

Department of Energy and Climate  
Change

**Review of Renewable Electricity  
Generation Cost and Technical  
Assumptions**

Study Report (Solar PV Only)

Final | 14 December 2015

This report takes into account the particular instructions and requirements of our client.

It is not intended for and should not be relied upon by any third party and no responsibility is undertaken to any third party.

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**ARUP**

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## **Disclaimer**

The views expressed in this report and those of the authors, not necessarily those of the Department of Energy and Climate Change (not do they reflect Government policy).

# 1 Summary

Arup was appointed by the Department of Energy and Climate Change ('DECC') in February 2015 to carry out a review of generation cost and technical performance of renewable technologies in the United Kingdom ('the Study'). Arup's work provided an independent assessment and was based on data supplied via a stakeholder engagement process, published and internal sources.

**This extract of the Study provides new estimates of generation cost for small scale (1MW to 5MW) solar photovoltaic ('PV') for the year 2015 only. Please note that the new estimates produced for the Study are part of a larger piece of renewable cost and technical performance analysis, including a wide range of technologies and covering a forecast of levelised costs to 2030.**

The findings from the Study will support DECC in its policy formation and inform strategic decisions. A key requirement of DECC was that the Study drew a comparison between the last review of generation costs carried out by 'Arup 2011'<sup>1</sup> and 'DECC 2013'<sup>2</sup>. A key objective for DECC was to improve its evidence base on the cost of solar PV with an aim of improving value for money.

**Table 1: Solar PV Categories**

Technology group	Data collection phase	Renewable sub-categories
Solar	Phase 1	<ul style="list-style-type: none"> <li>1MW- 5MW (building mounted)</li> <li>1MW- 5MW (ground mounted)</li> </ul>

The data and analysis from the Study will be used to inform policy and a range of strategic decisions.

The Study included a significant primary research and data gathering exercise. The methodology is set out in **Appendix A**. To generate a representative and robust dataset Arup gathered data from the following sources:

- **Stakeholder survey:** industry stakeholders were contacted, across the technology groups with a standardised questionnaire. The questionnaire is provided in **Appendix C**.
- **Third party reports:** reports produced by external companies such as Bloomberg New Energy Finance ('BNEF'), World Energy Council ('WEC'), International Renewable Energy Agency ('IRENA') amongst others were used

<sup>1</sup> Arup. October 2011, Review of Generation Costs and Deployment Potential of Renewable Technologies in the UK

<sup>2</sup> DECC. July 2013, Electricity Generation Costs 2013

for benchmark cost and technical information. Please note that a full list of the third party reports used is presented in **Appendix E**.

- **Arup internal sources:** a review of internal research reports on generation cost and technical performance.

The data captured was used to estimate a ‘representative’ set of costs and technical parameters for solar PV. For more details see **Appendix C**. Data was prepared and subject to a rigorous internal and external review. The Study included a comprehensive desk study which took into account and built upon the considerable literature available within the public domain.

A stakeholder consultation was carried out with various organisations contacted to confirm the findings from the data provided. Where appropriate, Arup clarified key assumptions with stakeholders. An extensive range of stakeholders (manufacturers, developers, and operators) were consulted and asked to input to the study. The objective was to ascertain cost data but also obtain stakeholder’s views on expected future change in cost and technical performance for solar PV.

All costs are in 2014 prices, and all costs are in terms of when a project reaches financial investment decision (start of construction).

## 2 Solar

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### 2.1 Introduction

Solar power in the United Kingdom ('UK') has increased rapidly in recent years as a result of a reduction in the price of photovoltaic cells and the introduction of support mechanisms. Projects are located all over the country, but with highest concentration in the South of England where the best solar insolation can be achieved.

Central to the deployment of PV has been the reduction in component costs at the global level, deployment and improvements in the UK supply chain. Compared to historic forecasts, the rate of cost reduction within the sector has generally outperformed expectation. To add to the analysis Arup has also reviewed published and internal sources of data.

For the Arup 2011 study DECC had previously requested that the data was collated for ranges that included: <50kW; 50kW-5MW; 5MW-10MW and >10MW. For this Study Arup has collected data on two categories of solar, reflecting scale of plant and location:

- PV 1 to 5MW, ground mounted.
- PV 1 to 5MW, building mounted.

It should be noted that there was a limited number of responses from stakeholders and a notable lack of data for PV building mounted systems. Where there was a shortage of data Arup has used alternative published sources, benchmarks and size categories that are close to the scale under review.

### 2.2 Data Collection

Data was collected from stakeholders, internal and published sources. For the data collection process Arup contacted manufacturers, developers, trade associations and utility companies. Overall data was collected from internal projects and 6 developers, yielding 20 project data points.

Based on the data collection criteria outlined in **Appendix A**, 8 data points were assessed to be robust, representative and useful to the analysis. At the PV 1-5MW (ground) and PV 1-5MW (building mounted) level, 3 and 5 data points were available respectively. As set out in the introduction and methodology sections, to provide a robust analysis Arup benchmarked the original stakeholder data against third part reports (see Appendix E) and internal sources.

In terms of installed capacity the initial 15 data points collected represented 16.0MW of projects at various stages of development (operational, under construction and planned). Post-evaluation the final 8 data points used for the analysis had an estimated capacity of 14.0MW (the seven projects removed had a combined installed capacity of 2.0MW).

