



cutting through complexity



UK solar beyond subsidy: the transition

July 2015

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Executive Summary

This report has been prepared by KPMG LLP, the UK member firm, at the request of the Renewable Energy Association to assess the continuing cost reductions of solar photovoltaics (PV) in the UK and propose a few policy options that can enable the transition to a sustainable, subsidy-free PV industry. Our analysis demonstrates that:

■ **PV is the most popular renewable energy in the UK and its deployment is rising rapidly**

PV deployment reached 8.1GW installed capacity at the end of March and installations continue since then, projected to reach 11GW in 2016. The UK has become the most dynamic PV market in Europe. PV is becoming the most popular renewable energy among British electricity consumers, both in the domestic and commercial sectors.

■ **PV is becoming the most competitive new build renewable technology**

PV is already one of the cheaper sources of renewable energy. The UK PV industry has achieved impressive cost reductions of nearly 70% in the past five years. This trend in cost reduction is likely to continue, with another projected 35% decrease in levelised costs by 2020.

■ **The 20 GW deployment scenario in 2020 offers lower cost per additional MWh (under current subsidies)**

We have modelled 14GW and 20GW capacity scenarios for 2020/21. Under current subsidies 14GW would cost £130 million p.a., and 20GW would require £340 million p.a. The higher scenario offers more installations for a lower subsidy per MW. The 14GW scenario is 300 MW per year which would result in a significant decline in the size of the UK industry.

■ **PV will be the first renewable technology to achieve “grid parity”**

Similar to other countries, as PV costs are coming down, they will begin to compare favourably to retail electricity prices, so that a need for direct subsidy will no longer exist. This transition from a subsidised technology to a mainstream technology will need continued innovation to take place over several years.

■ **Phasing out subsidies for PV requires a transition plan to avoid a “cliff edge”**

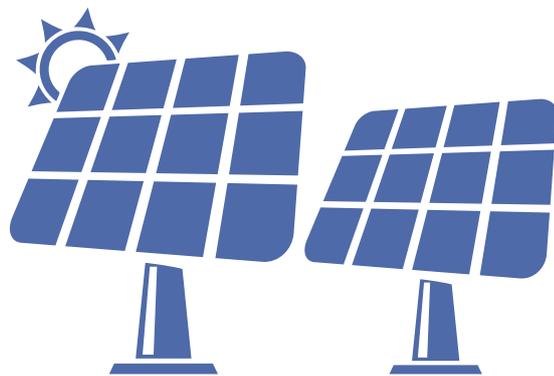
The UK Government needs to consider a managed transition away from subsidies over a 5 year period and beyond, rather than the immediate cessation of support that will result in job losses and industry consolidation. We propose the following policy options:

- A combination of net-metering and enhanced building regulations in the residential sector. This would help to create demand for PV on both new build and retro-fit houses.
- An improved tax regime for non-domestic properties taking into account business rates, capital gains allowance and corporation tax alongside clear rules on required EPC ratings for leased properties would help drive growth in this sector.
- A strategy to transition and integrate PV into energy markets and distributed energy systems

The role of PV will be maximised if it operates in synergy with other innovative technologies such as energy storage, electric vehicles, demand response and smart metering. Also PV will benefit from electricity distribution networks that are designed to make full use of distributed generation.

A transition to energy systems with decentralised generation and the use of energy storage will allow PV to operate in the same markets as conventional power.

As a versatile technology, PV will be included in new products and services that will be offered in emerging new utility business models, and thereby contribute to bill affordability and security of supply.



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Introduction

During the past 12 months, the UK has emerged as the European leader in deployment of Solar Photovoltaics (PV), the fastest growing renewable energy technology in the world. It is estimated that more than 8GW of PV capacity will be installed in the UK by Q2 2015, nearly 50% more than a year ago. Although PV deployment started later in the UK than some other European countries, such as Germany or Italy, the UK is currently experiencing a PV deployment sprint. This is driven by a combination of support schemes and ever-decreasing costs for PV systems.

PV costs in the UK have experienced a sharp decline of nearly 70% in the last five years. PV is rapidly becoming a fully commercial technology that already competes with other established renewable technologies and soon will be competing with conventional power generation technologies. As costs for PV continue to fall, so will the need for direct subsidy.

This report reviews the recent performance of solar PV in the UK and predicts its likely course to full commercial maturity over the next five years. It also aims to estimate the amount of further support required as the need for subsidy fades away; and what needs to be done to ensure that this transition will eventually lead to a sustainable PV industry in the UK.

The report is structured as follows:

- Section 2 presents the story behind the emergence of PV as the fastest growing renewable energy technology in the world, and provides a historic view of its deployment so far in the UK. It also presents the impressive cost reduction record of the technology so far and provides an estimate for its future cost reduction potential in the UK.
- Section 3 describes the historic evolution of PV support levels and the route to the end of subsidies. We explain the concept of grid parity and present our estimates for each market segment. We also estimate the additional level of support that will be needed by 2020, and describe what parity means for the sector and what happens after that.
- Section 4 reviews the PV industry's contribution to the UK macro-economy and also the role that PV can play in the future UK energy mix.
- Section 5 presents a few opportunities and challenges that come with PV deployment, and also potential synergies with other technologies.
- Finally, Section 6 concludes by providing some recommendations for actions in the next few years to enable deployment and reduce costs.

We provide detailed assumptions and methodology used to estimate PV costs and their comparators in Appendix A. Also we provide a detailed overview of current PV tax treatment across all PV market segments in Appendix B.





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The promise of solar PV

2.1/ International deployment and cost reduction: the story so far

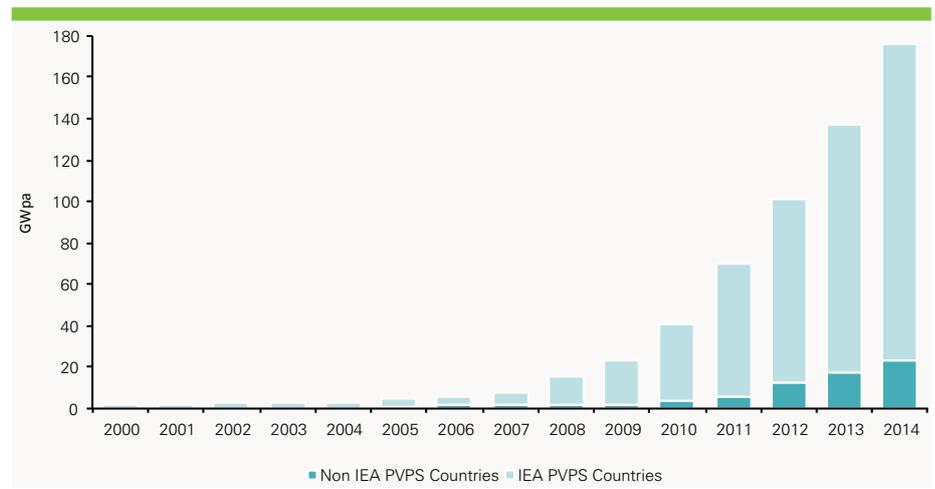
During the past decade, PV has been the most rapidly growing renewable technology in the world. During the last five years, despite the negative effect of the financial crisis, PV capacity has been deploying at an impressive 42% average annual growth rate, according to the IEA. Global cumulative installed capacity reached 177GW by the end of 2014, from only 40GW in 2010 (see Figure 1).

Further growth is expected as some of the biggest markets in the world such as the US, China or India, realise some very ambitious PV deployment plans. In 2014, the majority of new installations came from countries outside Europe, with Asia now taking the lead in year-on-year PV installation growth. (see Figure 2).

The emergence of solar PV as the fastest growing renewable technology has been driven mostly by huge reductions in module prices, especially in the last 5 to 7 years, as deployment volumes increased in Europe (see Figure 3). Other third party scenarios suggest that cost reductions are likely to continue over the coming decade, albeit at a slower rate than witnessed in recent years¹.

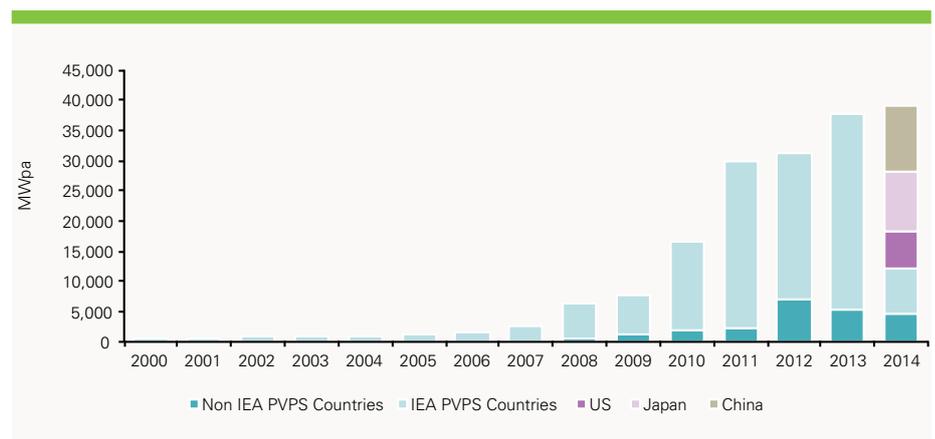
The global industry has been able to expand significantly over recent years in order to meet increased worldwide demand. The fundamental 'scalability' of the solar modules has enabled the industry to take advantage of significant economies of scale, with the fixed costs of manufacturing investment spread over a larger volume of modules.

Figure 1:
Annual Incremental Global PV Installed Capacity



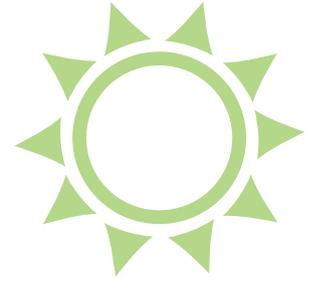
Source: IEA

Figure 2:
Evolution of Global PV Installed Capacity



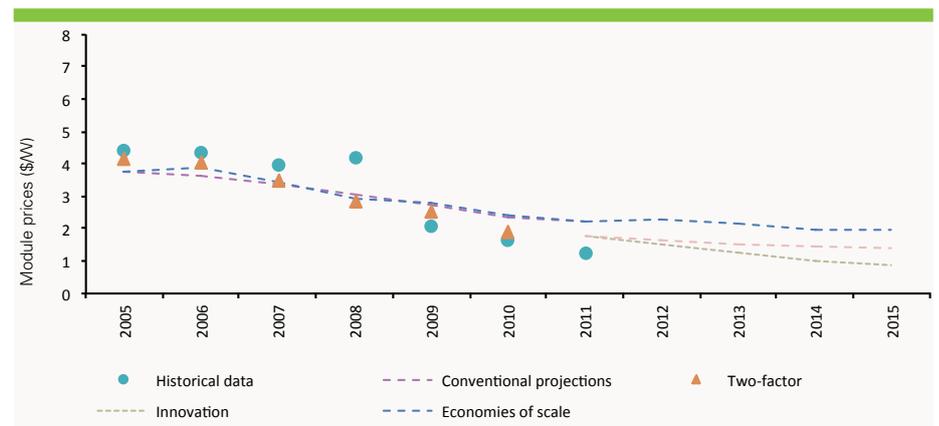
Source: IEA

Footnote: ¹01. Current and Future Cost of Photovoltaics: a report by Fraunhofer Institute ISE Feb 2015.



Similar to other electronics-based technologies, PV cost reductions were initiated by increases in efficiency and then followed by cost gains from mass production. Another important factor that has contributed to manufacturing cost reductions is vertical integration in the manufacturing process from polysilicon feedstock to wafer manufacturing, cell manufacturing and finally module manufacturing.

Figure 3:
Historic and future cost reductions



Source: Zheng Kammen, 2014

Figure 4:
Solar Photovoltaics: How it works and its components

Solar Photovoltaics (PV) is a technology for conversion of solar energy to electricity via the use of semiconducting materials. The photovoltaic effect is an electrochemical process that takes place when solar light comes into contact with a semiconductor; this results in atoms being ionised and generating direct current electricity.

PV systems have no moving parts and consist of a panel that made up of solar cells, a ground or roof-mounting frame and electric cables, and an inverter to convert Direct Current (DC) electricity to Alternating Current (AC) that can be used on-site or exported to the electricity grid. In bigger projects, PV systems can include isolator switches to protect the system, trackers (moving frameworks for PV panels) that can track the sun as it moves in the sky, and metering equipment.



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The promise of solar PV

2.2/ Popularity and deployment to date in the UK

Solar PV has gone from being a marginal technology in the UK energy mix to a technology of rising importance in a very short space of time. Since the introduction of subsidy schemes by DECC, such as the small-scale Feed in Tariffs (FiTs) and the Renewables Obligation (RO), deployment of solar PV has gone from virtually zero to more than 8GW by the end of the first quarter of 2015². In that time, solar PV has moved from a high cost technology requiring over £450/MWh in subsidy to achieve an acceptable rate of return³ to one which

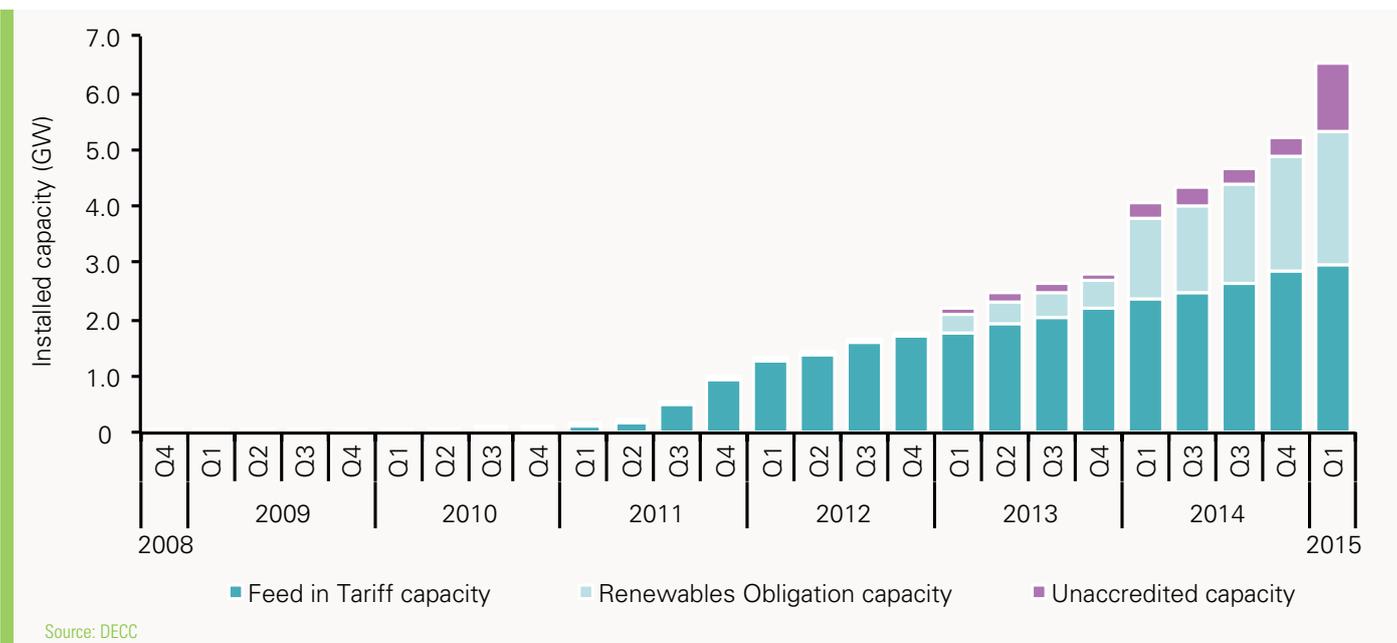
can compete with other renewable technologies such as onshore wind. This was evident in the recent first allocation round⁴ for Contracts for Difference under the Government’s Electricity Market Reform (EMR).

