Community Energy?

An evaluation of the business case for investing in Solar PV technology for civic and community buildings.

Executive Summary

Renewable energy is seen as an important part of the UK's contribution to carbon reduction. Whilst Solar PV has considerable user acceptance there have been doubts about its cost-effectiveness and financial viability as a renewable energy solution.

A survey of installed Solar PV sites across the South East confirmed that electricity generation met, or exceeded, the standard for UK sites of 800 kWh for each kWp installed. This standard return is not expected to change significantly with technological innovation.

Analysis of the installation costs and performance of the surveyed sites established that the business case for investing within the installation of Solar PV technology before the introduction of the Feed-in Tariff was poor, with payback periods often significantly more than the assumed 25 year economic life of Solar PV installations.

There are significant price variables within the market place for the installation of equivalent Solar PV systems, reiterating the importance of competitive tendering to achieve best value on cost.

Over the last ten years installation costs have fallen approximately 50%, and there is widespread agreement that they will fall further. Industry estimates suggest that they will halve again by 2020. Taking account of this, and a range of forecast energy prices, Solar PV could payback, without subsidy, by 2020.

The Feed-in Tariff (FIT), however, means that Solar PV is now viable, with forecast returns on investment over a 25-year period of between £2,50 to £3.00 per £1.00 invested, and an Internal Rate of Return of up to11%.

Given the healthy returns on investment, there may be opportunities for Local Authorities to invest in Solar PV on their estate, reducing energy costs and/or generating income through the export of renewable energy. The Government has clearly indicated its support for such an approach, with the removal of the restriction on selling renewable electricity, giving local authorities the opportunity to benefit from incentives.

Alternatively local authorities may choose to simply lease roof space on their civic and community buildings to specialist renewable energy generators; this still has the benefit of reducing carbon dioxide emissions, while generating income.

There are number of variable factors which, over time, will significantly influence the business case for investing within renewable energy. These include:

- Installation costs
- Electricity prices
- The Feed-in Tariff rate for generation and export
- Inflation and Interest rates

When developing the business case the installation of Solar PV from an invest to save perspective, consideration will also need to be given to the performance benefits in the context of the Carbon Reduction Commitment (CRC) Energy Efficiency Scheme.

The Feed-in Tariff has been designed to factor in falling costs for Solar PV, with rates falling from 2011. Even with this, the returns on investment are forecast to remain high, generating some debate about the cost-effectiveness of supporting Solar PV through the Feed-in Tariff, especially considering the constrained nature of public finances. As the Feed-in Tariff has been designed to produce a target rate of return between five & eight percent, there is a significant risk that rates may be reduced at the first review in 2013.

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1. Background

1.1 Global warming is regarded as the one of the greatest challenges facing our communities over the coming years and it has been emphasised by the Local Government Association’s Climate Change Commission that local authorities have a pivotal role to play in tackling climate change.

1.2 Many local authorities have demonstrated a willingness to act though signing up to the Nottingham Declaration and more recently signing up to the 10:10 campaign, committing to achieve a 10% reduction in carbon emissions by 2010.

1.3 Over the last five years many local authorities have also developed climate change strategies and committed to positive steps to reduce carbon dioxide emissions; both managing energy consumption and promoting behavioural change, as well as delivering energy efficiency and sustainable technology based projects to reduce carbon dioxide emissions and energy consumption.

1.4 Aligned with this the Government has invested significant funding in renewable energy, with Solar PV being one of the most popular microgeneration technologies supported. There have however been doubts as to business case for installing Solar PV technology.

1.5 The UK Renewable Energy Strategy (2009), states that: “We need to radically increase our use of renewable electricity, heat and transport. This Strategy explains how and why we will do so. It sets out the path for us to meet our legally-binding target to ensure 15% of our energy comes from renewable sources by 2020: almost a seven-fold increase in the share of renewables in scarcely more than a decade.”[1]

1.6 One of the key elements of the Renewable Energy Strategy is the Feed-in Tariff, which was established in February 2010, and rewards investment in the installation of small scale alternative energy plants.[2] This follows the experience of other European countries, which has led to wide scale adoption of domestic energy generation, although tariff levels are now being reduced.

[1] *The UK Renewable Energy Strategy, Executive Summary*
[2] *Feed-in Tariffs: Government’s Response to the Summer 2009 Consultation*

1.7 Concern has been expressed that many Local Authorities do not have the resources – either in terms of finance or other powers – to develop energy systems, and reforms in financing and local planning rules may be necessary.[3]

1.8 The Government has recently removed the restriction on Local Authorities selling electricity produced from renewables. This is seen as part of a "desire to give local authorities the freedom to innovate and to benefit from taking a leading role in the low-carbon revolution."[4]

1.9 This report presents a detailed evaluation of the performance of a number of existing Solar PV installations across the region and considers the impact of the introduction of the Feed-In-Tariff on the business case for investing in solar technology within civic and community buildings.

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[3] *Transforming the UK's Energy System, SPRU, 2010*
[4] *The Rt Hon Chris Huhne MP, Secretary of State, Department of Energy and Climate Change, 9 August 2010: letter to all leaders and chief executives of local authorities*

2. Methodology

2.1 TV Energy, an independent renewable energy consultancy, collated data on the output and cost of Solar PV installations. 10 locations in the South East and two others (Norfolk and Cumbria) were identified, with a range of capacities from 0.5 kWp to 11 kWp.[5] The total kWh produced to January 2010 was standardised by the number of months operational to give an equivalent annual output.

2.2 This equivalent annual output was used to calculate the income / savings, over a 25 year life, taking into account the subsidy available under the Feed-in Tariff and a range of electricity prices. Current commercial electricity prices are approximately 10p per kWh, with domestic prices 11-12p per kWh, but these rates are forecast to rise. Ofgem's Project Discovery, for example, has forecast price rises under different scenarios of 20% - 40%.

2.3 The income / savings available were compared with the cost of installation, based on surveys of current suppliers, to produce a simple payback period. For ease of analysis, these costs have not been discounted.

2.4 Desktop research was carried out to establish some of the parameters for the current and future costs and income of solar PV. The main sources were the Department of Energy and Climate Change (DECC), Office of the Gas and Electricity Markets (Ofgem), UK Solar PV and academic and media commentators.

2.5 Further analysis was carried out based on a range of electricity costs and modelling of future solar PV installation costs.