## 2.3 Project Costs

Panels form the largest proportion of total construction cost at around 45%, grid connections and racks also represent a significant item. The pre-development costs varied between PV categories ranging from £60/kW to £15/kW for a PV 1-5MW ground and building mounted system respectively. Pre-development includes pre-licencing, technical design development and regulatory reporting. Costs are expected to vary significantly depending on the site specific conditions, planning hurdles and requirement for appeals.

The medium construction cost for PV 1-5MW ground and building are £884/kW and £867/kW respectively. Developers reported that they are continuing to experience cost reductions related to the roll-out of plant from improved efficiency in deployment and site selection. The majority of the capital expenditure is spent on panels, electrical infrastructure and racking equipment. Infrastructure costs are reported to be £62/kW to £54/kW for PV 1-5MW ground and building respectively. Table 2 provides the estimated capital costs which are a summary of pre-development, construction and infrastructure (see definitions in **Appendix B**).

**Table 2 Capital Costs (Financial Close 2015), 2014 Real Prices, medium case**

£/kW	PV 1 – 5MW (ground)	PV 1 – 5MW (building)
<b>Low</b>	866	844
<b>Medium</b>	1,007	936
<b>High</b>	1,156	1,071

**Table 3 Capital Cost Breakdown for a Medium Project %**

%	PV 1 – 5MW (ground)	PV 1 – 5MW (building)
<b>Pre-development</b>	5.9%	1.6%
<b>Construction</b>	87.9%	92.6%
<b>Infrastructure</b>	6.2%	5.7%

Stakeholders indicated their views of what is considered to be the main cost drivers. The main drivers included changes to panel prices, inverter, exchange rates, labour and standardisation across the industry.

Based on the questionnaire stakeholders expect costs to continue and fall, including for panels and inverters. In addition, other factors such as growth within the UK supply chain, project pipeline and improvements in manufacturing efficiency are all expected to improve cost.

## 2.4 Operating Costs

For operating costs, Arup divided the cost into the following categories: fixed and variable operation & maintenance ('O&M'), insurance, and grid connection costs (see **Appendix B**). Operating costs comprise of fixed and variable O&M contracts, UoS charges, insurance and labour. The following table illustrates the variation in cost for each type of PV system.

Operating costs will vary significantly depending on the type of O&M services procured, local conditions such as availability of labour within the local market, local grid charges, price and availability of components. Overall, the O&M cost produced via the stakeholder data (see Table 4 below) is within the range Arup expected. At the high end, building mounted PV operating costs appear to be most expensive. It should be noted that O&M costs exclude land costs, rent etc. (please see the definitions outlined in the **Appendix B**), which explains the difference between Arup's figure and those produced by the Solar Trade Association (STA).

**Table 4 Operating Costs (Financial Close 2015), 2014 Real Prices, medium case**

£'000/MW/annum	PV 1 – 5MW (ground)	PV 1 – 5MW (building)
<b>Low</b>	8	9
<b>Medium</b>	12	16
<b>High</b>	18	24

For operating costs stakeholders identified labour and availability of components as an important cost driver.

## 2.5 Cost Breakdown

Based on the collected data Arup was able to generate new cost figures and compare these to DECC's current assumptions. The objective of the analysis was to identify where costs have changed and understand what is driving the change. Tables 5 to 7 below provide current cost estimates for 2015, the DECC

assumptions comparator and percentage change. It should be noted that the cost data collected is for PV projects that have commenced operation or under development.

In Table 5 below, current DECC assumptions refer to 250-5000kW large scale solar plants. This categorisation made no distinction between ground and building mounted plants, unlike the new data.

The costs shown under '2015 current figures' below include cost reductions previously assumed by DECC for plants that reach FID in 2015, in order to ensure that this is a like for like comparison with the new 2015 data.

Arup has prepared estimates of cost for PV 1-5MW ground based and PV 1-5MW building installed. New and old cost estimates for: pre-development; construction; infrastructure; and operating cost are presented below. The following provides Arup's view on what has caused the change in cost:

- **Pre-development cost:** it should be noted that no pre-development cost data was available for comparison with the Arup 2015 figure. Therefore, in the absence of any benchmark data Arup has continued to use the pre-development cost data provided by stakeholders.
- **Construction cost:** the current estimated construction cost of £867/kW to £884/kW is within Arup's expected cost range of £800/kW to £900/kW. The estimate was derived from stakeholder data and has reduced relative to DECC's current assumption. The change in cost reflects reductions in panel and inverter prices. Discussions with stakeholders also indicated that further cost reductions could be expected if "EU dumping" regulations were to be removed in the future. In addition the STA has also indicated that PV cost reductions have historically outperformed expectation from Government and industry<sup>3</sup>.
- **Operating cost:** following an internal and external review, total operating cost appears to be at the low end of the expected cost range. For example, Arup would typically expect the annual opex cost to range from £10k/MW to £20k/MW.

The Arup 2015 figure is significantly less than the current assumption of £23k/MW and the Solar Trade Association (STA) figure of £26k/MW. The current figures reported by the stakeholders were based on real reported figures. However, the information received was noted as being provided by large-scale developers which could be experiencing a large reduction in opex cost due to economies of scale and the ability to spread cost across a greater number of sites. It should be noted that the Arup estimate does not include land cost, rental or community payments. These costs are understood to be included within the STA's estimate.