Solar PV is characterised by its versatility. Panels can be effectively employed at a very wide range of scales and in different locations, ranging from domestic rooftops (where projects are typically 4kW or less in capacity) through to installations on larger roof spaces (e.g. those on commercial/ industrial/ Government buildings) up to very large ground mounted developments, the largest of which in the UK is 70MW⁵.

Figure 5 below gives an indication of how deployment is split between FiTs and RO up to the first quarter of 2015.⁶

According to DECC, solar PV is the most popular renewable technology with the general public. The findings of DECC’s Public Attitudes Tracker, show that over 80% of UK adults support the use of solar PV to generate electricity⁷.

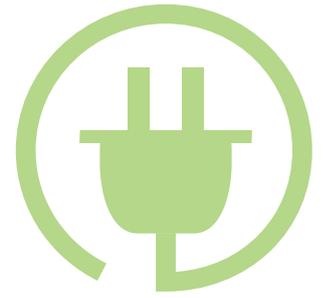
Figure 5: Cumulative PV deployment in the UK by accredited category



Footnote/ Sources: 02. Source: Latest DECC statistics and industry data.
 03. The original generation tariff under FiTs was set at 48.84p/kWh in today’s prices for domestic (sub-4kW) installations retrofitted to a property. The intention of the FIT was to provide investors with a pre-tax, real rate of return of 5%.
 04. The first allocation round granted solar PV achieved a strike price of £79.23/MWh for 2016/17 (real 2012), which, adjusted for CPI, equals to £86/MWh.
 05. Largest PV accredited project is currently Lyneham, 70MWp.
 06. <https://www.gov.uk/government/statistics/solar-photovoltaics-deployment>
 07. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/400404/Summary_of_Wave_12_findings_of_DECC_Public_Attitudes_Tracker.pdf



PV is the most popular renewable energy in the UK and its deployment is rising rapidly



2.3/ Evolution of PV costs in the UK

Although the supply of PV modules is a global market, country specific PV system costs are determined by a number of factors other than just PV module prices. In the UK, PV has seen much more rapid cost reduction than other renewable technologies. Using domestic scale solar PV as an example, the cost of a 4kW system fell from around £5,000/kW when the FiT scheme started in April 2010 to around £1,880/kW in April 2014, an average annual cost reduction of around 16% (see chart Figure 6)⁸.

Other pieces of solar equipment such as inverters and switch gear are not subject to the same cost reduction dynamics as solar PV modules. Inverters and switch gear are established technologies where scope for efficiencies from cost reduction and increased volumes are more marginal.

Nevertheless, the cost of inverters has fallen over recent years, and where previously they made up around 15% of total project costs, they now comprise less than 10%⁹. Furthermore, the continued development of inverter technology will drive increased performance from PV modules in future.

The prices of the electrical components for solar PV are largely determined by global demand, meaning that the UK alone has little influence over them. However, the falling costs of the electrical components of solar PV means that an increasing proportion of costs lie in the development and installation of projects, and in these areas the UK solar industry and the regulatory framework in which it operates has much more influence in driving down costs. Indeed, cost data for recently completed projects suggests that panels and inverters now

Figure 6:

UK solar PV cost reduction, 2010-2014 (4kW system)



Source: Green Business Watch

account for around 50% of ground mounted projects on average, with the proportion as low as 40% for some projects. As the UK solar industry has increased in size over recent years, there have been considerable reductions in installation costs as developers have found innovative ways of reducing the complexity of project delivery and also achieving efficiencies as deployment increases in scale.

In addition, solar PV is much faster to plan and install than other renewable technologies¹⁰. Even large PV projects can move from conception, to planning and commissioning in 12 months or less.

Footnote/ 08. For more details, see <http://greenbusinesswatch.co.uk/uk-domestic-solar-panel-costs-and-returns-2010-2014>

Sources: 09. Confidential source).

10. DECC. 'UK Solar PV Strategy Part 2', 2014.



PV is becoming the most competitive new build renewable technology

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The promise of solar PV

2.3.1/ Current solar PV costs and performance in the UK

We have used data from recent solar projects provided by REA members, independent sources and academic studies to produce an estimate of the current levelised¹¹ cost of solar at different scales. We have combined our compiled cost and performance data from the REA with existing DECC assumptions for factors such as project lifetime and discount rate¹².

Our estimates for the levelised cost of solar for the three main market segments (domestic rooftop solar, commercial rooftop solar and ground mounted solar) are set out in Table 1.

Our 'base' figures provide a capacity weighted average from a sample of recent installations, while our 'best' are based on published least cost point references. Our 'high' figures represent some of the highest price per MWh we have observed. However, these higher prices may be attributed to project specific factors such as very high installation costs, high efficiency modules or microinverters, and/or

Table 1:

Current estimated PV LCOE in the UK by market segment

LCOE (£/MWh, 2015 prices)	High	Base	Best
Ground Mounted	91	84	77
Commercial Rooftops	143	133	117
Domestic Rooftops	190	175	166

Source: Industry sources, KPMG Calculations, Note: All figures do not include grid connection costs-where applicable.

site specific cost additions (e.g. roof reinforcement works).

A comparison with DECC's latest set of levelised cost projections¹³ shows that solar PV in the UK has far exceeded expectations in terms of cost reduction. Table 2 shows DECC projects for the levelised costs of domestic rooftop and large-scale ground mount solar under a range of cost reduction scenarios out to 2030.

Although DECC has not produced LCOE estimates for the commercial market, comparison of the two tables shows that domestic rooftops are currently ahead

of DECC's "Low" LCOE scenario, and that under its central cost reduction scenario, costs were expected to reach current levels in approximately 2025. The costs for ground mount PV are now at a level that DECC projected would be reached in 2020 in its central cost reduction scenario.

So in both domestic and ground mounted, this analysis shows that the current PV LCOE has outperformed the latest Government estimated projections by about ten and five years respectively.

Table 2:

DECC PV Levelised Costs

LCOE (£/MWh, 2015 prices)		2014	2016	2020	2025	2030
Large-scaled solar PV	High	136	115	98	84	74
	Central	127	108	92	79	70
	Low	118	101	86	75	65
Solar <4kW	High	317	290	251	222	203
	Central	247	226	197	174	160
	Low	199	183	161	142	131

Footnote/ 11. Explanation of the term 'levelised' is provide in Appendix A

Sources: 12. Details of assumptions used in calculations are provided in Annex A

13. DECC, 'Electricity Generation Costs Update' December 2013, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/269888/131217_Electricity_Generation_costs_report_December_2013_Final.pdf



2.4/ Potential for further cost reductions

Forecasting future costs of any technology is highly uncertain. This is particularly true of solar PV. As Candelise (2013) observes, 'while historical trajectories describe a sustained long term reduction in PV technologies costs over time, both at module and system level, a closer look reveals alternating periods of cost/price stabilisation and reduction rather than steady progress along a prescribed curve', meaning that cost reduction forecasts over a shorter timeframe (for example from now until 2020) are volatile and hard to predict.

2.4.1/ Interviews with industry stakeholders

As part of this study KPMG has conducted interviews with UK solar industry stakeholders from all levels of the supply chain. Stakeholders have given us views on the future cost reduction potential of the various components of the cost of solar PV systems. Their views are summarised below.

Electrical parts (modules, inverters, switch gear)

In general, increases in volume are driving increases in efficiency for module manufacturers. Silicon prices are currently below their long-term average of around US\$20/kilo, and the price of polysilicon can be expected to fall as volume is added in its production. In addition, new cell/module technologies such as 5-BusBar or rear contact cells are now implementable: these have the potential to significantly reduce world prices from current levels by improving cell efficiency.

In addition, alternative module types are now emerging alongside polysilicon, for example CIS (Copper, Indium, Selenium), which may offer advantages in UK conditions due to factors such as better shade tolerance. As an emerging technology, CIS is still to hit the 'sweet spot' where the balance of cost and efficiency is optimised, meaning that its costs of energy can be expected to continue to fall. Despite the higher prices we found in the interviews that approximately 300MW of CIS systems were installed in the UK in Q1 2015.

There is also a trend towards assembling modules in Europe, in line with consumer electronics industries where high value parts are exported from Asia and assembled in local markets: this allows module manufacturers to save on the high transport costs of shipping completed modules from Asia to local markets.

Stakeholders agreed that these developments are likely to have positive impacts on cost reductions across all sub-sectors.

A major impediment to continued reductions in solar PV prices is the EU's Minimum Import Price (MIP) restriction. This sets a minimum price for solar PV modules and cells manufactured in China that are imported into the EU, and was put in place a few years ago to stop dumping by Chinese PV manufacturers. The MIP currently stands at 0.56EUR/Watt for solar modules, and 0.28EUR/Watt for solar cells. The MIP stands significantly above the prices Chinese manufacturers would be able to offer in its absence, meaning that if the MIP were ended, significant falls in module prices would occur not just in the UK but also in the rest of the EU. Stakeholders we spoke to for this report stated that removal of MIP could lead to a one-off drop of 10% in the price of a PV system in the UK.

For inverters, a major driver of price is volume: if developers are able to secure volume contracts with inverter manufacturers, this can drive significantly lower prices. In addition, a move towards higher voltage inverters will drive costs down by reducing system losses and increasing efficiency.

Balance of system/installation

There was a consensus among interviewees that Chinese manufacturers are increasingly entering the balance of system market in the UK, which will drive competition and help to reduce costs further.

The UK installer base has built up in terms of both volume and skill level over recent years. Developers are increasingly finding ways to reduce the complexity of the installation process, and are achieving ever higher build rates, with some developers now able to install in excess of 10MW/week, which drastically reduces site overheads.

For larger projects, the flexibility offered around commissioning dates in CfD contracts should spell an end to the 'rushes' to install prior to the end of the financial year that have characterised solar PV deployment under the Renewables Obligation in recent years. This in turn will mean lower development costs as demand for equipment will be more evenly spread throughout the year. However, CfD auctions remain uncertain given the small number of PV projects approved and the auctions taking place only once a year. Solar developers can accomplish projects in weeks once the planning process has been completed. Indicatively, and according to industry sources, the 70MWp project in Lyneham was completed in around two months.

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The promise of solar PV

Grid costs

Given the recent mass deployment of Q4 2104 to Q2 2015, interviewees expected an upward trend in distribution connection costs and delays due to grid capacity issues. They felt that DNOs had experienced difficulties in catching up with connecting new renewable energy capacity. It was generally felt that the whole process of DNO grid connections for new projects is under strain. These issues are covered in more detail in Section 5.

Pre-development costs

The number of approved sites for large ground-mounted grid connected projects in the UK is going down, with an increasing number of projects failing at the planning stage. This increases the risk for new projects and increases the costs for developers who must recoup the pre-development costs of aborted schemes.

Technology performance (yields)

Irradiation in many instances has been higher than predicted, allowing higher yields. In addition, new innovations such as East to West orientation and single axis trackers could allow yields in the range of 12-13% (1050-1140kWh/kW/yr), for ground-mounted projects located in the South of England.

In summary, industry stakeholders felt strongly that cost reductions and performance improvements would continue into the future across all areas of the solar PV cost base.

This view is corroborated by other sources. For example, ITRPV (2015)¹⁴ highlighted continued improvements in materials, process and products that would drive significant reductions in system costs in the near and medium term. The contribution of cost reduction by component, according to ITRPV, is shown in Table 3, which shows that the majority of the cost reductions are likely to originate from cost reductions in modules.

Potential future cost reduction profiles for solar PV are further discussed in Section 3.

Table 3: Relative PV System Cost Reduction by component (US and Europe for systems >100kW)

	2014	2015	2017	2019	2022	2025
Modules	58%	54%	47%	43%	37%	33%
Inverters	12%	11%	10%	9%	9%	8%
Wiring	8%	8%	8%	8%	7%	7%
Mounting	14%	15%	13%	13%	12%	10%
Ground	8%	7%	6%	6%	6%	6%
Total Costs Reduction	100%	95%	85%	79%	71%	65%

Source: ITRPV 2015, Note: these do not include planning costs, grid connection, financing and overall 'soft' costs that can vary by country and project.

Footnote/ Sources: 14. International Technology Roadmap for PV 2015



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Road to end of subsidies and beyond

3.1/ Current level of direct subsidies

Solar PV is eligible for the following Government schemes supporting the deployment of low-carbon electricity:

- Small-scale Feed in Tariffs (FiTs): for sub-5MW projects. An end date for FiTs has not yet been specified by Government;
- Renewables Obligation (RO): for sub-5MW projects since April 2015, previously open to projects at all scales. The RO closes to new entrants in March 2017;
- Contracts for Difference (CfD): for projects over 5MW, with the first auction being held in Autumn 2014. The first allocation round granted solar PV achieved a strike price of £79.23/MWh for 2016/17.