[5] A Solar PV system is rated in kWp or 'peak kilowatts', see also paragraph 3.2

3. Performance of Solar PV systems

3.1 The power a Solar PV system can generate is reasonably well understood, both in terms of its theoretical output and the actual power delivered.

3.2 A Solar PV system is rated in kWp or 'peak kilowatts'. This is the power a Solar PV system can generate when the sun is very bright, with an intensity of 1000 W/m², at the optimum incident angle (rays perpendicular to the plane of array) with a relatively cool temperature of 25°C. The actual conditions in the UK are of course not always like this and a Solar PV system will generate correspondingly less.

3.3 Most Solar PV systems are roof mounted, requiring an area of 7-8 square metres to generate 1 kWp. Most domestic installations are between 2-3kWp, generating between 1,700-2,500 kWh per annum. Figure 1 below shows what a large domestic installation may look like; the system pictured is a 3.25kWp Solarcentury Sunstation Solar PV system, covering 25m2

Figure 1: A domestic Solar PV system

3.4 From 1991 to 1995 the German Government initiated the German 1000 Roofs Programme, the main purpose of which was to assess the technical aspects of installing a large number of domestic Solar PV systems. The systems installed as part of the programme were monitored intensively in order to analyse the performance data. As a result of this programme, it was concluded that the average Solar PV system, installed on a south facing roof at a roof angle of 35°, would generate approximately 850 kWh annually per kWp installed, i.e. 1 kWp of Solar PV installed in Germany will generate around 850 kWh per year.

3.5 During the period 2000 to 2005, the then Department of Trade and Industry conducted the *Domestic Field Trial* (DFT) of around 100 photovoltaic installations on domestic buildings in the UK. The aggregated results from the DFT project comprise the largest

UK dataset allowing an assessment to be made of annual energy generation from Solar PV systems in the UK. Many of the DFT systems operated in line with the above expectation and provided annual yields of above 800 kWh per kWp.

3.6 The DFT established that the actual output of a system varies according to a number of factors, including:

- The efficiency of the system
- The amount of sunlight
- The orientation of the system
- Whether there is any shading
- Inverter outages[6]

3.7 The DFT concluded that all systems with annual yields below 600 kWh per kWp had clearly identifiable losses, such as long term inverter outages or high levels of shading, while annual yields below 750 kWh per kWp usually exhibited occasional losses due to shading, short-term inverter outages or inverter thresholds. In some cases, poor weather conditions also reduced the yield.[7]

3.8 These studies provide sufficient evidence to indicate that a Solar PV systems installed in the UK will annually generate approximately 800 kWh per kWp, which is the assumption used for the BRE Standard Assessment Procedure (SAP) for Solar PV generation.[8]

3.9 Table 1 provides details of the capacity and energy generation performance data collated by TV Energy, for Solar PV installations primarily located within the Thames Valley Area. A more detailed analysis of this data is available in Appendix A.

3.10 Because this data relates to Solar PV systems installed in more recent years it can be used to validate the assumption that Solar PV system installed in the UK will annually generate approximately 800 kWh per kWp.

3.11 The analysis confirms that the annual generation in kWh per kWp is consistent with wider expectations, in that average yields are above 800 kWh per kWp, with 858 kWh per kWp the mean and 834 kWh per kWp the median yield.[9]

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[6] An inverter changes direct current coming from a solar cell into the alternating current used in homes and offices; the power generated is not usable during an outage.

[7] *Domestic Photovoltaic Field Trials, Final Technical Report, DTI URN 06/2218*

[8] The BRE is a UK trust dedicated to research and education in the built environment, see www.bre.co.uk

[9] The mean is the most commonly used average; the median is the number in the middle of a set of ranked numbers, and is not affected by abnormally high or low figures.

Table 1: Survey data for Solar PV sites

Site	Date installed	Capacity (kWp)	Annual generation (kWh per kWp)
West Berks Council Offices, Newbury	Dec-08	11	951
Faringdon School, Faringdon	Feb-09	10.4	1,052
Sheepdrove Farm, Lambourne	Oct-08	5.4	825
West Oxford Community Centre	Apr-07	5	805
Poringland Library, Norfolk	Feb-08	3.9	822
QE School SRC, Wimborne	Jun-09	2.3	915
The Living Rainforest (partly shaded)	Mar-06	2.1	619
Archers Farmhouse, Banbury, Oxon	May-08	1.9	955
Hesketh Hall, Cumbria	Mar-09	1.3	680
Weyhanger, Farnham	Jan-08	1.3	834
Aeppel House, Tingewick	May-08	0.5	983
Mean / median		**4.5 / 2.3**	**858 / 834**

3.12 Table 2 below summarises this data by the size of site and shows the following average generation:

Table 2: Output of Solar PV sites

	No of sites	Mean site size (kWp)	Mean annual output (kWh)	Mean annual output (kWh per kWp)
Small < 5 kWp	7	1.9	1,556	830
Medium 5-10 kWp	2	5.2	4,257	815
Large > 10 kWp	2	10.7	10,699	1,001

Note of caution: The two large sites, with a mean capacity of 10.7 kWp, have a significantly higher annual output per kWp, which will have an impact on later calculations on payback periods. As there are only two sites involved for this and for the medium sized installations, there may be statistical anomalies introduced.

4. Cost of Installed Solar PV Systems

4.1 The installed cost of Solar PV systems has decreased significantly (by around 50%) over the last ten years. At the turn of the millennium, Solar PV system prices were around £10,000 per installed kWp. A decade later, similar systems are being installed at between £4,000 and £6,000 per kWp. These costs can be further reduced for large-scale systems.

4.2 Table 3 shows the installed system costs for the Solar PV installations surveyed by TV Energy across the Thames Valley. The table shows the low and high costs of installation to demonstrate the range of prices currently quoted by Solar PV system installers.

Table 3: Current installed system cost data

Solar PV system: power installed KWp	Cost of system, including scaffold, excluding VAT		Cost £ per kWp		% Price difference: Low to High	% Cost vs cost of small site (averaged)
	Low	High	Low	High		
1.3	£6,500	£8,000	£5,000	£6,154	123%	100%
3	£12,000	£18,000	£4,000	£6,000	150%	90%
5	£19,000	£27,500	£3,800	£5,500	145%	83%
10	£36,000	£55,000	£3,600	£5,500	153%	82%
50	£160,000	£250,000	£3,200	£5,000	156%	74%

4.3 The analysis confirms that that installation prices have reduced by approximately 50% over the last ten years, with installation ranging at between £3,200 and £6,150 per kWp.