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<sup>3</sup> Solar Trade Association, Cost Reduction Potential of Large Scale Solar PV – An Analysis Into The Potential Cost Reductions That The UK Solar Industry Could Deliver to 2030 With Stable Policy Support, November 2014

Since the first large-scale PV farm installations began in 2009/2010, opex costs have continued to fall as a result of a movement away from Original Equipment Manufacturers ('OEMs'), with a trend toward more 'in-house' engineering.

**Table 5 Cost Comparison between Arup 2015 and DECC Current, 2014 Real Prices, medium case**

	Assumption	Unit	PV 1-5MW Ground	PV 1-5MW Building
<b>Arup 2015</b>	Pre-development	£/kW	60	15
	Construction	£/kW	884	867
	Infrastructure	£/000	221	36
	<b>Total capex</b>	<b>£/kW</b>	<b>1,007</b>	<b>936</b>
	Fixed O&M	£/MW	9,577	7,629
	Variable O&M	£/MWh	0.0	3.4
	BSUoS	£/MWh	0.0	0.0
	Insurance	£/MW	1,368	3,068
	UoS	£/MW	1,513	1,513
	<b>Total opex</b>	<b>£/MW</b>	<b>12,458</b>	<b>15,526</b>
<b>DECC Current</b>	Pre-development	£/kW	0	0
	Construction	£/kW	1,060	1,060
	Infrastructure	£/000	0	0
	<b>Total capex</b>	<b>£/kW</b>	<b>1,060</b>	<b>1,060</b>
	<b>Total opex</b>	<b>£/MW</b>	<b>23,453</b>	<b>23,453</b>
<b>% Change</b>	Pre-development	%		
	Construction	%	-17%	-18%

Assumption	Unit	PV 1-5MW Ground	PV 1-5MW Building
Infrastructure	%		
<b>Total capex</b>	<b>%</b>	<b>-5%</b>	<b>-12%</b>
<b>Total opex</b>	<b>%</b>	<b>-47%</b>	<b>-34%</b>

Arup reviewed the estimates it produced against benchmark costs from other renewable market reports. The objective was to provide validation of the findings and provide comfort around the observations. To understand the change in costs Arup analysed different development, construction and opex benchmark data for PV. Overall, the following was observed when compared to the Arup 2015 figures:

- **Construction costs:** comparator data was available from STA which estimated cost to be £1,028/kW. The Arup 2015 estimates including pre-development, construction and infrastructure are £1,007/kW and £936/kW approximately 2% to 9% lower than the external benchmark cost. Post-evaluation and internal review Arup was comfortable with the figures generated by the analysis despite being lower than the external benchmark.
- **Operating cost:** data was available from the STA which indicated cost to be around £26k/MW and understood to include costs Arup has not (lease costs, business rates etc.). Arup's 2015 update is less than the STA's estimate. Based on internal benchmark data it was concluded that the operating cost value produced by the dataset was potentially low but followed the trend Arup expected and matched observed cost from internal benchmarks. Therefore, the stakeholder data has been used for the analysis. Please note that for building mounted PV systems variable O&M cost data was provided by stakeholders but not for ground based. Arup has therefore been able to provide additional breakdown of operating cost.

## 2.6 Technical Assumptions

Based on the data received from developers Arup was able to carry out a comparison with DECC's current LCOE technical assumptions. The following provides a summary of the observations made:

- **Net Power:** since 2010 the overall average installed capacity of a PV development has increased significantly. The current assumption used by DECC is 350kW, significantly smaller than the current average capacity computed to be 3.5MW and 0.7MW for 1-5MW ground and building respectively.
- **Availability:** it is understood that the typical availability for a PV installation can be assumed to be 99%; this figure allows for some downtime for part

replacement and washing of panels. A comparison with DECC's current assumption indicates a small overall change.

- **Load factor:** When DECC's current load factor is compared to the current load factor reported by stakeholders it is understood to be very close (within 1%) of the current DECC assumption. Arup validated its assumption by contacting stakeholders to find out their expected load factors; overall the load factors reported were close to the current benchmarks from the Solar Trade Association ('STA'). Arup has therefore used 11% as the load factor which is consistent between stakeholder values and published figures.
- Stakeholders typically assumed a technical life of 25 years.

**Table 6 PV 1-5MW Ground Technical Assumptions**

Assumption	Unit	DECC	Arup	Change (% points, net)
Net Power	MW	0.35	3.55	3.20
Availability	%	100%	99%	-1.0%
Load factor (gross)	%	11%	11%	-0.2%
Load factor (net)	%	11%	11%	-1.2%

**Table 7 PV 1-5MW Building Technical Assumptions, medium case**

Assumption	Unit	DECC	Arup	Change (% points, net)
Net Power	MW	0.35	0.67	0.32
Availability	%	100%	99%	-1.0%
Load factor (gross)	%	11%	11%	-0.2%
Load factor (net)	%	11%	11%	-1.2%

## **Appendix A**

### **Methodology**

## A1 Methodology

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This chapter provides a summary and overview of the Arup methodology used to develop a representative set of data. The aim was to provide an overview of the approach and logic used to arriving at the cost and technical estimates provided in the report. The main steps in the methodology were as follows:

- Apply a methodology that was consistent with previous studies, taking into account previous allocation of cost.
- Cross-check and compare stakeholder data with external third party evidence on generation cost and performance for a new renewables project being developed in 2015.
- Establish project cost ranges (high, medium and low). This included current project cost for pre-development, capital and operational expenditure. Other key technical project data was also collected from stakeholders, including load factors.

