
Reference plant size	MW	11			9			18		
Average load factor (net of availability)	%	35%			30%			31%		
Efficiency (LHV)	%	100%			100%			100%		
Pre-development period	**Duration** and % spend per years 1 & 2	**2 years**	77%	23%	**3 years**	33.3%	33.3%	**4 years**	23.3%	23.3%
	% spend per years 3, 4, & 5				33.3%			23.3%	23.3%	7%
	% spend per years 6, 7, & 8									
Construction period	**Duration** and % spend per years 1 & 2	**2 years**	70%	30%	**2 years**	50%	50%	**2 years**	55.5%	44.5%
	% spend per years 3, 4, & 5									
	% spend per years 6, 7, & 8									
Operating period	**Duration**	41 years			20 years			22 years		
		Commissioning year			**Commissioning year**			**Commissioning year**		
		2018	**2020**	**2025**	**2018**	**2020**	**2025**	**2018**	**2020**	**2025**
Pre-development £/kW	High	300	300	300	-	-	270	-	-	270
	Medium	60	60	60	-	-	130	-	-	130
	Low	40	40	40	-	-	40	-	-	40
Construction £/kW	High	3,100	3,100	3,100	-	-	6,200	-	-	6,000
	Medium	3,000	3,000	3,000	-	-	4,500	-	-	4,200
	Low	1,600	1,600	1,600	-	-	2,600	-	-	2,400
Infrastructure £'000s	High	-	-	-	-	-	7,000	-	-	10,500
	Medium	-	-	-	-	-	5,100	-	-	7,400
	Low	-	-	-	-	-	2,900	-	-	4,200
Fixed O&M £/MW/year	Medium	45,100	45,100	45,100	-	-	40,600	-	-	91,400
Variable O&M £/MWh	Medium	6	6	6	-	-	24	-	-	7
Insurance £/MWh/year	Medium	-	-	-	-	-	11,900	-	-	2,500
Connection and Use of System charges £/MW/year	Medium	-	-	-	-	-	32,300	-	-	60,400

		Solar 100-1000kW			Solar <10kW			Onshore <50kW			Onshore 250-1000kW		
Reference plant size	MW	0.455			0.003			0.010			0.482		
Average load factor (net of availability)	%	11%			11%			21%			26%		
Efficiency (LHV)	%	100%			100%			100%			100%		
Pre-development period	**Duration** and % spend per years 1 & 2	**0 years**			**0 years**			**0 years**			**0 years**		
	% spend per years 3, 4, & 5												
	% spend per years 6, 7, & 8												
Construction period	**Duration** and % spend per years 1 & 2	**0 years**	100%		**0 years**	100%		**0 years**	100%		**0 years**	100%	
	% spend per years 3, 4, & 5												
	% spend per years 6, 7, & 8												
Operating period	**Duration**	30 years			30 years			20 years			20 years		
		Commissioning year			**Commissioning year**			**Commissioning year**			**Commissioning year**		
		2018	**2020**	**2025**	**2018**	**2020**	**2025**	**2018**	**2020**	**2025**	**2018**	**2020**	**2025**
Pre-development £/kW	High	-	-	-	-	-	-	-	-	-	-	-	-
	Medium	-	-	-	-	-	-	-	-	-	-	-	-
	Low	-	-	-	-	-	-	-	-	-	-	-	-
Construction £/kW	High	1,300	1,200	1,200	1,900	1,800	1,700	4,600	4,500	4,300	2,700	2,700	2,500
	Medium	1,000	1,000	900	1,500	1,500	1,400	3,700	3,600	3,500	2,200	2,100	2,000
	Low	800	800	700	1,200	1,100	1,000	2,800	2,800	2,600	1,700	1,600	1,500
Infrastructure £'000s	High	200	200	200	-	-	-	-	-	-	200	200	200
	Medium	200	200	200	-	-	-	-	-	-	200	200	200
	Low	200	200	200	-	-	-	-	-	-	200	200	200
Fixed O&M £/MW/year	Medium	9,400	9,400	9,200	23,500	23,400	23,200	29,700	29,600	29,600	56,900	56,900	56,700
Variable O&M £/MWh	Medium	-	-	-	-	-	-	-	-	-	-	-	-
Insurance £/MWh/year	Medium	-	-	-	-	-	-	-	-	-	-	-	-
Connection and Use of System charges £/MW/year	Medium	-	-	-	-	-	-	-	-	-	-	-	-