4.4 The analysis also highlights that there is significant range in the installation costs, with variations of over 50% in cost for similar installations, and over 25% dependent on the size of sites. In extremes, a low cost large (50 kWp) site is nearly half the cost, per kWp, of an expensive small (1.3 kWp) site, highlighting the importance of competitive procurement to achieve value for money and indicating that larger installations deliver greater value for money.

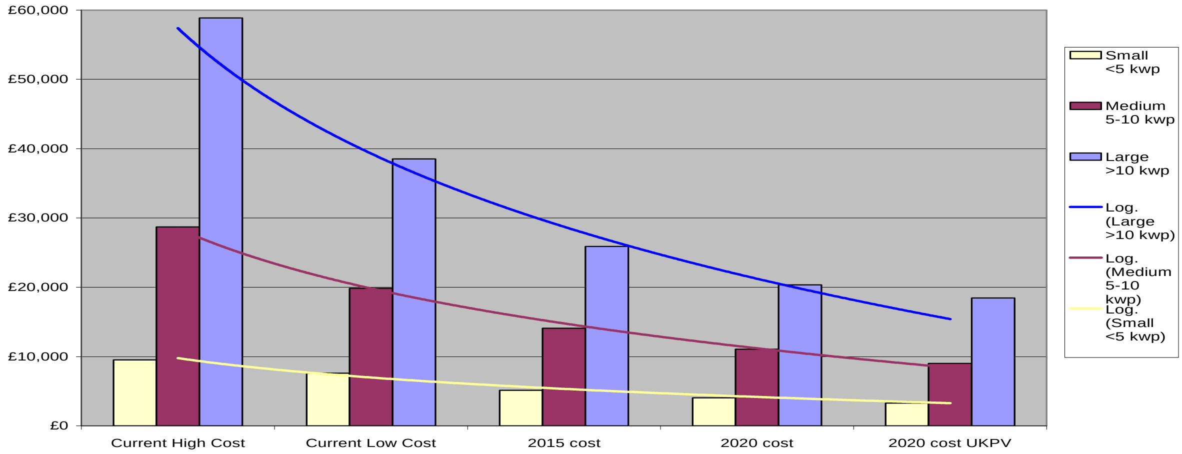
4.5 Modelling by the Solar PV industry and independent consultants has predicted that costs will fall further. Element Energy, contracted by DECC/BERR, have modelled Solar PV costs in the UK for large, medium and small installation as falling from £4,200 per kWp - £4,800 per kWp today to £1,900 per kWp - £2,500 per kWp by 2020 (See Appendix F for detailed tables).[10] Element Energy state, “Cost projections allow for a significant reduction in cell cost through technical evolution and material supply improvements.” SolarCentury forecasts for costs of installed Solar PV in 2020 are slightly lower than Element’s.[11]

4.6 Table 4 uses the installed site data in Tables 1 and 2 to establish a comparison between the current and future costs, based upon the average size of small, medium and larger installations. This data is graphically represented in Figure 2.

Table 4: Cost of Solar PV sites under different scenarios

Size of site	Average capacity kWp	Annual Output kWp	Current High Cost	Current Low Cost	2015 cost	2020 cost	2020 cost UKSolar PV
Small < 5 kWp	1.90	830	£9,509	£7,607	£5,133	£4,032	£3,282
Medium 5-10 kWp	5.22	815	£28,710	£19,836	£14,089	£11,066	£9,010
Large >10 kWp	10.70	1,001	£58,850	£38,520	£25,894	£20,330	£18,468

Figure 2: Forecast installed cost of surveyed sites



4.7 What this analysis demonstrates is that significant savings expected in the installation costs of Solar PV over the next ten years, generally at least halving the cost by 2020. The most significant savings are projected to be achieved on large sites, which will benefit the most from savings on technology as installation costs (scaffolding, labour etc) form a smaller proportion of the overall installed cost.

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[10] *Design of Feed-in Tariffs for Sub-5MW Electricity in Great Britain, Element Energy, July 2009, 09D/704*

[11] *2020 A vision for UK Solar PV: An up to date and accurate analysis on the investment case for solar photovoltaics (Solar PV) in the UK, UK Photovoltaic manufacturers association*

5. Savings Generated from Installed Solar PV Systems

5.1 It is unusual for Solar PV installations in the UK to provide all the electricity demand of a site. Usually they provide for part of the overall electricity requirement. In some cases (e.g. schools), peak production may occur at a time of low demand, allowing the sale of this surplus generation to major electricity generators, and providing an additional income.

5.2 On the basis that existing Solar PV systems in civic and community organisations have been installed it to reduce electricity demand from the grid, it is legitimate to use retail electricity prices, rather than wholesale, to analyse the savings delivered by Solar PV.

5.3 Historical data on energy prices shows that energy prices have steadily increased, with sizeable price increases over the last five years. Larger organisations, such as Local Authorities, are able to negotiate individual contracts, and it has been assumed that such consumers will achieve current retail prices of approximately 10p per kWh.

5.4 It is generally accepted that electricity prices are likely to continue to rise over the next decade, due to a combination of increasing energy demand, reductions in capacity and the need for new investment feeding through to consumers.

5.5 The UK Renewable Energy Strategy estimates that household electricity bills will increase by 15% by 2020, compared to what they would have been otherwise. By taking into account greater energy efficiency, the rise in average household energy bills would only be 8% to 2020.

5.6 Ofgem's Project Discovery modelled different scenarios, which "represent a series of diverse, but plausible and internally consistent futures for testing current arrangements and future policy measures. They do not represent forecasts, and many other plausible outcomes can be envisaged." The four scenarios envisage the following impacts on domestic consumer bills:

- **Green Transition:** increase by approx 20% by 2020
- **Green Stimulus:** increase by 13% by 2020
- **Dash for Energy:** rise with high and volatile commodity prices, increasing by nearly 52% by 2016 before falling back.
- **Slow Growth:** relatively low in early years but increase by 19% by 2020 as market tightens.

5.7 Project Discovery also modelled the impact on Industrial and Commercial electricity costs over the period to 2020, showing an overall increase of between 94% and 115% in electricity costs. This translates into costs of 12p – 13p/ per kWh even for the largest users with the greatest purchasing power.[12]

5.8 Given the above, it is reasonable to assume that the price for electricity will approximate 12p per kWh for larger consumers, with a cost of 14p per kWh more appropriate for domestic and community installations without access to favourable terms.