### A1.1 Research Design

This section provides an overview of the method for collecting primary data via stakeholders that are active in the development of new solar PV generation. The stakeholder survey was split between Part A that focussed on collecting new data and Part B that focussed on collecting stakeholder views on future change in technology cost and performance (which will be provided in the full report). The aim was to collect enough reliable data so that a representative lifecycle cost for each technology could ultimately be produced.

Stakeholders were asked to provide data around the cost of bringing a project from pre-development i.e. the planning stage, to construction and operation. The data gathered by the survey is more detailed than any previous renewables data collection exercise<sup>4</sup>.

To check for consistency in the responses Arup carried out an internal check of the stakeholder data. This involved checking that the values were entered correctly into the questionnaire and reviewing parameters against internal knowledge.

Part B of the questionnaire asked stakeholders to provide commentary (qualitative and quantitative) around expectations for future change in cost and what the key drivers are. For example cost drivers could include supply chain effects, commodity prices and labour.

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<sup>4</sup> The following provides a link to the previous generation cost report produced by Arup for DECC:  
[https://www.gov.uk/government/uploads/system/uploads/attachment\\_data/file/66176/Renewables\\_Obligation\\_consultation\\_-\\_review\\_of\\_generation\\_costs\\_and\\_deployment\\_potential.pdf](https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/66176/Renewables_Obligation_consultation_-_review_of_generation_costs_and_deployment_potential.pdf)

## A1.2 Criteria for Identification and Inclusion of Data

An examination of the cost data was carried out to determine:

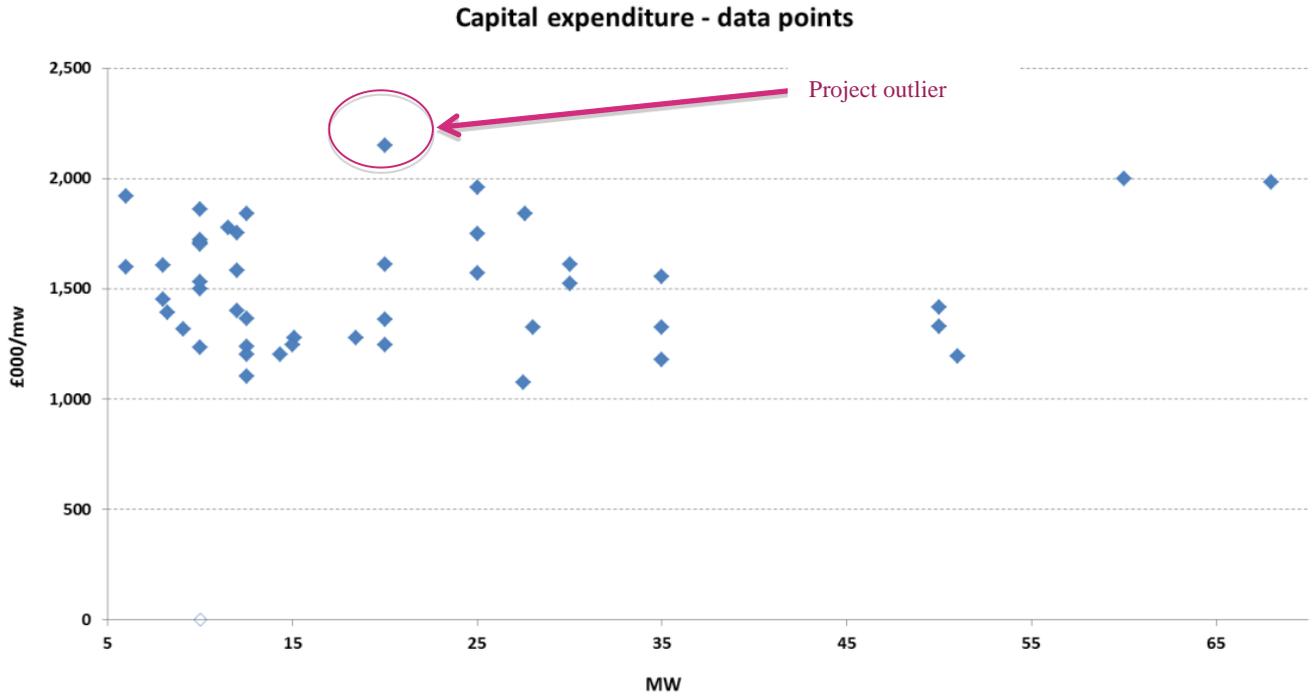
- How reliable the data was.
- Whether cost falls within the expected range.
- Whether the questionnaire has been interpreted correctly.
- What is included within each element of cost.
- Whether there is consistency across datasets.
- Whether the data presented is in a consistent price base.