Current support available for new installations under FiT and RO schemes is summarised in Table 4 and Table 5.

3.2/ End of subsidy for solar PV is on the horizon

3.2.1/ Defining 'grid parity'

A useful concept for assessing when solar PV will be attractive to businesses and households without the direct subsidy of the FiTs, RO or CfD is that of 'grid parity': in other words, when will the costs of electricity generated by solar PV fall below the cost of alternative means of supplying that power, so that subsidy will no longer be needed.

Given the range of scales and applications we see solar PV operating in, 'grid parity' means different things for different segments of the solar market. Therefore we have approached this question by market segment, as different factors are important.

Table 4:

Current (April-June 2015) generation tariffs under Feed in Tariff

Tariff Band	Generation tariff, p/kWh	Generation tariff, £/MWh
0-4kW	13.39	113.9
4-10kW	12.13	121.3
10-50kW	11.71	117.1
50-150kW	9.98	99.8
150-250kW	9.54	95.4
250-500kW	6.16	61.6
Stand alone	6.16	61.6

Table 5:

Support levels under Renewables Obligation

		2015/16	2016/17
Ground Mounted	ROCs/MWh	1.3	1.2
	£/MWh (2015 prices)	63.4	58.5
Building mounted	ROCs/MWh	1.5	1.4
	£/MWh (2015 prices)	73.1	68.3



PV will be the first renewable technology to achieve “grid parity”



For the large ground mounted sector, which almost exclusively exports electricity produced back into the network with little or no on-site use, the most suitable cost comparator for solar PV would be a measure such as the day (or “peak” 7am to 7pm) wholesale price, or the levelised cost of a new, load following CCGT plant, which would be the closest conventional technology that will be displaced by PV, given solar’s load profile (i.e. production during daylight hours).

For commercial or domestic solar PV, which are characterised by higher levels of on-site use of the electricity produced, a better measure for assessing competitiveness may be a comparison with the retail electricity tariff, at which homes and businesses would need to buy power if they did not have a solar PV installation.

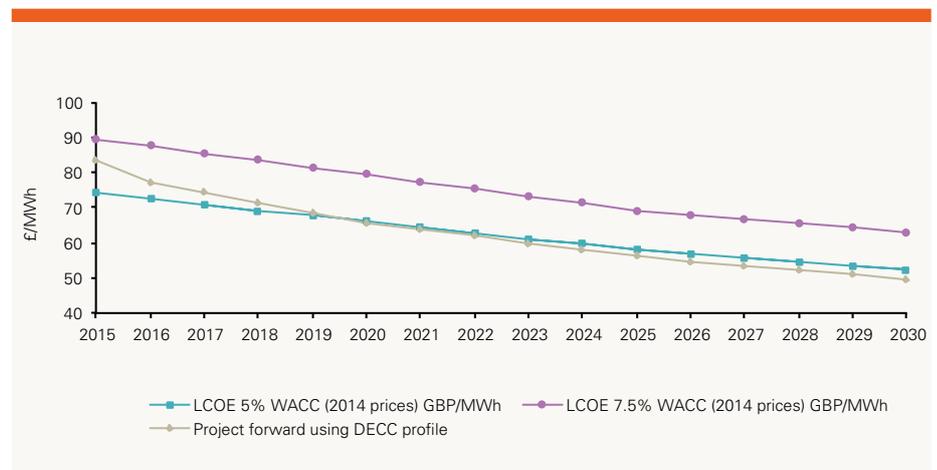
However, ‘grid parity’ will ultimately be determined by the specific circumstances for an individual investor. Within these different market segments, there is significant variety in factors such as site-specific costs, investor desired returns, levels of on-site consumption of the electricity produced, and effective electricity tariff, all of which will influence whether the solar installation has indeed become competitive. Therefore ‘grid parity’ will be reached over a period of time rather than at a specific point.

3.2.2/ Cost reduction profiles

DECC and others have produced projections of how they anticipate the levelised costs of solar PV to fall over time¹⁵. DECC have published levelised cost projections for domestic roof PV (<4kW in size) and for large-scale ground mounted solar PV. As indicated previously in Table 1 and Table 2, DECC’s estimates are above where costs currently are according to REA data for current projects: we have

therefore combined an estimate of current levelised costs based on REA data with the DECC cost reduction profile going forwards. We have used DECC’s cost reduction profile, adapted to start from the current LCOE. These are shown for large-scale ground mounted costs in Figure 7 below, together with a projection of levelised costs for utility-scale projects in the UK from an independent source, under the assumption of 5% and 7% Weighted Average Cost of Capital.

Figure 7:
PV LCOE reduction projections for the UK



Based on this approach projected LCOE projections converge at about £66/MWh in 2020. This indicates there is some consensus that PV may be on route to becoming the least-cost electricity generation technology among all new-built technologies in the UK within the next 5 years or so.

In the following Section 3.4, we set out some suggestions to help the industry maintain their cost reduction profile.

Footnote/ Sources: 15. See [DECC, Electricity Generation Costs Update, DECC 2013], and [link to Energiewende report]

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Road to end of subsidies and beyond

3.2.3/ Domestic rooftops

As set out previously in Table 1, we estimate a current levelised cost of £175/MWh for domestic rooftop installations up to 4kW in capacity.

Figure 8 shows how levelised costs for domestic PV will evolve if they fall at DECC/industry/KPMG rates. These cost reduction profiles are compared to DECC projections of the retail electricity price for domestic consumers. We believe the area at which the “low” levelised cost for domestic solar crosses the retail electricity tariff line indicates the point at which domestic solar PV begins to become attractive without subsidy for domestic consumers and the figure shows how different systems will cross the electricity tariff line at later points.

Comparing the levelised cost of solar to the retail price implicitly assumes that all of the electricity produced by a domestic solar PV installation is being used to offset consumption of grid electricity: in reality, households will typically consume less than the total output of a PV system due to the mismatch between household demand and the load profile of PV. As time goes on, and electricity prices rise and the costs of solar fall, solar PV will become an attractive investment without subsidy even for households that use lower proportions of the electricity generated.

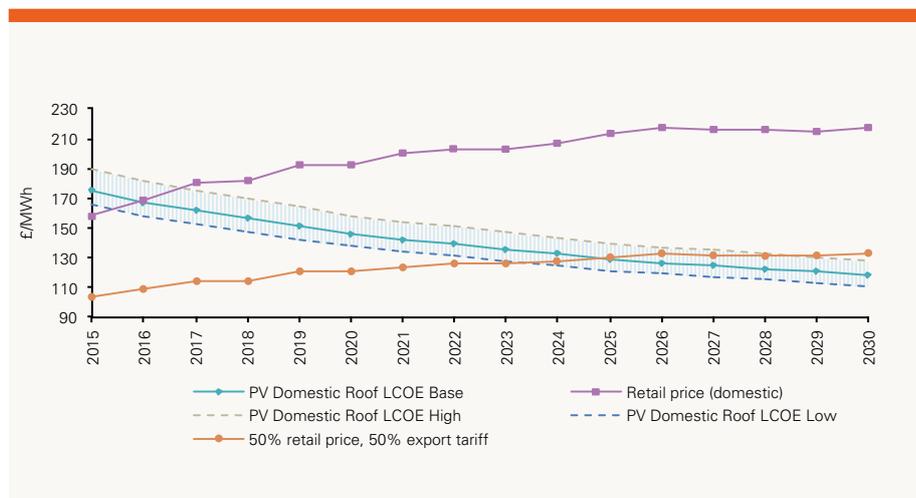
DECC FiTs analysis assumes a 35-year installation lifetime. However it is not proven that solar PV panels will maintain high levels of reliability over such a long period given that the technology is still new in a domestic context. We have also modelled levelised costs assuming a 25-year installation lifetime. However, there is some evidence from very old systems that if PV systems are properly maintained they can still generate electricity well after 35 years.

For the purposes of LCOE estimation, we have taken in the assumption of 35 years applying to our ‘Low’ scenario range. More details on all assumptions used in our scenarios are provided in Appendix A.

Figure 8 below compares the LCOE of domestic solar installations to two electricity price comparators:

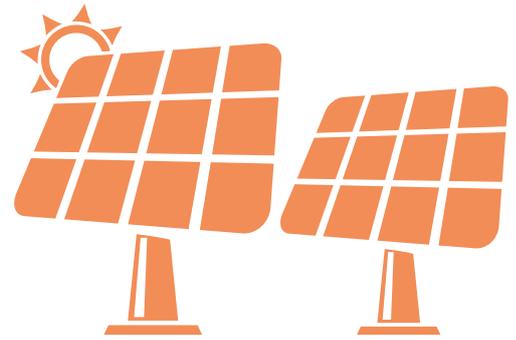
- Domestic retail tariff (taken from DECC Updated Energy Projections): relevant comparator for homes that are able to use 100% of the electricity generated to offset consumption of grid electricity
- Hybrid measure (average of domestic retail tariff and export tariff¹⁶) that is a suitable comparator for homes that are able to use 50% of the electricity generated.

Figure 8: Domestic PV LCOE versus electricity tariff comparators



The chart emphasises that reaching grid parity will be a gradual process in the domestic sector, reflecting wide variations in household usage patterns.

Footnote/ Sources: 16. Currently all electricity produced by domestic PV that is not locally consumed and exported to the grid is set by government to attract an ‘export’ tariff, equivalent to 4.77p/kWh. We note that this tariff is offered on a ‘deemed’ basis, meaning that actual export quantities are not metered just roughly estimated per size/electricity consumption of household and system size..



3.2.4/ Commercial rooftops

Although DECC has not published a cost reduction profile for commercial rooftops, we have assumed that the cost reduction profile for commercial rooftops would more closely resemble the profile for domestic roofs than that for large-scale ground mount, as the underlying cost assumptions for commercial and domestic rooftop installations are taken from the same source¹⁷.

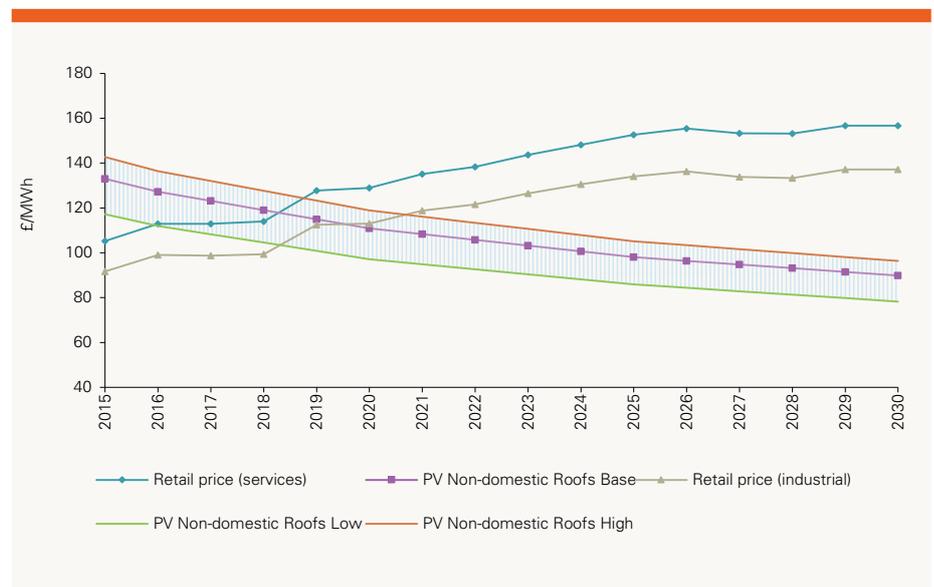
The commercial rooftop sector encompasses many different types of investor, from small businesses up to very large companies such as supermarket chains. Different types of business will face very different retail electricity prices: small businesses might face a price closer to that faced by households, while very large firms with high electricity demand might face a price more in line with that faced by big industrial users.

Furthermore, there will be considerable divergence in the extent to which businesses are able to use the energy generated by their solar PV installations on-site: whereas businesses with refrigeration units (such as supermarkets or food warehouses) will have significant electricity demand during the day which solar PV can help meet, other businesses whose demand tends to be higher at night (e.g. entertainment venues) will be able to use less of the electricity they produce.

Factors such as these mean solar PV will become an attractive subsidy-free investment at different times for different types of firm.

In order to capture the wide variety of players in this market, in Figure 9 we have compared the costs of solar to two different DECC projections of the retail electricity price: the retail electricity price for the 'services' sector, and that for the 'industrial' sector, under the assumption that the very largest firms investing in rooftop solar PV will face electricity prices close to those faced by large industrial users.