5.9 Table 5 uses the energy generation data collected from the surveyed Solar PV installations to forecast of the savings generated, assuming a 25 year lifespan, and the impact of increasing electricity prices on these savings forecasts. Calculations showing annual savings are also provided in Appendix D.

Table 5: Savings generated by Solar PV sites with different electricity prices

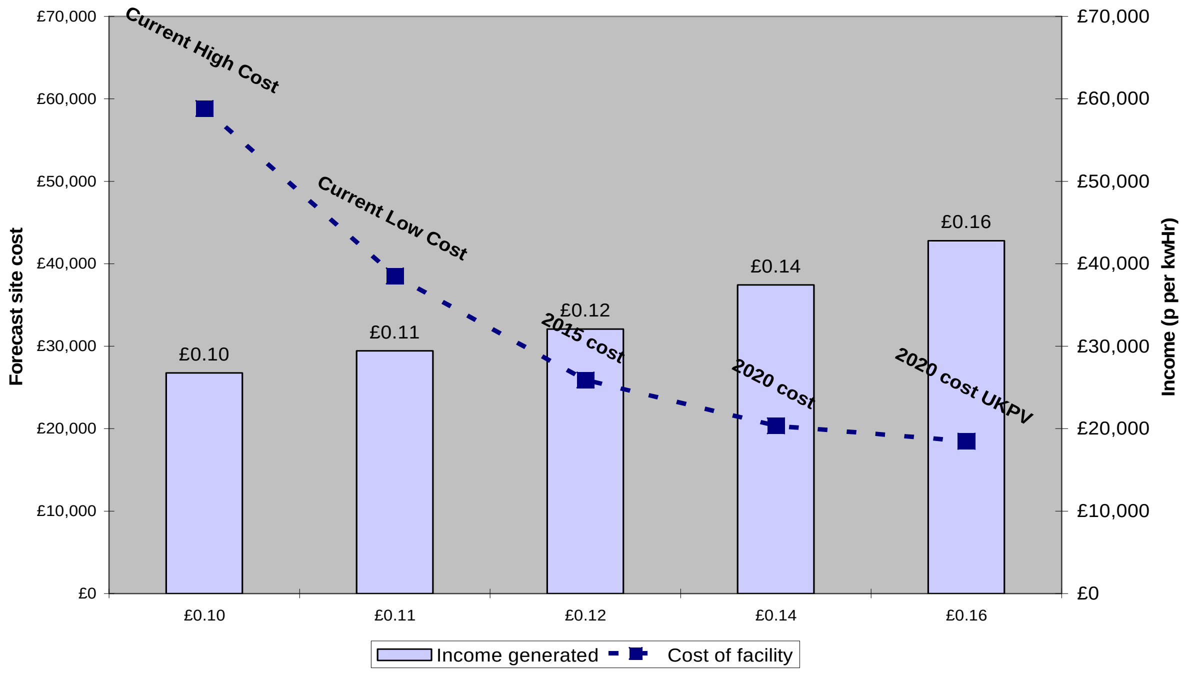
Savings generated							
Size of site	**Average capacity kWp**	**Lifetime Output (kWh)**	**10p**	**11p**	**12p**	**14p**	**16p**
Small < 5 kWp	1.90	38,912	£3,891	£4,280	£4,669	£5,448	£6,226
Medium 5-10 kWp	5.22	106,430	£10,643	£11,707	£12,772	£14,900	£17,029
Large >10 kWp	10.70	267,464	£26,746	£29,421	£32,096	£37,445	£42,794

5.9 It is also possible to compare the installation costs of the surveyed Solar PVs with the energy savings forecast over the economic life of the installation in Table 5 above.

5.10 Figure 3 graphically represents this for the more efficient large Solar PV sites. The dotted line show the cost of installation under different scenarios, while the bars represents the lifetime income generated at different energy prices; the gap between the line and the bars shows the potential profit or loss from an installation.

[12] *Project Discovery – Options for delivering secure and sustainable energy supplies. Ofgem February 2010. Ref 16/10; Project Discovery – Energy Market Scenarios Update*

Figure 3: Cost vs savings for Large Solar PV sites, excluding subsidy



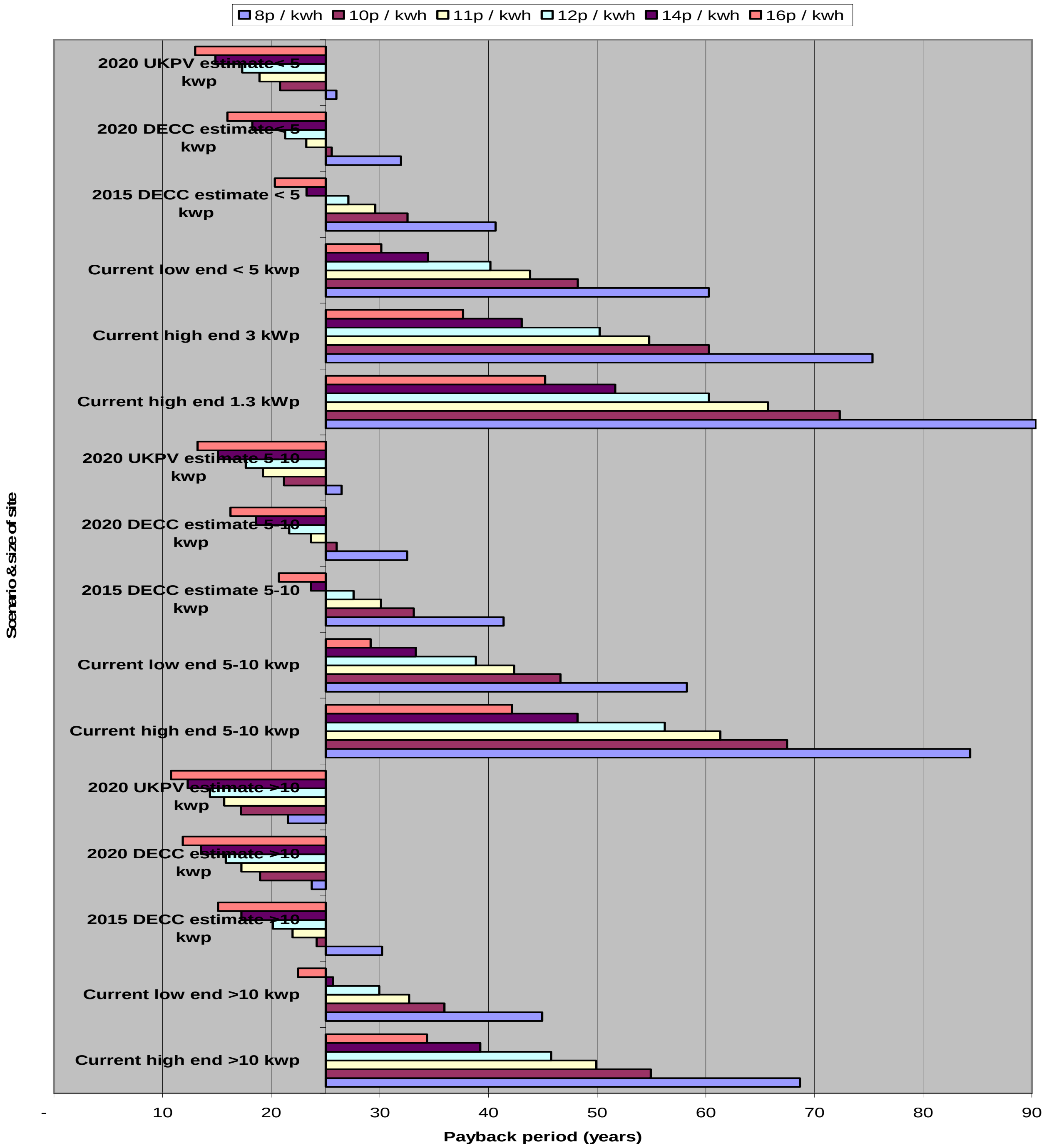
5.11 What this analysis shows is that without subsidy Solar PV does not represent a good investment, as based on a current electricity price of 10p it would take longer than 25 years to obtain a positive savings return on the initial investment for installation.