The questionnaire data has been reviewed against the criteria outlined above to ensure consistency of approach with previous analysis. The following points summarise our approach against criteria above:

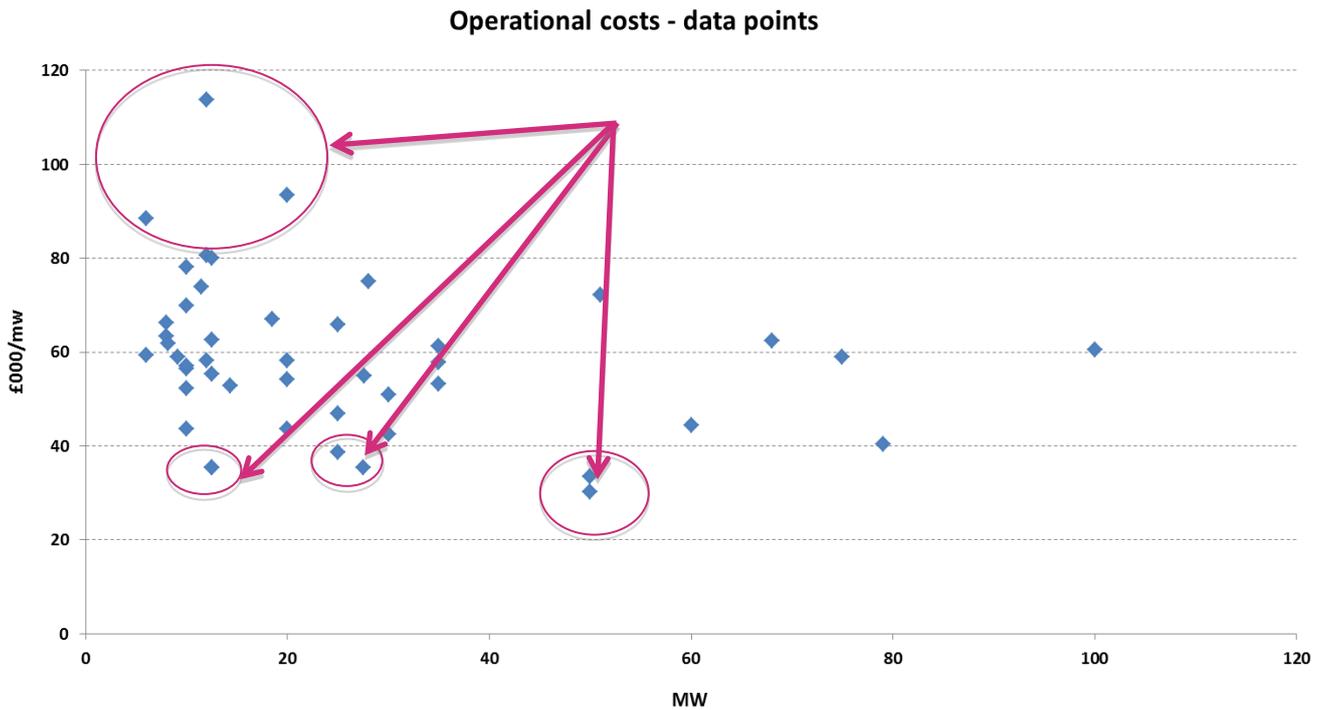
- **Cost:** Arup's approach has been to check each questionnaire and ensure consistency across the dataset. This involved checking whether the data was in the same format, currency and cost base. The model uses capital cost figures in £000/MW and operating costs £000/MW/year. All numbers presented in this report have where been adjusted to 2014 prices where necessary. For the indexing the latest GDP deflator figures published by the Office for National Statistics (ONS) were used (consistent with the Arup 2011 study).
- **Stakeholder interpretation:** a review of the questionnaires indicated that most stakeholders provided data in the format required. However, in a few instances where values did not appear to be at the correct level, when compared to internal benchmarks and external published values, clarification was sought on what was included. Arup has reviewed each questionnaire and established its overall usefulness to the Study in terms of providing accurate information.
- **Data range:** for consistency with the Arup 2011 study the same data analysis methodology was applied to establish cost ranges. Arup's initial step was to generate a scatter plot of the pre-development, capital and operating costs for the data points collected. Data plotting allowed for outlier projects, defined as significant variations from the mean or median cost to be visually identified.
- **Age and scale:** projects below a minimum size for the technology (please see table 1 above) and older than five years were excluded from the analysis. However, where data was poor alternative secondary sources of data were used along with cost data collected from some small-scale projects.

Figures 1 and 2 provides an example plot of data showing size of project (MW) versus the capital and operating costs. The review of the data allowed the high, low and mean/median range of operating and capital cost reported.

**Figure 1 Stakeholder Data Scatter Graph – Outlier Identification**



**Figure 2: Example Stakeholder Data Scatter Graph – Outliers Identification**



### A1.3 Outlier Identification

The aim of the outlier identification exercise was to establish a representative set of project costs. Following the same Arup 2011 methodology the initial step was to review the stakeholder data and identify which projects have capital and operating costs that sit outside of the expected range.

Following the same methodology applied for the Arup 2011 study high and low costs were calculated based on percentile ranks, 90 and 10. Cost was characterised as falling into one of three categories:

- Mean or median range (defined as between the 10th and 90th percentile).
- High cost (90th percentile).
- Low cost (10th percentile).