Figure 9: Non-domestic PV LCOE versus retail electricity tariff (industrial and services)



Footnote/ 17 Parsons Brinckerhoff research for Phase 2A of the FITs Comprehensive Review.
Sources:

3.2.5/ Large scale ground mounted

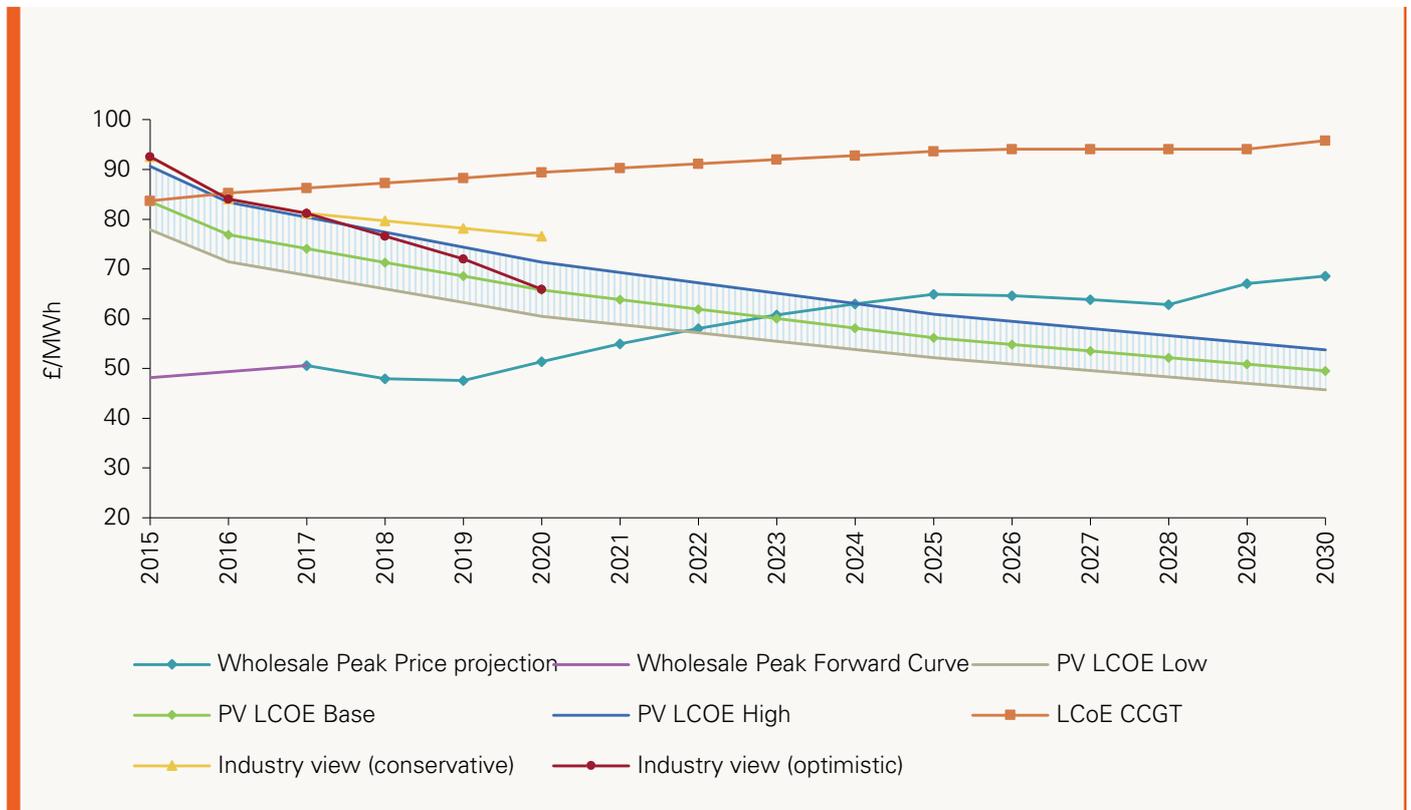
Large scale ground mount PV typically exports all electricity produced back into the grid, meaning that there is not the same variability in the use of power that characterises other segments of the market. Given the load profile of solar PV i.e. production during the day, we have compared it to the levelised cost of a load following new CCGT plant, based on DECC's estimates for the low

case of a new CCGT with load factor of 61% (in reality a load following CCGT is likely to have less than half of this load factor) and the peak wholesale electricity price, based on the current peak (or day) forward curve (7:00am to 7:00pm) and its projection.

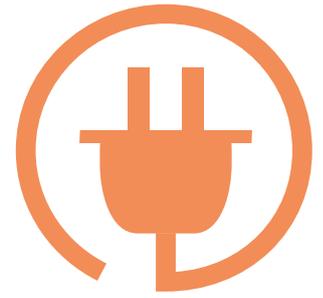
We have also included (in Figure 10), current projections provided by industry stakeholders for comparison with current wholesale prices. While the comparison with a new CCGT seems

rational, in reality there's a certain degree of caution over this comparison as CCGT is considered as 'firm'¹⁸ or dispatchable capacity (meaning it's not intermittent and can be used exactly at levels required by National Grid to balance the system), unlike PV. Also, another element that makes the comparison with CCGT cautious is the fact that CCGT, along with other thermal technologies would receive capacity payments from 2018.

Figure 10:
Ground mounted PV LCOE versus new build CCGT



Footnote/ Sources: 18. As firm capacity in this context we mean a guaranteed amount of MW that can be delivered at a specific time (so called capacity credit). PV capacity is more suitable to be used in trading with forward products (like month ahead, quarter ahead etc.), when traded as part of a portfolio. More analysis is required to simulate the system operation using a market model, to be able to estimate capacity credits for PV and what additional costs would be required to make up for these credits. A US study [<http://eetd.lbl.gov/sites/all/files/publications/lbnl-5933e.pdf>] estimates PV would need an additional £1-5/MWh to make up for a full capacity credit. In the UK, the actual amount of back up generation needed to always meet a "reliability" standard requires system and time specific calculations that are beyond the scope of this report.



3.3/ Decreasing subsidies over the next five years

Under current FiT policy, a tariff degression¹⁹ is applied every quarter, according to the level of incremental MW installed two quarters previously, so that a degression rate is applied to the corresponding market segment tariff. This means that the higher the rate of installation, the more the FiT will reduce (see Table 6). The degression mechanism will be effective in controlling overall policy support costs against the volumes of MW installed, so that accelerated deployment can 'trigger' reductions to support tariffs (up to 28% per quarter).

Table 6:

FiT Degression Rates per market segment and quarterly increment

Up to 10kW	Rate	10kW to 50kW	Rate	More than 50kW	Rate
<100MW	0	<50MW	0	<32.5MW	0
100-200MW	3.5%	50-100MW	3.5%	32.5-65MW	3.5%
200-250MW	7%	100-150MW	7%	65-97.5MW	7%
250-300MW	14%	150-200MW	14%	97.5-130MW	14%
>300MW	28%	>200MW	28%	>130MW	28%



Footnote/ Sources: ¹⁹ This term denotes the contingent decrease of the support tariff.

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Road to end of subsidies and beyond

So far the degression progress of the FiT scheme has shown that the domestic (<10kW) segment is performing according to DECC expectations, as can be seen in Table 7. The other market segments (10-50kW, and above 50kW) are somewhat slower to pick up quarterly installation rates so as to trigger mandatory tariff degenerations.

Table 7:
Quarterly deployment and degression in FiT

Tariff band	Solar photovoltaic 0-10kW		Solar photovoltaic 10-50kW		Solar photovoltaic over 50kW (including stand-alones)	
Quarter	Deployment in period (kW)	Degression	Deployment in period (kW)	Degression	Deployment in period (kW)	Degression
Q2 2012	163,769	3.5% (contingent)	57,091	3.5% (contingent)	13,938	none
Q3 2012	61,048	none	12,563	none	24,657	none
Q4 2012	50,268	none	8,641	none	40,867	3.5% (mandatory)
Q1 2013	44,213	3.5% (mandatory)	12,395	3.5% (mandatory)	13,945	none
Q2 2013	93,416	none	42,654	none	11,913	none
Q3 2013	66,605	none	17,716	none	30,547	3.5% (mandatory)
Q4 2013	88,621	3.5% (mandatory)	22,224	3.5% (mandatory)	26,750	none
Q1 2014	98,447	none	31,886	none	59,649	3.5% (contingent)
Q2 2014	83,294	none	19,307	none	42,224	none
Q3 2014	102,958	3.5% (contingent)	24,558	3.5% (mandatory)	29,538	none
Q4 2014	123,688	3.5% (contingent)	38,172	none	52,774	3.5% (contingent)
Q1 2015	103,046	3.5% (contingent)	21,652	none	52,305	3.5% (contingent)

The commercial PV sector has been underperforming compared to DECC expectations and may need more attention. We discuss some forms of potential additional incentives (not linked to the FiT scheme) later.

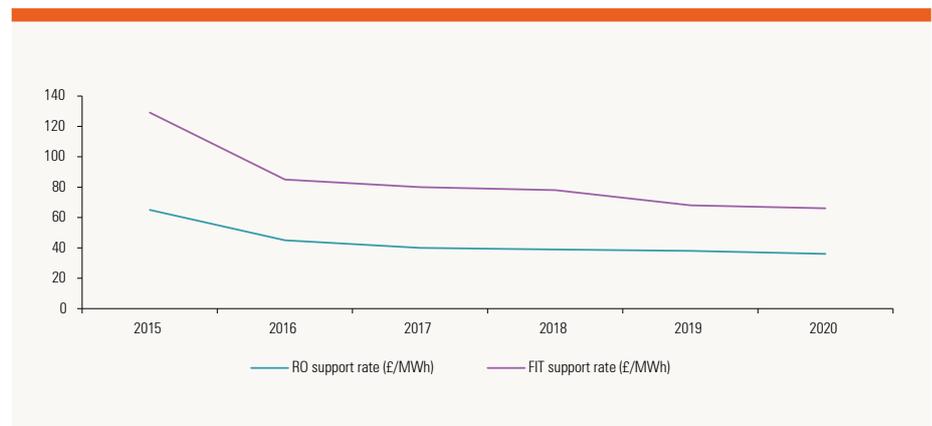
As the UK installed capacity grows and the supply chain matures to accommodate increasingly larger volumes, it is inevitable that technology specific support would begin to fall, being replaced with broader forms of support that the whole energy industry is able to take advantage of. It is down to the industry, working closely with government to monitor progress, to match rate of installations and tariff degression with LCOE reductions, so that momentum is continued and the sector does not face a 'cliff edge'.

In order to assess the potential cost to the Levy Control Framework (LCF) of solar over the coming years, we have developed 2 scenarios for deployment and cost reduction. It is important to bear in mind that there is considerable uncertainty about future levels of solar deployment: these scenarios are intended to give a potential range for the costs of solar PV subsidies out to 2020/21, the final year of the current LCF settlement²⁰.

Common to both scenarios is an assumption that in order to limit over-expenditure under the LCF DECC takes action to reduce the level of support on offer to solar PV, following high levels of deployment in 2014/15. We have assumed that support for ground mount solar <5MW under the RO will reduce to 0.9 ROCs (equivalent to onshore wind) from its current level of 1.3 ROCs in April 2016. FiT rates are assumed to fall by

Figure 11:

Projected Support Rates for PV FiT and RO (£/MWh)



the same proportion in April 2016 as a result of the second FiTs Comprehensive Review. Future reductions in support will then vary between the scenarios depending on deployment. Figure 11 show the assumed profit for future support rates:

- 14GW scenario:** in this scenario total PV deployment reaches 14GW in 2020/21 from its current level of approximately 8GW, with 11GW being deployed by April 2016. Half of the additional deployment is assumed to occur under FiTs, with the other half under RO/ CfDs. From April 2016, deployment is slow, with only 3GW more deployed up to the end of March 2021. We have therefore assumed that only mandatory FiT degressions (i.e. 3.5% every 9 months) occur for all tariff bands, and that these reductions in support are mirrored under ROCs/CfDs.
- 20GW scenario:** in this scenario total solar deployment reaches 20GW by 2020/21 from its current level, again

with 11GW being deployed by April 2016. Under this scenario, 5GW of additional deployment is assumed to come under FiTs, with the remaining 4GW under RO/CfDs. We assume that, in line with current trends, the majority of deployment under FiTs will occur in the sub-10kW capacity bands, and that this will lead to a 3.5% degression every quarter. Degression for installations of 10kW and above will be slower, although eventually they will begin to degress at the same rate as sub-10kW tariffs²¹. We have therefore calculated tariff reduction trajectories for each of the 3 rooftop degression bands²² in this scenario. Support for large scale installations under the RO and CfD is assumed to reduce proportionally to FiT, based on the average of reductions across the 3 FiTs degression bands.

Footnote/ Sources: 20. Under the terms of DECC's settlement with HM Treasury, costs to consumers resulting from the schemes that fall under the LCF (FiTs, RO, CfDs and Warm Homes Discount) must not exceed £7.6bn (2011/12 prices) in 2020/21.

21. This is because sub-10kW tariffs fall to the same level as those for installations of 10kW and above: once this happens, tariffs for installations of 10kW and above must fall in line with those for sub-10kW installations, as under FiTs it is not permitted for a tariff in any band to be greater than that in bands for smaller installations.

22. We have assumed there will be no deployment in the FiTs standalone degression band from 2016 onwards due to the consecutive 28% degressions that are likely to take place in the coming months.



The 20GW deployment scenario in 2020 offers lower cost per additional MWh (under current subsidies)

/03
Road to end of subsidies and beyond

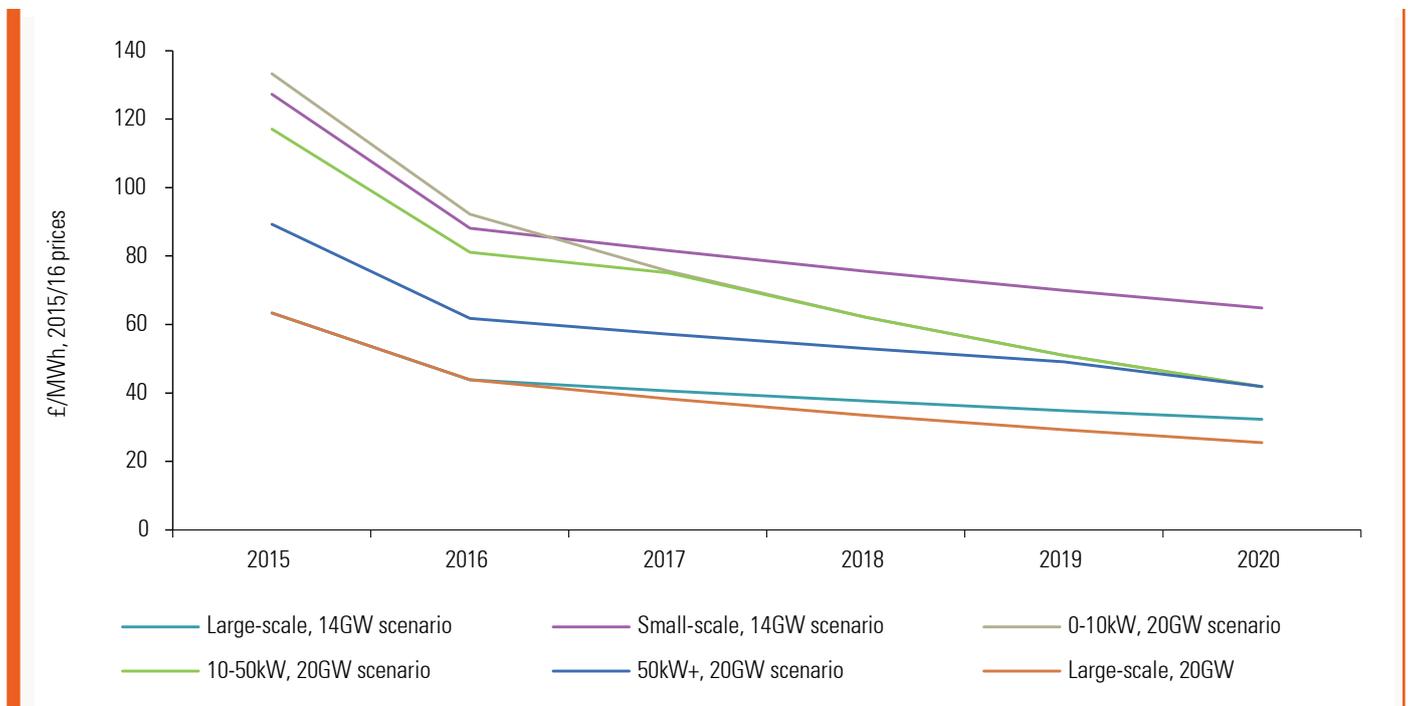
We have estimated the subsidy costs of new deployment from April 2016 until March 2021 under both scenarios. Subsidy costs under both scenarios are summarised in Table 8 below:

Table 8:
Subsidy costs under 14GW and 20GW scenarios
(£m, 2011/12 prices, rounded to nearest £10 million)

	2016/17	2017/18	2018/19	2019/20	2020/21
14GW scenario	20	50	80	100	130
20GW scenario	50	140	220	290	340

It can be observed that although the 20GW scenario sees three times as much deployment post April 2016 as in the 14GW scenario (9GW as opposed to 3GW) total subsidy costs per GW are less than three times those in the 14GW scenario. This is explained by the faster rate of tariff reduction in the 20GW scenario, which is set out in Figure 12 below:

Figure 12:
Tariff reduction in 14GW and 20GW scenarios



Another important point is that as the level of support falls, so will the cost of carbon saved by FiTs. Due to the substantial cost reductions, according to latest Ofgem report²³, the FiT is constantly reducing from year to year; £613/tonne in Year Three compared to £526/tonne in Year Four. The cost for installations registered in Year Four was £378/tonne which compares to in excess of £600/tonne in Years Two and Three.

Footnote/ Sources: 23. Source: <https://www.ofgem.gov.uk/environmental-programmes/feed-tariff-fit-scheme/feed-tariff-reports/annual-report>
24. Source: https://www.db.com/cr/en/docs/solar_report_full_length.pdf



Phasing out subsidies for PV requires a transition plan to avoid a “cliff edge”



3.4/ Post parity world

The analysis above shows that, under current projected retail and wholesale prices, solar PV is starting to become an attractive investment without direct subsidy incentives within the next five years or so at all scales. There are also other policy incentives in place, and while the Government has recently announced it will discontinue some favourable policies for renewables (such as the recent removal of the Climate Change Levy exemption for renewables, and the Allowable Solutions carbon offsetting schemes for Zero Carbon Homes), it is also conducting a review of business energy tax policy to improve and simplify the landscape.

Even though less and less direct subsidy and policy support will be required for solar in the coming years the industry is far from becoming fully self-sustained and companies have not yet managed to convert their strategies from technology push to demand pull. So far demand for PV systems in the UK has been mostly driven by the RO and FiT support (together with decreasing PV costs) so that supply of PV aims at offering some very attractive returns to investors, rather than fulfilling a real consumer need. But as costs continue to fall, consumers and businesses are likely to recognise that it is more cost efficient to ‘self-produce’ electricity, rather than consume grid electricity.

International experience in other countries has shown that reaching parity cannot guarantee that the industry could be fully self-sustainable. Figure 13 shows the boom-and-bust effect that took place after the end of support schemes in Italy, Spain (both have achieved parity²⁴) and Greece, where no provision was made in time to sustain the indigenous PV developed industry.

Therefore, it will be prudent for the UK to start preparing a ‘post parity’ plan for the PV industry, allowing it to continue to build volume and scale, and ensuring that over time solar becomes not just competitive with other technologies, but the cheapest electricity generating technology, which will drive lower electricity prices and enhance macroeconomic benefits for the UK economy as a whole. There are several ways that this can be achieved; we describe our suggestions for each market segment.

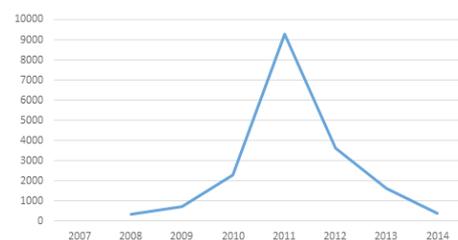
3.4.1/ Domestic Sector

There is scope for the UK Government to consider mandating the installation of PV on all new buildings by adding it to part L of the building regulations. PV installation guidelines in building regulations can be fairly easy to implement and will link new

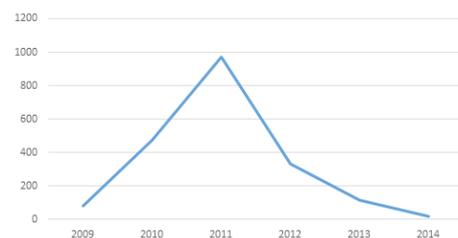
Figure 13:

Illustration of PV Industry ‘Cliff Edge’ in Italy, Spain and Greece (YoY PV MW deployed)

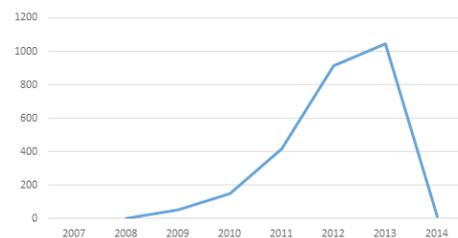
Italy



Spain



Greece



Source: EPIA.

PV installations to the churn rate of property capital stock. This initiative will create a steady demand stream for the sector and can drive efficiency in design and innovation (and hence reduce installation costs even further). Especially in social housing, PV can contribute immediately to lower bills for lower income groups, thereby contributing into mitigating fuel poverty.

Also there is the opportunity to incentivise home-owners to install rooftop PV through the existing property tax system.

Since 2007, zero carbon homes (residences that do not consume fossil fuels for heat and power) are subject to reduced stamp duty rates. Properties valued at less than £500,000 are completely exempt from the tax whereas properties with a selling price greater than £500,000 are subject to a reduction of £15,000. A report published in 2013 by the UK Green Building Council (UK-GBC) articulated the importance of zero-carbon homes and how the introduction of a discount on council tax or stamp duty payments for more energy efficient homes would do a lot to help incentivise the installation of renewable energy systems²⁵. A recent study found that “at today’s prices, the typical additional cost of building a semi-detached house to the zero carbon standard could be less than £5,000, and by 2020 could be less than £3,500”²⁶.

Although this recommendation addresses all energy efficiency technologies, it’s obviously relevant to rooftop PV or building integrated PV. So a Government review of the stamp duty application, that addresses PV installation, could contribute into sustaining demand for domestic PV. An alternative approach could be to channel incentives through Council Tax. A study has shown that a Council Tax discount was identified as being the most promising fiscal incentive to explore incentives for energy efficiency/microgeneration, given its broad impact in the market²⁷.

3.4.2/ Commercial

In the commercial rooftop sector, there are a number of barriers to installation which have meant that the PV deployment has been slower to develop in this sector. Complications arise through the ownership structures of these buildings with many leased

through full repair and insurance (FRI) leases. Some of these barriers have been overcome in the private sector and changes to planning rules for PV systems up to 1MW have been a positive move for the industry.

Adjustments to the way that income from subsidies is taxed could help to support this sector. Currently, the FiT is taxable income, on which it pays corporation tax. As such, all PV originated revenues do not have special treatment for tax purposes. However, this could be taken into account in a post parity world by the Government to incentivise take-up of PV in the commercial sector.

When FiTs are taxable as business income, a claim can be made for capital allowances for the cost of the panels. Capital allowances are claimed at 18% on a reducing balance basis (i.e. 18% of the cost in the first year, then 18% of the remaining 82% in the second year and so on) until such time as the ‘capital allowance pool’ is depleted. For PV, Annual Investment Allowance (AIA) may be available. This is a special form of capital allowance giving 100% tax relief (instead of 20% reducing balance) of up to £500,000 (£200,000 from January 2016) subject to the AIA not being used on other capital purchases. We note that PV does not attract enhanced capital allowances (ECAs). We provide more details on these forms of tax relief in Appendix B. These current regimes for tax relief on capital depreciation could also be used to incentivise PV, after subsidies are phased out. For instance, in a post parity world without subsidies, PV could be awarded unlimited AIA and/or ECA if it can prove it meets certain criteria.

Another potential route for providing incentives for PV take up is through the application of business rates.

Currently, businesses that have installed PV are subject to an additional increment on payable business rates that is proportional to the size of the system and a multiplier that is set by Central Government (see more details in Appendix B). An exemption is applied to this business rate increment if the size of the system is less than 50kW or if the business consumes most of the electricity produced (although this exemption is set to expire by 2017). There is clearly scope for the Government to re-examine the application of business rates as a way to incentivise and encourage PV, instead of penalising it, especially after the support schemes are phased out. This could be achieved by the application of special lower multipliers or extension of exemptions in both size (e.g. up to 100kW) and duration (e.g. for the lifetime off the asset).

An alternative approach to incentivising deployment in the commercial sector, similar to the domestic sector, could be through changes to building regulations and the application of EPC certificates. The energy performance of a non-domestic property is calculated through a CO₂ based index. It takes into account energy used for heating, ventilation and lighting, this energy use can be offset through renewable generation for both heat and/or power. Buildings with lower CO₂ emissions receive higher EPC ratings. The Energy Act 2011 stated that by April 2018 a provision must have been implemented that will mean that it is unlawful to lease both domestic and commercial properties unless they meet a specified EPC rating. There is an opportunity for the Government to implement this through the next changes to building regulations, it provides an opportunity for solar as one of the lowest cost renewables to offset energy use in buildings.

Footnote/ 25. http://www.ukgbc.org/sites/default/files/Impact%2520Report%2520WEB_2.pdf

Sources: 26. <http://www.ukgbc.org/news/cost-building-zero-carbon-homes-has-fallen-according-new-analysis>

27. Dresner and Ekins, Whole House Fiscal Measures to Encourage Consumers to Improve the Energy Efficiency of their Homes, 2004.

Current public perceptions accept that PV can be mounted on domestic roofs or on the ground. However all roofed structures like car parks, train stations, bus stops etc., can potentially host PV modules. Also, similar incentives to the ones we proposed above for the domestic sector can apply through the property taxation of commercial buildings, e.g. stamp duty.

3.4.3/ Ground mounted

As mentioned earlier, recent CfD auctions have identified ground mounted solar as one of the cheapest new build technologies with a strike price of £79/MWh. Given the expectation of future declining costs there is an opportunity for Government to allow cheaper technologies such as ground mounted PV to compete for more of the CfD budget, not just the 20% allocated to 'Pot 1'. This means that more renewable MW's can be obtained from the LCF budget.

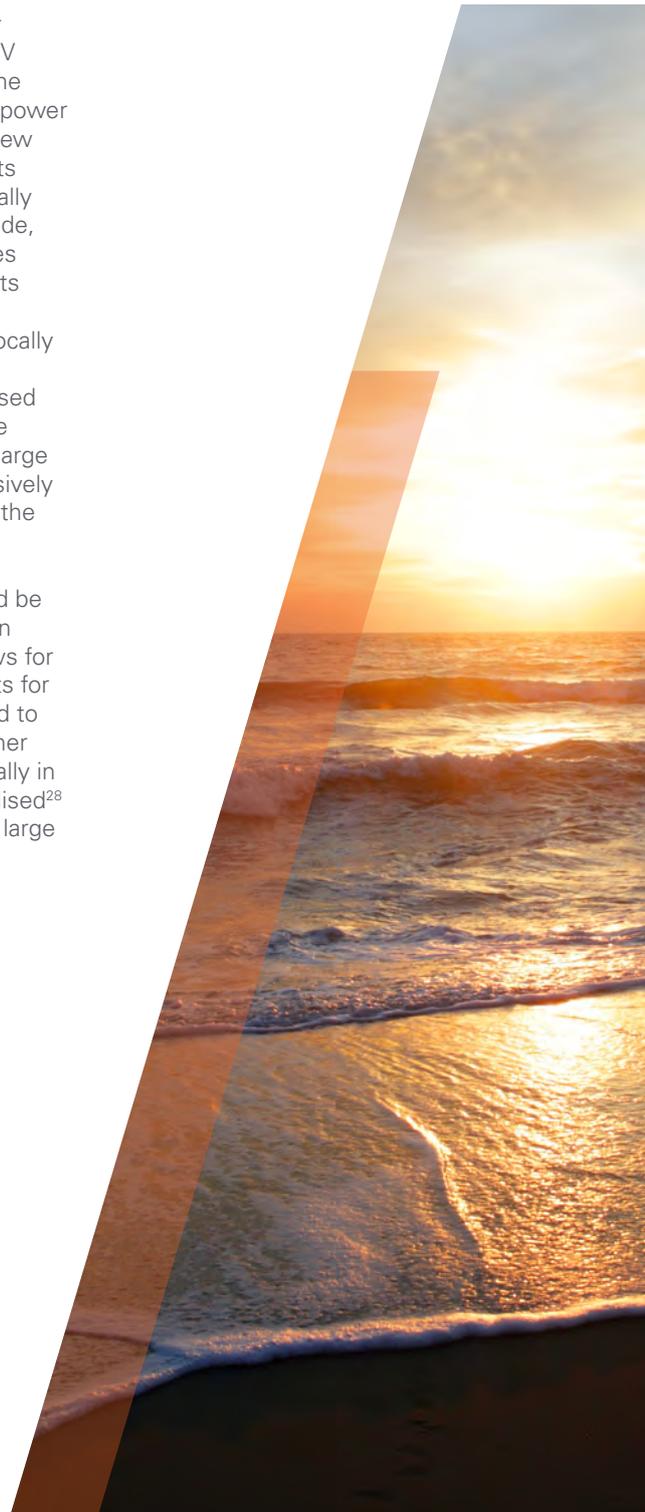
As previously outlined for commercial PV installations a review of the tax and rate regimes is as important as margins on these projects become tighter.