		AD < 250kW			Hydropower <100kW			Hydropower 500-2000kW		
Reference plant size	MW	0.155			0.033			1.046		
Average load factor (net of availability)	%	65%			60%			40%		
Efficiency (LHV)	%	38%			100%			100%		
Pre-development period	**Duration** and % spend per years 1 & 2	**0 years**			**0 years**			**0 years**		
	% spend per years 3, 4, & 5									
	% spend per years 6, 7, & 8									
Construction period	**Duration** and % spend per years 1 & 2	**0 years**	100%		**0 years**	100%		**0 years**	100%	
	% spend per years 3, 4, & 5									
	% spend per years 6, 7, & 8									
Operating period	**Duration**	20 years			35 years			35 years		
		Commissioning year			**Commissioning year**			**Commissioning year**		
		2018	**2020**	**2025**	**2018**	**2020**	**2025**	**2018**	**2020**	**2025**
Pre-development £/kW	High	-	-	-	-	-	-	-	-	-
	Medium	-	-	-	-	-	-	-	-	-
	Low	-	-	-	-	-	-	-	-	-
Construction £/kW	High	7,900	7,700	7,300	7,800	7,800	7,800	4,100	4,100	4,100
	Medium	5,800	5,700	5,400	6,300	6,300	6,300	3,300	3,300	3,300
	Low	3,700	3,600	3,400	4,800	4,800	4,800	2,500	2,500	2,500
Infrastructure £'000s	High	100	100	100	-	-	-	400	400	400
	Medium	100	100	100	-	-	-	400	400	400
	Low	100	100	100	-	-	-	400	400	400
Fixed O&M £/MW/year	Medium	758,700	758,700	758,700	83,300	83,300	83,300	18,200	18,200	18,200
Variable O&M £/MWh	Medium	-	-	-	-	-	-	-	-	-
Insurance £/MWh/year	Medium	-	-	-	-	-	-	-	-	-
Connection and Use of System charges £/MW/year	Medium	-	-	-	-	-	-	-	-	-

Table 20: Fuel and Gate fee costs (selected)

Year		2016	2018	2020	2025	2030
Uranium (£/MWh)	High	6.5	6.5	6.5	6.5	6.5
	Central	5.4	5.4	5.4	5.4	5.4
	Low	4.3	4.3	4.3	4.3	4.3
Biomass 5-50MW (£/MWh)	High	31.20	31.20	31.20	31.20	31.20
	Central	9.66	9.66	9.66	9.66	9.66
	Low	3.55	3.55	3.55	3.55	3.55
EfW Gatefee (£/MWh)	High	-20.3	-20.3	-20.3	-20.3	-20.3
	Central	-30.8	-30.8	-30.8	-30.8	-30.8
	Low	-36.7	-36.7	-36.7	-36.7	-36.7
AD Gatefee (£/MWh)	High	-3.68	-3.42	-3.18	-3.18	-3.18
	Central	-4.78	-3.90	-3.18	-3.18	-3.18
	Low	-6.26	-4.46	-3.18	-3.18	-3.18
ACT Gatefee (£/MWh)	High	-10.4	-10.4	-10.4	-10.4	-10.4
	Central	-12.1	-12.1	-12.1	-12.1	-12.1
	Low	-13.5	-13.5	-13.5	-13.5	-13.5
Conversions and Biomass CCS (£/MWh)	High	36.8	36.8	36.8	36.8	36.8
	Central	29.0	29.0	29.0	29.0	29.0
	Low	26.2	26.2	26.2	26.2	26.2

All fuel costs are gross of efficiency factors listed in table above for each technology (except for uranium which is net of efficiency).

- No gate fees apply to the AD<250kW technology.

Department for Business, Energy & Industrial Strategy
3 Whitehall Place, London SW1A 2AW
www.gov.uk/decc