The application of the above rule was dependent upon the total number of data points available for the analysis. It should be noted that if there was less than 10 data points, the mean was calculated as a central value. In addition, where there were only three data points available, minimum, maximum and mean values were calculated.

Applying percentiles to the data allowed Arup to determine a reference range of cost which is consistent with the approach adopted for the Arup 2011 study.

### A1.4 Load Factor Methodology

The approach adopted for estimating load factors included an initial review of publications and reports published in the UK and globally along with results from stakeholders.

The literature review examined publications that provided guidance on market trends. A full list of reports used for the analysis is provided in **Appendix E**.

Arup also reviewed European and Global markets to understand what technical innovations in other countries could be delivered in the UK. Arup reviewed data and publications from reputable sources such as the IEA, IRENA and BNEF. By reviewing international data it provided additional perspective on potential UK market trends. Technical journal articles were also reviewed to provide an additional level of validation for our assumptions.

At the same time as Arup's work, Parsons Brinckerhoff ('PB') has also carried out a review of small-scale renewables.

Where possible, Arup used stakeholder responses as the basis for the load factor forecast comparing it to information obtained from the literature review. Following the comparison Arup integrated the results based on the assessed robustness of the information obtained via the stakeholder and literature review.



## **Appendix B**

### **Cost Components**

## B1 Cost Components

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This section outlines the main cost components and provides an approach which is consistent with the approach previously adopted by DECC.

### B1.1 Pre-development Costs

Pre-development costs include:

- Pre-licencing cost, technical and design was assumed to include costs associated with licensing, technical design, development and design selection.
- Regulatory and public enquiry cost was assumed to include, public enquiry and local community engagement costs.

### B1.2 Capital Costs

Based on the stakeholder questionnaire capital costs were assumed to include the following:

- Total capital cost is assumed to include project design, procurement and EPC construction cost. In addition, other capital costs such as site works, roads and utility connections (water, gas etc.) were captured here.
- It should be noted that capital cost excludes interest costs during construction and cost of land.
- Infrastructure cost was assumed to comprise of grid connection costs, local substation and transformer stations and is a separate line item.
- Land costs, the cost of leasing or purchasing land. For consistency with previous work these costs have been excluded from the cost estimation.

### B1.3 Operating Costs

Operating costs include:

- Fixed Operation & Maintenance ('O&M') costs such as labour, planned and unplanned maintenance, spares and consumables.
- Variable O&M is calculated per MWh of generation. These are output related O&M expenditure.
- Insurance.
- Network Use of System ('UoS') charges. These are the costs of connecting to and using the transmission network. The UoS cost reported in Arup's analysis includes TNUoS and DUoS costs only calculated as a £/kW. BSUoS cost is charged to a generator on a £/MWh basis. For the analysis Arup has therefore included the BSUoS cost element with the variable operating cost.

## B1.4 Use of System Cost

Stakeholders were asked to provide data on UoS charges. After an internal and external review of the data it was concluded that both TNUoS and DUoS charges were representative. For BSUoS Arup used benchmark cost data provided by LeighFisher, a consultancy appointed to undertake a similar study for DECC on cost and technical assumptions on non-renewables, and represents an average balancing cost for UK generation.



## Appendix C

### Stakeholder Survey

# C1 Stakeholder Survey

The following provides a copy of the data collection survey that was issued during Phase One.