5.12 The analysis does however indicate the business case has the potential to change within the decade, as electricity prices rise and installation costs fall. With electricity prices at 12p per kWh there is a marginal profit by 2015; with forecast increases in electricity prices, most sites would be able to generate significant value by 2020, regardless of the subsidy regime.

5.13 Whilst many organisations will make investment decisions over renewable energy based on the environmental benefits delivered by the project, consideration can be given the payback period for the investments, meaning the period of time it will take for the values of savings to be equivalent to the installation costs.

5.14 In this context Figure 4 forecasts the payback periods without subsidy for different sizes of installation based on the project installation costs scenarios shown in Table 4 and the electricity price scenarios shown in Table 5. The axis on the graph is set at 25 years payback, so scenarios to the right of the line are uneconomic while those to the left of the line have the potential to payback within 25 years.

Figure 4 - Forecast payback periods for unsubsidised solar PV sites



5.15 What this analysis shows is that without subsidy the payback period for Solar PV installations reviewed will be significantly more that 25 years with some installations projected to have pay back periods in excess of 60 years. It also shows that, if installation prices reduce and electricity prices rise, by 2020 most Solar PV installations will have payback periods significantly less than 25 years.

6. <u>The Feed-in Tariffs</u>

6.1 The government has introduced a system of Feed-in Tariffs (FITs) to incentivise small scale, low carbon electricity generation. As well as increasing the amount of electricity generated from renewable sources the scheme aims to engage more people in directly tackling climate change, bringing greater acceptance of the behavioural changes that we need to make, and encourage more responsible and efficient use of electricity.

6.2 FITs are paid to generators from metered sites with qualifying technologies. The tariff paid varies according to the technology, the generating capacity and the date of installation.

6.3 The FIT comprises two elements:

6.3.1 **Generation Tariff -** This differs by technology type and scale. It will be paid for every Kilowatt Hour (kWh) of electricity generated and metered by a generator. The Generation Tariff will be paid regardless of whether the electricity is used onsite or exported to the local electricity network.

6.3.2 **Export Tariff -** This has been set at 3p per kWh exported (for very small generators it is simply assumed to be a proportion of their generation). Larger generators will be paid the guaranteed rate on the basis of metered generation exported, but will be free to negotiate to sell their energy to an energy company for a higher rate.

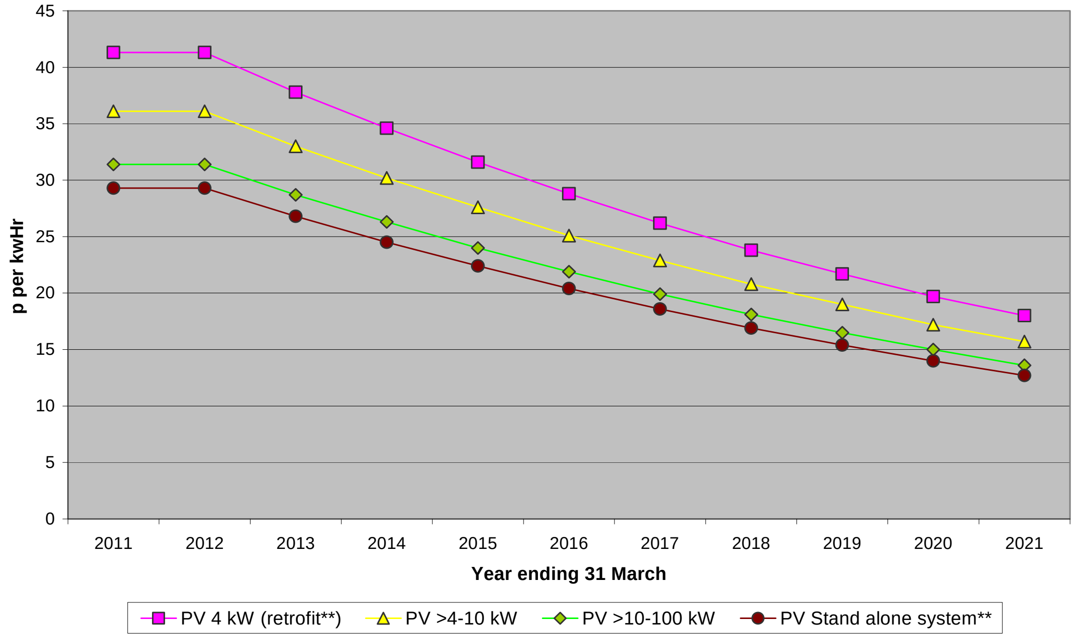
Table 6: Generation Feed-in Tariff levels for Solar PV sites

Tariff level (pence/kWh) for new installations in period ending:	Mar-11	Mar-12	Mar-13	Mar-14	Mar-15
Solar PV <4 kW (new build**)	36.1	36.1	33	30.2	27.6
Solar PV <4 kW (retrofit**)	41.3	41.3	37.8	34.6	31.6
Solar PV >4-10 kW	36.1	36.1	33	30.2	27.6
Solar PV >10-100 kW	31.4	31.4	28.7	26.3	24
Solar PV >100kW-5MW	29.3	29.3	26.8	24.5	22.4
Solar PV Stand alone system**	29.3	29.3	26.8	24.5	22.4

NB: The above rates will be increased with the Retail Price Index (RPI)

6.4 The FITs have been set to deliver an approximate rate of return of 5-8% for well-sited installations. As technology costs are predicted to reduce, the Generation Tariff is also set to reduce, in order to maintain this approximate rate of return. Figure 4 below shows graphically how the generation tariffs decline for Solar PV sites until 2021, (See Appendix C for a tabular format).