For larger projects that export their entire production to the MV/LV Grid, DNOs have had to manage the recent 'rush' in grid connection applications as a result of the RO deadlines.

Potential suggestions for improvement could be to adopt a more holistic approach to planning grid network upgrades. As international experience shows (e.g. Italy, Germany), grid connection and access issues can be the most significant barriers to the wider uptake of embedded large scale PV (and wider renewables) projects, and that situation is rapidly approaching in the UK unless action is taken.

Another critical point, especially for larger projects, is that large scale PV could start being implemented in the planning process for meeting local power needs, for example at large scale new housing developments. Investments on the LV side of the grid can typically mean less investment on the HV side, as PV generation normally translates as less demand in bulk supply points on the transmission network. This means that electricity that is sold locally in principle should be cheaper than electricity sourced through centralised generation that uses HV grid. These benefits could be amplified where large rural PV projects can provide exclusively their output to large users through the creation of a small privately owned network, however the relative cost and risk of duplicated assets should be considered. Current DECC policy on Private Wire Networks (PWN) allows for specific remuneration arrangements for CfD projects that are not connected to the distribution grid. However, further investment on private wire, especially in areas that the network is highly utilised²⁸ can be promoted so as to facilitate large scale project development.

Footnote/ 28. A latest map showing grid connection availability in one of UKPN distribution areas.
Sources:



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Solar PV contribution to UK economy

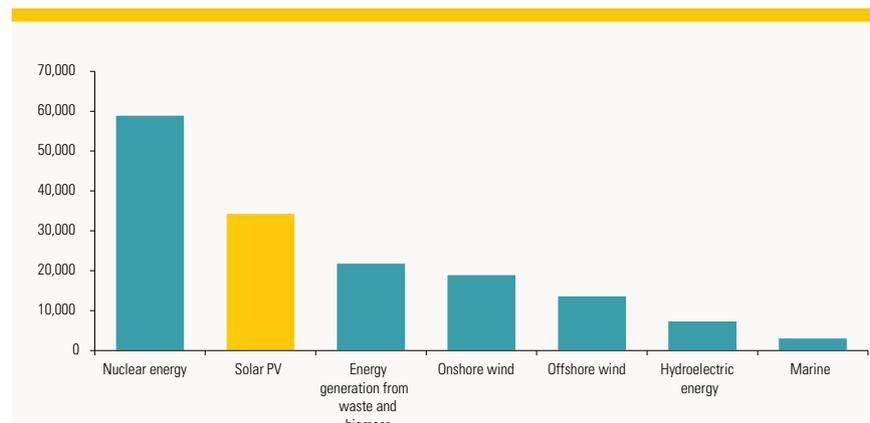
4.1/ Macroeconomic benefits

The solar PV sector is increasingly contributing to the UK economy and has positive macroeconomic benefits. A recent report by the Department for Business Innovation and Skills, highlights the increasing importance of the solar PV industry, compared to other low carbon electricity generation technologies. The sector's economic contribution in 2013 was approximately £3.3bn (GVA), an increase of 6.3% since 2010. Additionally, it is estimated that 71% of the firms involved in low carbon electricity generation are solar PV – this represents 2,380 out of 3,350. These numbers highlight that there are a large number of small firms involved in supply and installation.

The same publication estimates that there are currently around 34,400 full and part time jobs. (Figure 14) supporting the solar industry in the UK (including supply chain) – this represents 24% of total employment across all renewable technologies and an average annual increase of over 20% since 2010. This strongly suggests that the average solar company has fewer staff in comparison with other renewable energy technologies. Current cost reduction trends in the solar industry will be the key to sustainable jobs, especially as solar PV subsidies are unlikely to persist long into the 2020s.

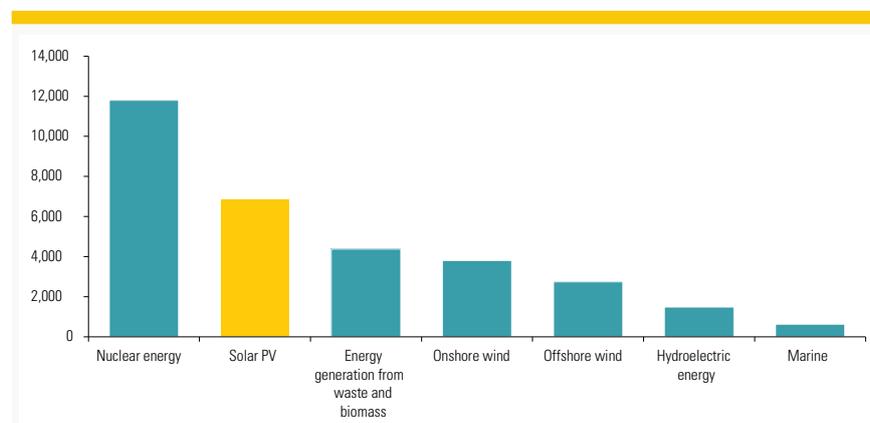
According to this report, from 2010 to 2013, the solar sector turnover increased from £6bn to £8.4bn (Figure 15), a compound annual growth rate of 11.9%. This represents 25% of the low carbon electricity generation turnover, coming in second place after nuclear power. From 2010 to 2014, the solar PV sector recorded £11.4 billion of estimated investment, helped by an increase in the amount of eligible solar PV schemes under FiT and RO.

Figure 14: Number of Jobs by Low Carbon Electricity Generation Technology (2013)



Source: BIS.

Figure 15: Turnover by Low Carbon Electricity Generation Technology (£ million)



Source: BIS.

While solar PV deployment increased at an exponential rate, the number of jobs increased by 1.8X from 2010 to 2012 and experienced a small decline from 2012 to 2013. This trend suggests that fewer jobs are needed per MW installed over the years, as productivity increases and skillset of workers is optimised to deliver more turnover at lower costs. Current PV cost reduction trends combined with an increase in solar PV deployment will be the key to sustainable jobs, especially as solar PV subsidies are unlikely to persist long into the 2020s. As discussed in the

previous section, a long term strategy for the PV industry in the UK, after the end of subsidies, will ensure that the industry's contribution to the macro-economy is sustained²⁹.

4.2/ Role solar PV can play in future UK energy mix

As more and more PV is installed in the UK, solar electricity will gradually start displacing fossil fuel generated electricity. According to the IEA, the UK is on track to achieve 2% of its total

Footnote/ Sources: 29. Second order macroeconomic effects (also known as Spillover effects) are not included in this analysis. If these were included the overall effect of PV on the UK economy would be higher.

electricity consumption in 2015 from solar PV. Based on our projections, this can rise up to 4-5% or even higher in 2020. For comparison, Germany is currently at about 6% and Italy 7%. As more and more PV is installed, it will displace fossil fuel electricity, meaning that less coal and gas needs to be imported, improving fuel security of supply. In addition, despite declining North Sea production, UK-produced gas that is not burned to produce electricity or heat can in turn potentially be exported.

Small scale PV is also contributing more and more to distributed generation which in turn contributes to lowering the cost, complexity and interdependencies associated with high and low voltage transport/distribution. Decentralised generation can enhance the resilience of the system, if properly managed, along with other low carbon technologies³⁰.

At current DECC projections, total installed PV capacity will reach (or even exceed) 14GW in the UK by 2020. Although this sounds like quite a large figure compared to current peak demand of around 50GW and total system installed capacity of around 67GW, in reality total contribution of PV to peak demand is likely to be much lower as, for example, in UK winter peak demand in the system happens around the evening tea to dinner time (normally 5pm to 7pm) when PV will not be generating as it will be dark. However, PV will still be contributing to winter day time demand albeit at slightly lower levels than at other times of the year. As most PV systems in the UK are only expected to generate electricity at 10-12% of the total hours in the year, this means that PV's contribution in meeting annual electricity consumption is likely to remain less than 5% even with 14GW installed.

In reality PV electricity produced during the day time will likely displace a certain

amount of the most expensive inflexible baseload capacity (e.g. coal and older less efficient gas units depending on the coal-to-gas spread), that might not find economic to run their power plant in daily cycles (i.e. shut down in the day and run at night). Despite the perceived low contribution of PV in overall electricity production with load factors at roughly 10%, PV can actually have a significant impact in the generation mix. As PV generates electricity when it is mostly needed (i.e. during the day), its actual load factor during times that it can generate (e.g. day time 7am-7pm) is nearly 20% or more. But because the annual load factor calculation of PV takes into account winter days that have shorter day time hours and lower irradiance, it is evident that during the six months or so of British summer time, PV day-load factors could be up to 40 or even 50%, with a day-to-day reliability of nearly 100%.

In order to put this number into context, if we assume that by 2020 there would be 15GW of PV installed and summer day peak demand is about 35GW, then PV would supply nearly 35-45% of system capacity in the day for nearly 6 months of the year. Although the above figures are ballpark estimates (and more detailed calculations are outside the scope of this report), we can still expect that PV's impact on UK generation mix will not be trivial.

Another important consideration is that all PV that is 'embedded' in distribution networks is 'invisible' to the System Operator, National Grid. Nearly all distributed PV electricity production will effectively reduce demand at distribution network supply points and be seen by the System Operator as 'less demand' on the national transmission network, so that every GWh generated by PV is displacing an equivalent amount of electricity generated and transmitted through the HV grid. This fact can

present National Grid with a number of technical challenges in terms of system balancing and provision of reserve, as forecasted demand on the HV grid can be more difficult to estimate and eventually will become more volatile. National Grid is currently in the process of finalising the availability of a whole new range of ancillary services that aim at contributing to maintaining system reliability and resilience, so as to facilitate more integration of intermittent PV and wind.

Despite PV's increasing significance in the UK energy mix, it would be misleading to consider that it can be a 'silver bullet': rather PV needs to be considered as a technology that works complementarily to other low carbon technologies like nuclear, wind and biomass. An empirical observation from other countries that have large amounts of wind, PV and nuclear in their energy systems (like Germany or Spain) has shown that wind and solar generation profiles tend to have a negative correlation, meaning that the wind tends to blow more at times that PV production is lower (winter, dusk to dawn). In that sense, all technologies can work in harmony complementing each other in balancing the system and meeting demand.

Another role of PV is that as it becomes more popular in the domestic and commercial sectors inevitably it increases the population's awareness of the need for low-carbon electricity and the value of energy efficiency. This increase in public awareness comes as a second order benefit of PV in the energy mix, and although it is difficult to quantify, it is not negligible. DECC has announced³¹ some initial results from a survey on the impact of energy consumption patterns, and initial results show that households that install PV have a tendency to reduce their electricity consumption.

Footnote/ Sources: 30. System resilience here means the ability of the system to recover from an unforeseen event that brought loss of supply. Decentralised generation means less dependence of the final user on large power plants and transmission lines, as power is produced near to the point of delivery.
31. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/404641/energy_usage_in_households_with_solar_pv.pdf

/05

Key future opportunities and challenges with solar

5.1/ Promise of electricity storage

Although weather forecasting has improved significantly over the past few decades the predictability of cloud coverage in the near term remains low. Electricity generation from PV still remains an ‘intermittent’ source, as cloud coverage and solar irradiance can vary significantly from, day to day and across the seasons. As electricity generation from PV follows solar irradiance, the profile of production from PV in the UK does not match the demand profile that normally peaks in early evening. Therefore PV has been traditionally considered as ‘non-firm’ capacity that normally would require back-up from conventional technologies (like gas).

However, the availability of PV electricity is likely to change with the advent of energy storage. Energy storage, in its various forms (from utility scale to domestic) has the potential to capture and ‘store’ excess electricity production from PV and other renewable technologies such as wind, and make that electricity available at times when the sun is not shining. Energy storage for use in electricity systems has had limited applications so far worldwide, as costs remain high and the industry remains immature.

But battery storage technologies, such as Li-ion, have seen significant cost reductions in recent years, partly as a direct outcome of their increasing use in personal electronics and electric vehicles. The use of ‘second life’ batteries (enabled through UK battery manufacturing) also has a role to play. This provides an opportunity for the renewables industry as the continuing cost reduction of energy storage technologies has the potential to significantly improve the role of

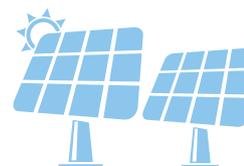
intermittent renewable technologies in meeting demand and flattening out intermittency. Even today, utility scale storage can be economical in certain grid applications. DNOs report that in certain cases it is already cheaper to employ storage rather than network reinforcement solutions. A representative example here is the 2.5MW Li-ion system installed by Northern Powergrid in Darlington, justified as investment deferral. Other smaller projects have been installed by other DNOs, and several projects are under way³². Large scale storage could then provide the benefit of storing excess renewable electricity and help to de-congest parts of the distribution networks that are overloaded, subject to Ofgem provisions for justifiable investment in these areas.

As the cost of storage falls, it seems that its commercial viability is not far off even for domestic applications. The combination of a domestic PV system with storage (and possibly an electric vehicle) could truly revolutionise the way that households consume electricity, as they will be able not only to store excess PV production and use it in evenings, but also take advantage of the price differentials in grid electricity costs between day and night to lower their bills.

The Government has a clear opportunity to set a strategy and policies to enable the growth of energy storage.

5.2/ Grid connection

As more and more distributed PV generators are connected to the distribution grid, the capacity of the grid to accommodate even more PV decreases. Current distribution networks have been designed to accommodate unidirectional flows of certain amounts of power and voltage. As PV and other distributed generation technologies



are connected, it means that DNOs would eventually have to enhance the availability of new connections in certain parts of the network in order to accommodate the power available. In several cases, where larger ground-mounted PV is to be connected, connection in the specific area of the grid might not be technically possible due to e.g. the lack of capacity on the lines, low transformer rating ranges, or even lack of substations. As experience in other countries has shown³³, grid connection constraints are among the most significant non-economic barriers for large scale deployment of PV. From our discussion with stakeholders and our experience, it seems that already network capacity is already starting to impede PV connections in certain parts of England, contributing to a rising trend for grid connection costs, especially for larger ground-mounted projects. With the very quick lead time for PV projects, speed and efficiency in grid connection is of paramount importance for scale deployment, and DNOs will need to be responsive to the demands to execute large numbers of grid connection applications.