**Figure A1: Phase One Stakeholder Questionnaire**

Cost items	Unit	Response / comment	Capacity MW	Cost	Time Years	%	Future cost 2020 2030
<b>PLANT ASSUMPTIONS</b>							
Plant capacity MW(e) gross (please provide gross electrical capacity incl auxiliary load)	[MW(e)]	Primary: please comment on plant capacity					
Plant capacity MW(e) net (please provide net electrical capacity excl auxiliary load)	[MW(e)]	Primary: please comment on plant capacity					
Connection capacity (what is the connection capacity)	[MW]	Primary: Please comment on connection capacity					
<b>CURRENT ASSUMPTIONS</b>							
Currency, please select	[£, \$, €]	Primary: please indicate cost currency, preference is for £/sterling		Please select			
<b>PRE - DEVELOPMENT COST</b> (Please note excludes land costs, property and business rates tax costs, rental and community benefit payments. These items are required separately under additional data)							
To what year do the following costs apply? (e.g. 2014)	[Yr]	Primary: please indicate the cost base year					
Pre-licensing cost	[£]	Primary: please comment on what is included in pre-licensing cost					
Technical development cost (including design selection)	[£]	Primary: please comment on what is included within technical development cost					
Planning cost (including regulatory costs, licensing, public enquiry, 'local community engagement' costs)	[£]	Primary: please explain what is included / excluded from planning costs					
Timescale for pre-development (total pre-development period including pre-licensing, licensing, public enquiry)	[Yrs.]	Primary: please provide comment on pre-development timescale (e.g. 2.5 years)					
Is a contingency included within the above pre-development costs? If so what % of the above cost is contingency? (e.g. 10% of £1m (£100k contingency, £900k pre-development cost) / If no contingency is included what would the typical % included on top of pre-development cost be. (e.g. for potential cost overrun and development uncertainty)	[%]	Primary: please comment on the level of contingency included within the pre-development cost. If not included please indicate what level of contingency would typically be assumed for this phase.					
Distribution of the costs over the pre-development period (e.g. 50% cost upfront and rest straight line, straight line for full pre-development period or straight line with 50% of cost back-ended)	[%]	Primary: please provide information on the distribution of project pre-development costs: 2015 25%, 2016 35%, 2017 40%					
<b>CONSTRUCTION COST</b> (Please note excludes land costs, property and business rates tax costs, rental and community benefit payments. These items are required separately under additional data)							
To what year do the following costs apply? (e.g. 2014)	[Yr]	Primary: Please provide the cost base year					
Capital (overnight) cost (please provide either total cost or total cost per kW installed) (The cost item covers the projected design, procurement and construction costs e.g. EPC costs if applicable. It should include the full capital cost EXCLUDING interest costs during construction and excluding land costs. The below costs should be listed separately if available, otherwise please indicate if they have been included in this item.)	[£ or £/kW]	Primary: Please indicate what is included within the total capital cost. For example: engineering design; procurement construction; equipment included e.g. generation plant, processing equipment etc.					
Owner's costs (please provide total cost) (Includes procurement cost, project management - owner's engineer etc.)	[£]	Please indicate what is included within owner's costs. For example: procurement project management owner's engineer					
Grid connection costs (please provide total cost) (e.g. exclude pre-connection securities, but include any upfront connection payment)	[£]	Primary: please comment on grid costs. Can you please indicate km of overhead / underground cable and km of gas pipeline (if applicable).					
Substation and transformer costs (please provide total cost)	[£]	Please comment on the cost of substation / transformer station.					
Other infrastructure costs (please provide total cost) (if applicable e.g. water, roads, sites works etc.)	[£]	Primary: please indicate where other infrastructure costs are derived from. For example access roads, site works and security					
Is a contingency included within the above construction costs? If so what % of the above cost is contingency? (e.g. 10% of £10m (£1m contingency, £9m capex) / If no contingency is included what would the typical % included on top of capex cost be. (e.g. for potential cost overrun and development uncertainty)	[%]	Primary: please comment on the level of contingency included within construction cost. If not included please indicate what level of contingency would typically be assumed for this phase.					
Construction time period	[Yrs.]	Primary: please provide commentary on the construction timescale, what does the period cover?					
Distribution of costs over the construction period (e.g. 50% costs upfront and rest straight line, straight line for full construction period or straight line with 50% of costs back-ended)	[%]	Primary: please provide distribution of total costs over the construction period. For example 2016 50%, 2017 50%					
CHP equipment costs (please provide total cost) (please separate CHP costs if data is available)	[£]	Primary: if relevant please indicate the type and cost of the CHP engine. Have these costs been included in the above cost items?					
Cost of other equipment for example, feedstock processing and preparation equipment (please provide total cost)	[£]	Primary: if relevant please provide indicate what equipment and its cost e.g. feedstock processing and preparation equipment. Have these costs been included in the above cost items?					
Boiler equipment costs (please provide total cost) (please separate boiler costs if data is available)	[£]	Primary: if relevant please indicate the cost of the boiler. Have these costs been included in the above cost items?					
Construction cost comment	[Text]	If only the total capital cost has been provided can you please indicate what costs are included / excluded					
<b>OPERATIONAL COST</b> (Please note excludes land costs, property and business rates tax costs, rental and community benefit payments. These items are required separately under additional data) (Please provide the following operating cost data on a unit cost basis - i.e. per kW MW or kWh/ MWh as appropriate. If different from unit in 'column D' please indicate the unit your cost figures are reported in)							
To what year do the following costs apply? (e.g. 2014)	[Yr]	Primary: please provide the cost base year					
Fixed O&M cost (Includes operating labour costs, planned and unplanned maintenance, lifecycle capital renewable cost)	[£/MWh/a]	Primary: please indicate what is included within fixed O&M cost. For example: labour, planned maintenance and lifecycle replacement					
Variable O&M cost	[£/MWh]	Primary: please indicate what is included within variable O&M cost. For example planned and unplanned maintenance, water and chemical usage					
Insurance cost	[£/MWh/a]	Primary: please provide commentary on insurance costs					
Operational cost comment	[Text]	If only the total operational cost has been provided can you please indicate what costs are included / excluded					
Connection and UoS charge costs (e.g. TNUoS, BSUoS, DUoS and OFTO)							
TNUoS - cost (payment for use of the Transmission Network and including OFTO for offshore wind)	[£/MWh/a]	Primary					
BSUoS - cost (charge for the balancing actions of National Grid)	[£/MWh/a]	Primary					
DUoS - cost (charge for operating and maintaining local distribution network)	[£/MWh/a]	Primary					
<b>DECOMMISSIONING AND WASTE COSTS</b>							
Waste disposal cost (i.e. waste management and disposal costs during operational period)	[£/MWh/a]	Primary: please indicate what is disposed of under waste cost					
Decommissioning spend (i.e. decommissioning spend e.g. provisions to cover decommissioning expenditure after operation)	[£/MWh/a or £/MWh]	Primary: please indicate decommissioning spend and what period it is likely to occur in.					
Waste disposal cost (i.e. waste management and disposal costs post-operation)	[£/MWh/a]	Please indicate expected waste disposal cost post-operation.					
Decommissioning spend (i.e. post-operation)	[£/MWh/a]	Please indicate the expected decommissioning cost spend post-operation.					
Expected decommissioning period and timing	[Yrs.]	Primary: please indicate number of years and likely timing of decommissioning					