Figure 4: Generation Feed-in Tariff levels



6.6 This is a key factor influencing investment decisions in renewable energy, because once the Generation Tariff level for a scheme has been awarded, the Solar PV installation will receive the awarded tariff (increased with RPI) for its lifetime, up to a maximum of 25 years. So, for example, a 5 kW Solar PV site commissioned in January 2012 will receive 36.1p per kWh generated until December 2026, adjusted for RPI, while the same size site in January 2015 would receive payment until December 2029, at the rate of 27.6p per kWh generated, again adjusted for RPI.

6.7 It is important to highlight that the FIT scheme also includes a series of reviews, with any changes resulting from the first review being implemented in 2013, at which time the potential exists for the tariff levels to be reduced, as has recently occurred with Spain's equivalent scheme.

7. The impact of Feed-in Tariffs

7.1 The rates of subsidy available through the Generation Tariff are significantly above current electricity prices, and the FIT fundamentally alters the business case for investing in renewable energy.

7.2 This section of the report investigates the impact that the additional income from the FIT has on the business case for Solar PV installations, building on the cost and generation data collected from the surveyed installations in the Thames Valley.

7.3 Table 7 combines the analysis of energy generation from the surveyed installations (Table 1) with the published levels of Generation Tariffs for retrofits, in order to determine the lifetime subsidy income for similar sites.

Table 7: Generation Feed-in Tariff income: by site size and year

Site size: generator capacity	Ave size kWp	Mean ann. output (kWh)	2010: FIT income	Lifetime FIT: current installs	2015: FIT income	Lifetime FIT: 2015 installs	2020: FIT income	Lifetime FIT: 2020 installs
Small < 5 kWp	1.90	1,556	£643	**£16,075**	£448	**£11,200**	£280	**£7,000**
Medium 5-10 kWp	5.22	4,257	£1,537	**£38,425**	£1,069	**£26,725**	£668	**£16,700**
Large >10 kWp	10.70	10,699	£3,359	**£83,975**	£2,343	**£58,575**	£1,455	**£36,375**

7.4 The most significant issue shown by the analysis is that the income which could be obtained from the Generation Tariff falls rapidly, by nearly a third between 2010 and 2015, and more than halving by between 2010 and 2020.

7.5 Table 8 combines the analysis of the impact of electricity prices on savings from the non-subsidised Solar PV installations in Table 5 with the additional income that could accrue through the Generation Feed-in Tariff in Table 7.

Table 8: Forecast lifetime savings and income for Solar PV sites

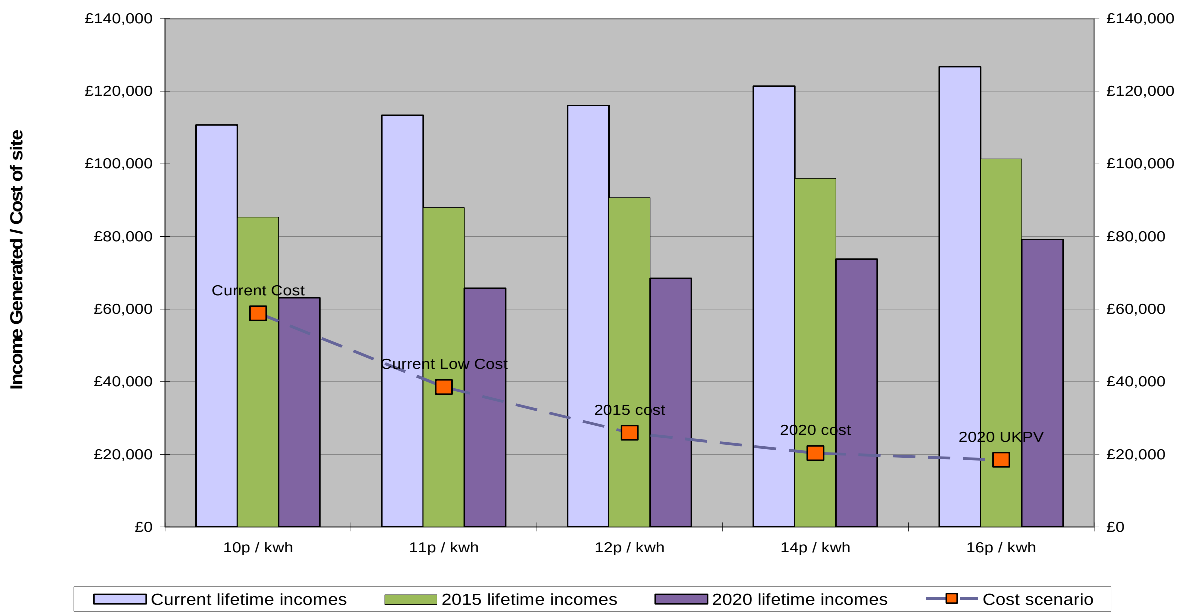
Year of install	Size of site	Ave size (kWp)	10p / kWh	11p / kWh	12p / kWh	14p / kWh	16p / kWh
2010	Small < 5 kWp	1.90	£19,963	£20,352	£20,741	£21,519	£22,297
2010	Medium 5-10 kWp	5.22	£49,055	£50,120	£51,184	£53,313	£55,441
2010	Large >10 kWp	10.70	£110,734	£113,409	£116,083	£121,433	£126,782
2015	Small < 5 kWp	1.90	£15,098	£15,487	£15,877	£16,655	£17,433
2015	Medium 5-10 kWp	5.22	£37,355	£38,420	£39,484	£41,613	£43,741
2015	Large >10 kWp	10.70	£85,321	£87,996	£90,671	£96,020	£101,369
2020	Small < 5 kWp	1.90	£10,891	£11,280	£11,669	£12,448	£13,226
2020	Medium 5-10 kWp	5.22	£27,355	£28,420	£29,484	£31,613	£33,741
2020	Large >10 kWp	10.70	£63,121	£65,796	£68,471	£73,820	£79,169

7.6 This analysis gives a clear indication of the potential total financial benefit (combined savings & income) that could be derived over a twenty-five period for any new installations of Solar PV commissioned in 2010, 2015 and 2020.