Both DNOs and the UK PV industry have proved that they are capable of connecting more than 2GW distributed PV in a quarter, among all other renewable technologies. When connection capacity is scarce (both in terms of DNO ability to serve all applications and investment needs in the network) and projects that have been granted connection don’t complete for several months, then PV projects may face “bottlenecks” in grid connection. This may add additional delay and

Footnote/ Sources: 32. More details and references here:: <http://www.energystorageexchange.org/policies>
33. Japan has recently revised FIT rules because of grid constraints.

uncertainty to a supply chain already impacted by the cyclical nature of PV deployment so far.

DNOs are governed by licences and an 8 year regulatory price control framework to incentivise outcomes and innovation (RIIO). Ofgem will need to monitor closely whether agreed outcomes are being delivered, so as to facilitate renewables integration. By the time of the next RIIO, it seems the UK will host in excess of 15GW of solar (up from less than 4GW in 2013/14). It's clear that the needs of networks will have evolved massively over this 8 year period.

Other than the need for grid upgrade investment, the increase of 'embedded' generation can have advantages for networks. It can increase distribution network load factors and reduce overall system losses. Also it paves the way for implementation of several innovations in network management, e.g. Active Voltage Control, Intelligent Network Switching, Phase shift transformers, Advanced Fault Current limiters. These are some of the technologies of the so-called "smart grid" of the future.

5.3/ Network management and system balancing

As discussed above, distributed PV represents a particular type of variable (or intermittent) energy resource, with three characteristics that set PV generators apart from conventional generators. First, distributed PV generators, by their very nature, provide installed capacity that is spread over numerous devices scattered across a large geographic area; second, their power output is variable because of the solar cycle and clouds. Third, their power output is uncertain because, although the amount of sunlight reaching the PV array follows a regular pattern on average, chaotic atmospheric changes account for large deviations that are difficult to predict precisely.



Previous experience in countries that have witnessed large scale deployment of PV, like Germany or Italy, has shown that there are ways to manage large load variations during the day by using traditional means (scheduled dispatchable generation, various system balancing ancillary services, curtailment) even without the need for massive storage infrastructure. This is because of the fact that especially gas fired plant generally have the capability to operate flexibly and 'follow' demand or excess supply on the grid, so that the system can remain balanced, even during a very windy summer noon or a still cold winter evening. Also, as more modern distribution grid technology is deployed and potentially storage, this would increase the capability of the distribution system to manage loads and variability, and sometimes even 'offer' system ancillary services (like power quality, voltage control and fault management).

5.4/ Power markets

In a system that has large amounts of PV and wind, coal power plants and nuclear reactors (that are less flexible than gas) are unable to follow the inherent load variability of demand with intermittent wind and solar. 'Flexible' here means the technical ability (and economic value) of plant operators being able to shut down for a few hours or at night. If the cost of 'cycling' coal plants is greater than the pre-agreed or market price, coal generators might be willing to operate at a loss. Also, normally nuclear reactors do not have the technical capability of shutting down intranight, their operators might opt to 'pay' to stay online. This technical issue has profound impacts for electricity markets and is currently illustrated, especially in the continent, by periods of 'negative' prices when the system is 'long' on inflexible capacity.

As older coal and nuclear plants are decommissioned, this issue will improve, showcasing the need for flexible gas plant designed to 'cycle' at low costs and high efficiencies. The overall effect will be a lower average wholesale power price, as has been shown both in theory and international practice, and also a higher average peak price and higher price volatility. In the absence of storage, and under the assumption that PV can compete in a market with other technologies, there is an inherent system threshold of the amount of PV that can be installed in any system. Under current market rules, as more PV is installed in the system, the lower the average wholesale price would be, and after a certain degree of deployment any further PV capacity would be uneconomic.

5.5/ Net metering

With the roll out of smart meters, domestic and small commercial properties will be able to have accurate metering of PV electricity. 'Net metering' is the practice of measuring 'import' and 'export' electricity, so that import electricity is credited to suppliers and export electricity is credited to pro-sumers³⁴. If there is an export surplus, the type of credit can either be a payment or rolling credits that can be used in forthcoming periods, when the export surplus becomes a deficit. Currently in the UK, as described in previous sections, exported electricity is 'deemed' (i.e. estimated) and a tariff applies. Smart metering will enable to be made precise payments to eligible pro-sumers, provided that a system of rules apply for the applicable tariff to be credited.

In countries with high penetration of PV, net metering is currently considered in various forms, so that it can provide a known, certain revenue to eligible users.

Normally, in net metering, dispersed PV is treated as any other conventional technology, carrying perhaps connection charges or Distribution Use of System Charges (DUOS). In that sense, net metering is a definitive pre-requisite for the post parity world.

Net metering can have several other benefits, other than the obvious need for less meters: as tariffs become more time dependent and cost reflective (even perhaps by moving to half-hour settlement for domestic/SME consumers) in the UK, eligible pro-sumers would be able to receive market dependent remuneration for electricity exported. A variation of this so-called market rate net metering has been applied in California.

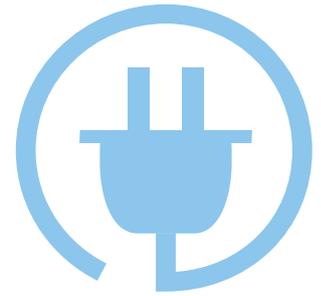
Recovery of distribution network costs in net metering rules under the principle 'the consumer pays' can create an uneven distribution of DUOS charges, so that consumers that are unable to fit PV or other renewable technology (e.g. flats) will bear a bigger burden in their tariffs than pro-sumers. This points to the development of communal PV, in which consumers can potentially participate collectively in PV schemes on communal spaces (e.g. schools, churches). In the UK, DECC has established a community energy code and according to latest reports there are at least 5000 community energy projects, in PV and other technologies.

Many wider benefits are possible with net metering, as the UK continues with a rollout of an increasingly smart grid. Smart metering will mean bills can be tailored far more closely to when electricity is consumed, allowing for tariffs to be lower at times when overall system demand is lower. Householders could programme many of their household devices to consume on-site generation when prices are low and export surplus when prices are high,

Footnote/ Sources: 34. The term denotes consumers that are also producers. Another term used widely is auto-producers.



A strategy is needed to transition and integrate PV into energy markets and distributed energy systems



thereby reducing balancing costs of the system as a whole. This potential could be taken even further if electricity storage becomes widespread.

Therefore, we consider net metering an absolute prerequisite for the long term sustainability of the PV sector in the UK, and will immediately enhance GB wide benefits from the smart metering programme.

5.6/ Evolving business models

Community participation in renewable energy projects normally focuses on local engagement, local project leadership and operation, and aims at the local community benefiting collectively from the outcomes. Collective participation has the strong benefit of communicating to communities the challenges of the transition to a low carbon future, and can often overcome obstacles relevant to planning or population acceptance. Clearly, local authorities can participate and incentivise community participation in PV schemes. Also, provisions for PV development could be implanted in the building planning permission processes with local councils, so that PV would be an integral part of local development, not only in housing but across the built environment.

Already, new entrant utilities in the UK look to develop business models that aim at being involved more with the local population, by launching co-operations with local authorities under 'white label' arrangements. Potential applications of this model means that housing associations, local councils and other local authorities can operate also as electricity suppliers. This is a model that is starting to pick up in the UK, and is quite popular in Scandinavia and Central Europe. In Germany, the

'Stadwerke' local utility model has seen a large percentage of PV deployment (and many other technologies, across electricity, gas and water sectors) that has been developed and owned by local authorities.

A popular earlier business model that emerged with PV is the so-called 'free-solar', that offered to consumers a bundled service for developers to have a leasing arrangements with landlord for the roof space. However, with the reductions to the FiT this declined in popularity. A different version of this model that is emerging in the UK is the 'Zero up-front' model that has proven popular in the US. In these models the systems belong to the PV company who installed them and a power purchase agreement (PPA) is agreed with the property owner, usually for less than their annual electricity bills.

Another model that is emerging is for the utility to offer not just electricity but also to install PV and other systems in the household, such as hot water tanks. Essentially, this business model aims at offering energy management 'outsourcing' services for households that can be applied with specially designed tariffs and incentives for households to participate. Bundled services can also be offered across sectors to include gas, heat, water, sewage and telecommunications.

Evolving utility business models are currently under review by Ofgem, who has recognised that current regulatory framework might not entirely fit to these emerging models. This initiative can perhaps drive changes in licensing and regulatory oversight rules, to allow for more competition in PV installation and electricity supply in general. Also it would contribute into lowering market concentration, enhance competition and create new jobs, and increase security of supply.

/06

Conclusions

In 2014, the UK installed the largest amount of PV in Europe, and a successful PV industry has been developed in the UK over the last five years. PV has achieved cost reductions of nearly 70% in the UK, with current deployment of more than 8GW installed capacity. PV has achieved dramatic cost reductions that have outperformed even the most optimistic projections in the past. We estimate a current LCOE of £84/MWh for ground mounted PV, £133/MWh for commercial rooftops and £175/MWh for domestic, with some 7-10% deviations around these central values.

As the UK PV industry grows, it brings several macroeconomic benefits to the UK in terms of gross value added, job creation, and others. In 2015, UK PV industry is likely to have a turnover of approximately £10 billion, with almost half of that as Gross Value Added, and employing nearly 35,000 people. PV is becoming the most popular renewable energy among British consumers.

By 2020 we expect PV LCOE to fall by approximately 35% from today's values. This means that PV is en route to becoming the cheapest way of generating electricity from any new technology.

We have modelled two scenarios for PV deployment to 2020: a scenario based on existing DECC projections of 14GW to 2020 and a more optimistic scenario of 20GW (both scenarios in 2011/12 prices). Under the first scenario, we estimate that the annual cost of supporting new deployment from April 2016 onwards will be £130 million in 2020/21. This scenario represents a dramatic slowdown of deployment from

2-3GW a year down to 300MW a year. This effectively means that industry development declines, with several thousand job losses and shrinking of industry's gross value added, while still in need of subsidy even for installing 300MW a year. This scenario clearly paints a non-sustainable picture for the future of the UK PV industry.

For the 20GW scenario, we estimate that deployment is 1.5GW a year, which is lower than current deployment rates and represents a more sustainable industry (and would minimise the effect on employment in the sector). We estimate that in this scenario, the annual cost of support for new PV from 2016 onwards will be £340 million in 2020/21. This means that the unit cost of support falls dramatically delivering better value for money, and substantial deployment of low carbon capacity in just a few years' time. All scenarios are subject to grid connections being available.

The UK is gradually entering the so called PV grid or socket parity period, where PV costs compare closely or even outperform comparators (e.g. the retail tariff, or the equivalent LCOE of a new CCGT). Over time more and more projects will find that PV is becoming competitive without the need for further subsidy. At current estimates, domestic and commercial PV will begin to reach parity during the next five years (in certain cases, some domestic or smaller commercial projects might already be there). Large systems whose revenue stream is reliant on selling directly to the market (and are unable to secure a favourable power purchase agreement) will reach parity later than for other segments.

Avoiding the 'cliff edge' of deployment

It is now time for the UK to capitalise on the subsidies paid so far and the deployment achieved, and start planning for the post parity world, so that the industry can avoid a potential 'cliff edge' phenomenon. The 20GW scenario that we have considered provides the ongoing momentum to allow Government and industry to work together to achieve a plan for transition to the post subsidy world.

There are a number of options for the government to avoid the 'cliff edge' (as happened elsewhere in Europe) and allow for business continuity, by maintaining demand for domestic, commercial and ground mounted projects. These options include:

- Mandating PV in all new buildings through building regulations
- Provision of rewards/incentives for residential dwellings through Council Tax or Stamp Duty
- Extend exemption from higher business rates for businesses that install PV
- Increase Annual Investment Allowances only for PV and include PV in list of technologies that are entitled to Enhanced Capital Allowances
- Include PV in local authority planning process
- Implement net metering, to incentivise consumers to install PV

Once PV is able to compete equally with conventional generation technologies, it should in principle face the same treatment, including tax, grid access, and route to market.

Enabling new distributed energy systems

With the advent of energy storage and advanced distribution network control technologies, the role of PV as an energy source will be upgraded significantly. Storage applications can be made available to all parts of the grid; there are good opportunities for combining it with electric vehicles.

As PV and other new technologies emerge, the traditional utility business models start becoming outdated and the whole utilities sector enters a period of transformation. The versatility of PV technology deployment fits very well with emerging utility business models, so that PV is gradually becoming an integral part of new utility services and offerings. Although, the transition to these models is still evolving, it is quite evident that PV will be an integral part of this transformation.





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APPENDIX A

Cost and Performance Assumptions

Data sources

Capital Costs (current)

Our view of current capital costs for UK solar projects at all scales is based on a dataset provided by the REA with information for recently completed projects.

Load Factor

Load factors for all scales of project are based on the MCS estimation methodology, which takes account of the geographical location of projects.

Project lifetime

There is considerable uncertainty over the appropriate lifetime to assume for solar PV projects. For all scales of project, we have therefore developed cost scenarios assuming a) 35 year lifetime, consistent with assumptions developed by Parsons Brinckerhoff for DECC as part of the first FiTs Comprehensive Review³⁵, and b) 25 year lifetime, consistent with assumptions used by DECC in their Banding Review for Solar PV in Autumn 2012³⁶.

Investor hurdle rate

For rooftop installations, we have taken the midpoint of the hurdle rate ranges

developed by DECC for the first FiT Comprehensive Review³⁷.

These give a pre-tax, real hurdle rate of 8% for domestic installations (based on a hurdle rate range of 3.5-12.5%) and 8.5% for commercial installations (based on a hurdle rate range of 5-12%).

For large-scale ground mount projects, our hurdle rate assumptions are based on analysis DECC's Electricity Generation Costs Update. This estimates a pre-tax, real hurdle rate of 6.2% for projects commissioning under the Renewables Obligation, and 5.3% for projects commissioning under Contracts for Difference³⁸.

Panel degradation

For all sizes of installation, we have assumed a panel degradation rate of 0.5% per year. This is taken from DECC assumptions developed for the RO Banding Review for Solar.