TECHNICAL ASSUMPTIONS		
What proportion of electricity generation is for parasitic load and export	[%]	Primary: please indicate what proportion of generation is for parasitic load
Plant availability during full annual operation % (Availability is defined as the total time proportion that a plant is able to produce electricity over a full year)	[%]	Primary: please indicate.
Average annual reduction in plant availability (if applicable) %	[%]	Primary: by what % do you expect plant availability to decline over time What is the expected timing and impact of major refurbishment work on availability?
Average annual expected load factor (Defined as average operating hours at full load equivalent divided by hours per year)	[%]	Primary: please provide average annual load factor. In addition, if available what load factor improvements are expected over time i.e. taking into account different commissioning dates, maintenance etc. For example offshore wind: 2016 (36%), 2017 (38%) and 2018 (40%)
Expected reduction in average annual load factor (if applicable)	[%]	By what % do you expect plant load factor to decline over time.
Plant operational life (technical life) i.e. expected maximum operational life	[Yrs.]	Primary
TECHNOLOGIES WHICH REQUIRE FUEL INPUT(S)		
Fuel input type: e.g. biomass generation (virgin wood, waste wood, wood pellets); ACT (biomass, municipal waste treated to derive SRF/RDF).	[Text]	Primary: please indicate fuel input type
Fuel type mix %	[%]	Primary: please indicate fuel mix. For example, 20% wood chip, 80% SRF
What is the total tonnage of each fuel type expected to be used per year and the extended 5-year mix.	[Tons]	
What is the average renewable content of each fuel (Please indicate either in % mass or % energy content)	[% mass / % energy content]	Primary: please indicate average renewable content of each fuel, the % mass or % energy content
Fuel type under contract	[Tons]	Primary: please indicate the fuel type under contract
What is the length of each fuel supply contract in place?	[Yrs.]	
Are there any fuels not under contract?	[Text]	
What is the gate fee / price of each type of fuel e.g. ACT cost before/after waste processing €/MWh or €/ODT depending on the type of fuel.	[€/MWh]	Primary: please report cost in €/MWh, if not available €/ODT as appropriate. Please indicate if price before or after processing.
What is your expectation for change in gate fees / price to change over time?	[€/MWh]	Primary: please report cost in €/MWh, if not available €/ODT is also suitable. Please indicate if price before or after processing.
Net efficiency (LHV) %	[%]	Primary: please report the lower heating value efficiency of changing fuel input into electrical output, full condensing output
Net efficiency (HHV) %	[%]	Primary: please report the higher heating value efficiency of changing fuel input into electrical output, full condensing output
Expected annual change in efficiency	[%]	Primary: Is any change in efficiency expected over time (yes/no)? If yes, please report the expected annual change in efficiency.
CHP ASSUMPTIONS		
Average thermal output in MW <sub>thermal</sub>	[MW <sub>th</sub> ]	Primary.
What is the installations average heat to power ratio? (e.g. 2:1; 20MW heat, 10MW electricity)	[No.]	Primary: please indicate heat to power ratio
FINANCIAL ASSUMPTIONS		
Expected economic life (years) - expected period that plant will remain an economically viable operation	[Yrs.]	Primary.
Required IRR (%) - required rate of return on the project. Please state if the figure is pre or post-tax, in nominal or real terms.	[%]	Primary.
Risk perception of the project - low, medium or high	[Text]	Please indicate whether the project is of a low, medium or high risk rating
Type of finance - expected level of equity (%) or debt (%) financed	[Text / %]	If debt financed can you please provide information on the average interest rate over the construction and operation periods? What is the tenor of the loan?
ADDITIONAL DATA		
(Excluded from pre-development, construction and operation costs above)		
Land costs including land purchase but excluding mortgage cost and rental fees (Excluded from total capital costs above)	[£]	Primary.
On-going property and business rates tax cost	[€/MWh]	Primary.
On-going property rental cost	[€/MWh]	Primary.
Community benefit payments	[€/MWh]	Primary.
To what extent do you expect to meet the good quality CHP (CHP QA) standards?	[%]	

## **Appendix D**

### **Pre-development, Construction and Operational Time Periods**

## D1 Pre-development, Construction and Operational Time Periods

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The following provides a summary of the high, medium and low time period assumptions.

**Table D1: PV 1-5MW Ground Mounted (Years)**

Period	Low	Medium	High
<b>Pre-development</b>	0.5	0.8	1.0
<b>Construction</b>	0.2	0.3	0.5
<b>Operating</b>	25.0	25.0	25.0

**Table D2: PV 1-5MW Building Mounted (Years)**

Period	Low	Medium	High
<b>Pre-development</b>	0.5	0.8	1.0
<b>Construction</b>	0.2	0.3	0.5
<b>Operating</b>	25.0	25.0	25.0



## Appendix E

### Report Literature

## E1 Report Literature

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