7.7 It is also possible to compare the installation costs of the surveyed Solar PV installations with the forecasts of the total lifetime financial benefit delivered by Solar PV installations receiving the Generation Tariff in Table 8 above. This comparison confirms that, with the introduction of the Generation Tariffs, Solar PV installations now have the potential to generate a significant surplus financial benefit over their lifetime, of two to three times the cost of installation.

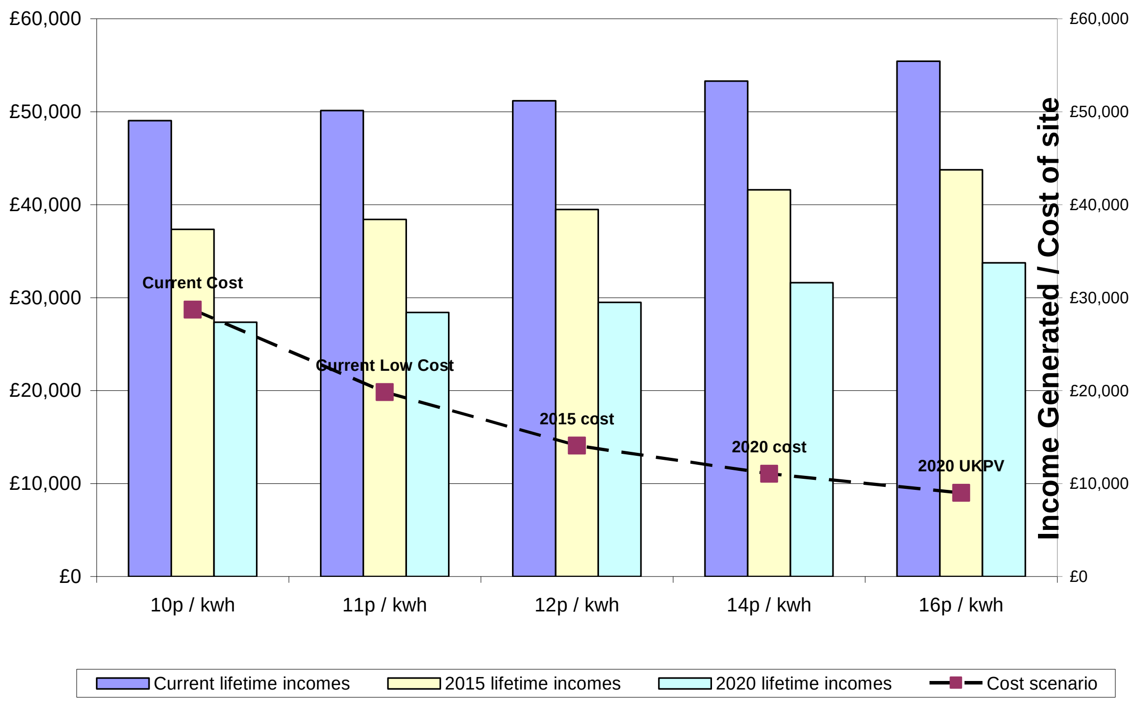
7.8 Figure 5 graphically represents this for the more efficient large Solar PV sites. The dotted line shows the cost of installation under different scenarios, while the bars represents the lifetime income generated at different energy prices at different time periods, taking into account the different levels of payment for the Generation Feed-in Tariff. The gap between the line and the bars shows the potential profit or loss from an installation.

Figure 5: Cost vs financial benefit for Large Solar PV sites, including Generation Feed-in Tariff



7.9 Figure 5 clearly shows that a current investment of £40,000 can generate a total financial benefit approximately three times greater, assuming that procurement achieves value for money on the cost of an installation and electricity prices rise to approximately 14 pence per kWh. By 2020, the investment cost has halved to £20,000, while the total income has increased to approximately £3.50 per £1 invested. This is equivalent to a current internal rate of return of 11%, rising to 13% by 2020, which compares favourably with other alternative investments.

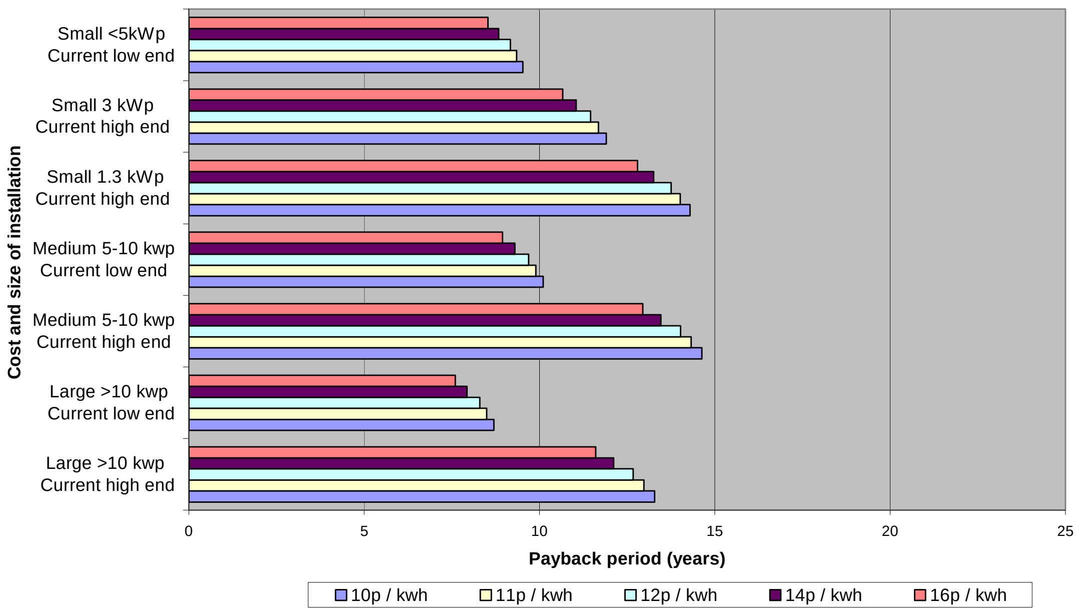
Figure 6: Cost vs income for Medium Solar PV sites, including Generation Feed-in Tariff



7.10 Figure 6 graphically represents this for medium Solar PV sites, on the same basis. The current return of investment is approximately £2.50 per £1 invested, rising to approximately £3.00 per £1.00 invested by 2020. These rates are below the returns achieved by large sites, but are more typical of the average installation, given the power generation established in the survey.