Opex

For rooftop projects, our estimate of annual opex is taken from Parsons Brinckerhoff assumptions developed for the first FiT Comprehensive Review. This includes the costs of inverter replacement, which is annuitised across the lifetime of the solar project.

For large-scale ground mount projects, our opex estimate is based on information on operating costs included in the REA dataset. This estimate also includes the cost of inverter replacement.

Calculating levelised costs

The levelised cost of electricity generation is the discounted lifetime cost of ownership and use of a generation asset, converted into an equivalent unit cost of generation in £/MWh. The levelised cost for a technology such as solar PV is calculated as the ratio of the total costs of a generic/representative plant to the total amount of electricity to be generated over the plant's lifetime. Both cost and output are expressed in Net Present Value (NPV) terms, i.e. future costs and output are discounted compared to costs and output today. Levelised costs do not reflect the revenues owners can earn e.g. electricity price revenues, or the wider costs of the project that may fall to parties other than the owner e.g. system balancing, network investment costs, or air quality impacts. The methodology for calculating levelised costs is set out below:

$$\text{NPV of total costs} = \sum_{i=0}^n \frac{(\text{Capex} + \text{Opex})_n}{(1+r)^n}$$

$$\text{NPV of total costs} = \sum_{i=0}^n \frac{(\text{Net Generation})_n}{(1+r)^n}$$

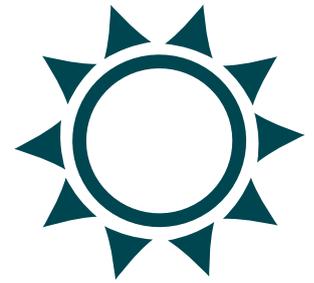
$$\text{Levelised Cost} = \frac{(\text{NPV of total costs})}{(\text{NPV of generation})}$$

Footnote/ Sources: 35. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/43083/5381-solar-pv-cost-update.pdf

36. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/66610/7366-impact-assessment-for-the-government-response-to-t.pdf

37. For more details see https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/43080/5391-impact-assessment-government-response-to-consulta.pdf

38. For more details, see: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/269888/131217_Electricity_Generation_costs_report_December_2013_Final.pdf

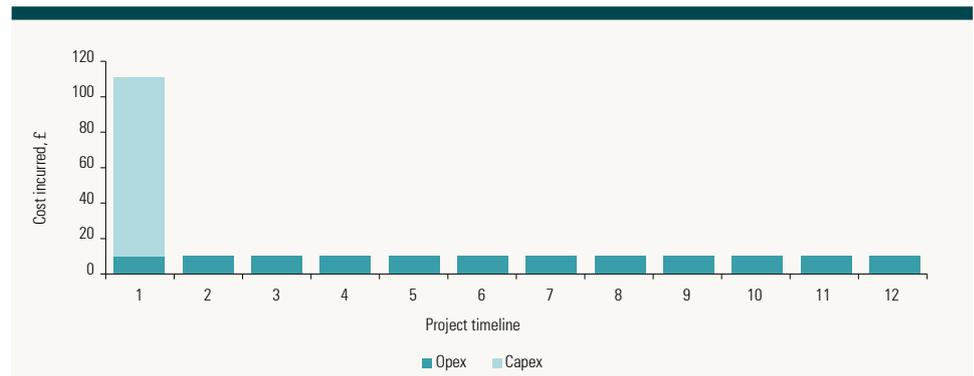


An important consideration when calculating levelised costs is how to apportion capital costs over time, i.e. whether to treat capex as incurred at the beginning of the plant's life or whether to spread it over the lifetime of the project. We have opted to annuitise capex over the lifetime of a solar PV investment, to reflect that owners will typically seek to borrow money to finance projects rather than seek to meet costs upfront. We have therefore used PMT functionality in Excel to calculate an annuitised value for capex across the lifetime of the plant. For the 'interest rate' in the PMT formula, we have taken a rate that reflects the typical costs of finance for each scale of project [this is not based on a particular source]. The approach we have adopted for how capex is spread over time, plus the alternative approach of apportioning it to project start, is shown in the charts to the right:

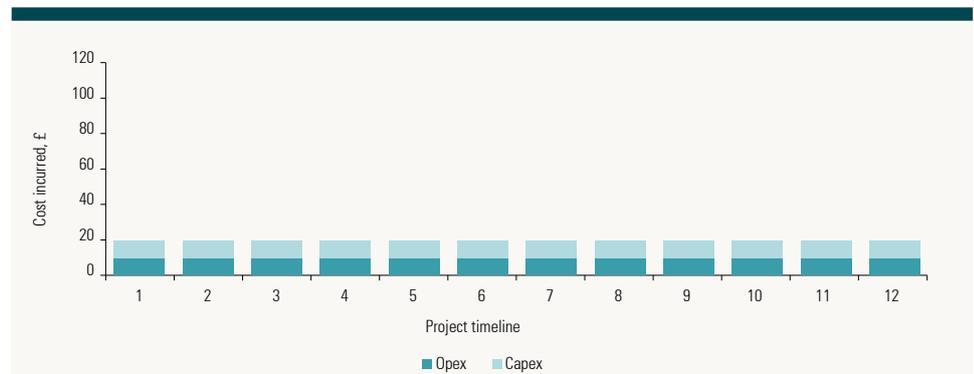
Levelised Costs sensitivities

In order to account for the uncertainty in the future costs of solar PV, we have developed sensitivities around levelised cost for each segment of the market. These are set out in the table to the right:

Cost profile, based on when costs incurred



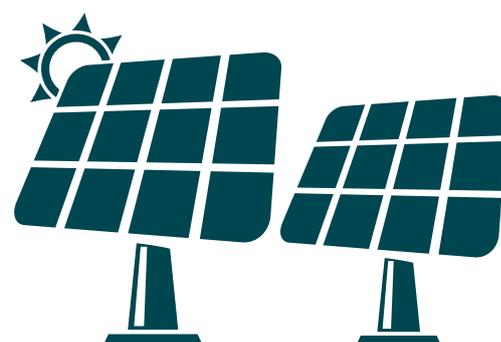
Cost profile, based on when costs faces by owner



Solar PV cost reduction profiles

To project future costs of solar, we have taken our estimate of levelised costs for current projects and applied cost reduction profiles from third parties. The cost reduction profiles used vary depending on the solar market segment. These are set out in the table below:

Sector of Solar Market	Cost reduction profile	Underlying methodology
Domestic, Commercial Rooftops	DECC, Electricity Generation Costs Update, December 2013	Levelised costs reductions calculated based on forecast cost reductions in Parsons Brinckerhoff for DECC, 'Solar PV Costs Update', May 2012. Other variables (hurdle rate, technology lifetime, load factor) assumed to stay at current levels
Large-scale ground mount	DECC, Electricity Generation Costs Update, December 2013	Levelised costs reductions based on forecast capex reductions in DECC analysis for RO Banding Review for Solar. DECC analysis uses Bloomberg New Energy Finance projections of future solar system costs. Hurdle rate is assumed to fall from 6.2% to 5.3% due to the transition from Renewables Obligation to Contracts for Difference. Other variables assumed to stay at current levels.
Large-scale ground mount	'Industry view'	A stakeholder from the UK solar industry provided KPMG with forecast of reduction in system costs of large-scale UK solar projects out to 2020. This was based on the developer's expectation of the evolution of costs in respect of the key components of overall system price (module price, Balance of System, development cost, grid connection cost). KPMG calculated a levelised cost reduction profile based on this, assuming that other variables (hurdle rate, technology lifetime, load factor) stay at current levels.



Sources for solar PV 'comparators'

We have used a range of cost comparators for solar PV projects at different scales, in order to analyse when solar PV might no longer require direct subsidy. These are set out in the table below across the different scales of solar project:

Sector of Solar Market	Comparator	Source
Domestic Rooftops	Electricity retail price, residential sector	DECC, Updated Energy and Emissions Projections ³⁹
Domestic Rooftops	Average of domestic electricity price, FiTs export tariff	DECC, Updated Energy and Emissions Projections (for electricity price) and Ofgem, FiTs Tariff Tables ⁴⁰
Commercial Rooftops	Electricity retail price, industrial sector	DECC, Updated Energy and Emissions Projections
Commercial Rooftops	Electricity retail price, services sector	DECC, Updated Energy and Emissions Projections
Large-scale ground mount	LCoE, new CCGT plant, 61% load factor	DECC, Generation Costs Update
Large-scale ground mount	Peak wholesale price	Platts, European Power Daily, 27 May 2015, and DECC, Updated Energy and Emissions Projections. Platts prices taken out to 2017 (average of winter 2016/17 and summer 2017 prices), then projected forward using annual % changes in wholesale price in DECC projections.

Price base

All costs are expressed in current (2015) prices. If underlying data is in another price base, it is converted to 2015 prices using the GDP deflator produced by the Office of Budgetary Responsibility (OBR).

Footnote/ Sources: 39. See Annex M at <https://www.gov.uk/government/publications/updated-energy-and-emissions-projections-2014>
40. See <https://www.ofgem.gov.uk/ofgem-publications/92754/fitptariffstablefor1april2015-amended-pdf>.

APPENDIX B

PV Tax treatment in UK business

Residential

Currently, there is no tax on the incomes from the FiT for roof-top solar PV installations. However, lettings are taxable and the landlord is subject to a tax on miscellaneous income on his/her self-assessment tax return. Additionally, the purchase of residential solar PV installations are charged at a rate of 5% VAT⁴¹.

Recently, there has been a court ruling⁴² in favour of the European Commission, against the application of VAT 5% in the UK across all energy saving materials, regardless of the type of household. According to the decision, applicable VAT should be equal to the one for other household items i.e. 20%. It is currently unknown if the UK will appeal this decision, or by when this will be effective. As such we have not taken this into account in our analysis.

Commercial/Industrial

The current tax regime on solar PV taxes the income from FiT for businesses with solar PV installations. In other words, the income from both the FiT and the export tariff are considered part of the business's earnings, which is subject to the standard rate of 20% corporation tax. However, VAT on solar panel purchases can be reclaimed by a business. Solar systems fall under the Government's annual investment allowance (AIA) scheme which allows businesses to reclaim tax on expenditure spent on PV installations. Since 2008, the AIA has changed four times and will change a fifth time to £25,000 on 1 January 2016.

Sole traders/partners	Limited companies	AIA (£)
6 April 2014 – 31 December 2015	1 April 2014 – 31 December 2015	500,000
1 January 2013 – 5 April 2014	1 January 2013 – 31 March 2014	250,000
6 April 2012 – 31 December 2012	1 April 2012 – 31 December 2012	25,000
6 April 2010 – 5 April 2012	1 April 2010 – 31 March 2012	100,000
6 April 2008 – 5 April 2010	1 April 2008 – 31 March 2010	50,000

Solar PV panels sourced outside the EU are subject to an import duty rate of 3.3%. No import duty is charged on imports from within the EU.

The treatment of solar PV in the UK tax system can be summarised as follows:

- Generation tariff income from FiT is not subject to income tax;
- Businesses are subject to tax on their income from tariffs;
- The purchase of panels may be subject to capital allowances;
- For businesses, VAT is recoverable on the cost of panels.

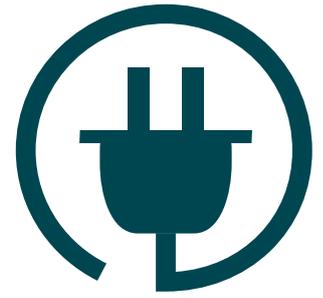
Regarding business rates, the Valuation Office sets a rateable value for each property, then applies a multiplication factor (set for different types of business) to set the level of business rate per property.

We note that the Government has in place an alternative capital allowance scheme for corporate investment in energy saving plant and machinery. The Enhanced Capital Allowances (ECA) allows companies investing in energy saving plant and machinery on

the Energy Technology List to write off the cost of equipment against taxable allowances. So if a firm invested £10,000 in equipment on the List, and paid corporation tax at 20%, it would be able to reduce its tax bill by £2,000. This compares to the normal capital allowance for investment in plant and machinery, which provides 18% relief on tax, so reduction in tax bill would be £2,000* 18% = £360. Currently solar PV isn't currently on the List (although Solar Thermal is), as PV is classified as electricity generation equipment. However, there are some technologies in the ECA technologies list (like CHP) that could be considered as generation technologies. These technologies would be eligible for tax breaks from both AIA and ECA. A key difference between the two schemes is that AIA eligible investment amounts vary over time (and currently are scheduled to fall down to £25,000 next year, whereas ECA applies for unlimited capital investments, provided that companies are not loss making.

Footnote/ 41. <https://www.gov.uk/tax-on-shopping/energy-saving-products>

Sources: 42. <http://curia.europa.eu/jcms/upload/docs/application/pdf/2015-06/cp150065en.pdf>



An additional tax that could be used to incentivise PV in the commercial sector is business rates. Out of business rates revenues, 50% to central Government to be redistributed, and 50% is retained by local councils. However, the methodology for setting the business rate will continue to be set centrally, i.e. local councils cannot squeeze more business rate revenue out of existing businesses, but do have an incentive to increase the number of businesses in the area e.g. by approving planning permission for more business premises.

Currently, solar PV feeds into the rateable value calculation: it is currently valued at £8 per kW installed. So for a 50kW installation, the rateable value would be $8 \times 50 = £400$. The business rate payable on the panels is then determined by a 'multiplier', which is set by Government. Multiplier is currently 46.2% for small businesses. So that means that the applicable business rate in this case would be $£400 \times 0.462 = £184.8$ per annum. There is a temporary exemption for payment of this business rate add-on for PV installed up to 50kW or where most of the electricity is consumed on-site.

Glossary

AIA	Annual Investment Allowances
BIPV	Building Integrated PV
CCGT	Combined Cycle Gas Turbine
CfD	Contract for Difference
DECC	Department of Energy and Climate Change
ECA	Enhanced Capital Allowances
FiT	Feed in Tariff
IEA	International Energy Agency
kWp (also MWp and GWp)	kilo (or Mega or Giga) Watt peak is the name plate capacity of an installed PV system
LCF	Levy control framework
LCOE	Levelised Cost of Electricity
MIP	Minimum Import Price
RO	Renewables Obligation
OFGEM	Office for Gas and Electricity Markets
PVPS	Photovoltaics Power Systems Programme

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