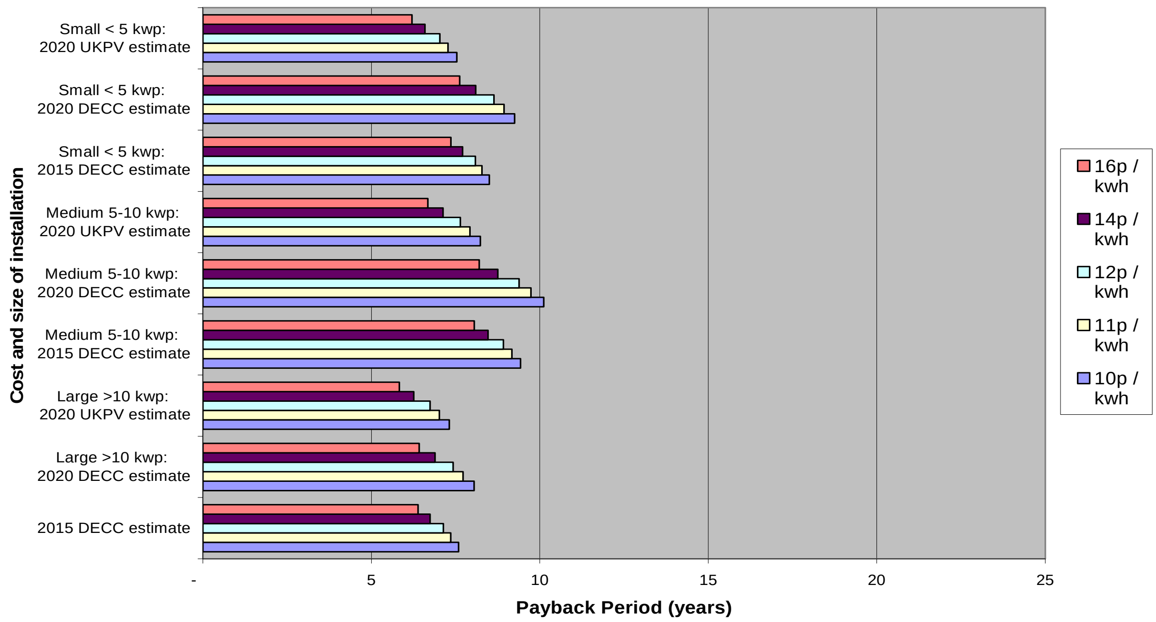
7.11 The analysis demonstrates that the Generation Tariff will therefore significantly reduce the payback periods for Solar PV installation. Figure 8 provides an analysis of payback periods based on 2010 installation costs and shows a range of payback periods between eight to fifteen years; given an assumed life of 25 years.

Figure 8 - Payback periods for Solar PV receiving Generation Tariff against 2010 installation costs.



7.12 Figure 9 shows the same the projected payback period for Solar PV installations based on 2015 and 2020, when both costs and levels of Feed-in Tariff will have fallen, and shows a range of payback periods between seven to ten years; given an assumed life of 25 years.

Figure 9 - Payback periods for Solar PV receiving Generation Tariff against 2015 and 2020 installation costs



7.13 The analysis above shows the Generation Tariff significantly improves the business case for investing in Solar PV technology, with the potential to reduce payback periods to below ten years and the opportunity to provide positive financial benefit, given the assumed lifetime of 25 years.

7.14 The returns available from the Feed-in Tariff have created a substantial market in Solar PV, with suppliers marketing the opportunity of "installing solar power Free of Charge", while taking the income from the Feed-in Tariff themselves. Given the cost of commercial borrowing, this may be an attractive proposition where loan finance would be required to fund the installation of Solar PV.

7.15 In circumstances where Solar PV could be installed without requiring commercial borrowing, or compromising liquidity levels, it is probable the best returns can be achieved by conventional procurement mechanisms.

8 The use of Solar PV technology for investment purposes

8.1 The restriction on Local Authorities selling electricity produced from renewables has been removed with effect from 18 August 2010. What this means is that there are now opportunities for Local Authorities to invest in Solar PV as a means to generate income, as opposed to the use of Solar PV technology to reduce the power purchased from commercial providers.

8.2 The basis of using Solar PV, or any other renewable energy, purely as an investment vehicle would be predicated on the basis of exporting the energy and benefiting from the Generation Tariff, and the additional income from the Export Tariff.

8.3 The challenge for determining the business case for this approach is that whilst the minimum Export Tariff has been set, generators of renewable energy are free to sell it to any energy company for a higher rate.

8.4 At the minimum, this would be the level of the Export Tariff, which is set at 3p per kWh. Given the differentials between this and the wholesale price of electricity, it is probable that higher returns could be achieved on the open market. For analysis purposes this report assumes returns of 6p per kWh.

8.5 It is therefore difficult to provide an analysis of the commercial returns that are available from investment in Solar PV as an income generating exercise; particularly since investment decisions will need to consider the impact of both inflation and interest rates. Given the long-term nature of Solar PV, the return is highly sensitive to assumptions on inflation and interest rates (see Appendix I for exploration of this).

8.6 Table 9, however, shows the potential income and rates of return available, standardised at 1kWp, through investment in Solar PV for export purposes, with an assumed export rate of 6p per kWh. The calculation of costs has been based on the lower estimates, as it is assumed that Local Authority procurement will achieve best value.

8.5.1 The analysis shows, in all scenarios, lifetime income is at least double the cost, producing rates of return varying between 6.8% and 10.6%. In general, the rate of return in 2020 has increased by approximately 10% on current levels.

Table 9: Returns from exporting power from Solar PV

Current investment scenarios Current low end	Cost per kWp	Income FIT only: generation tariff + export tariff		Income generation tariff + export to supplier @6p	
		Income	IRR	Income	IRR
Small <5kWp	£4,000	£9,065	7.6%	£9,679	8.4%
Medium 5-10 kWp	£3,800	£7,970	6.8%	£8,582	7.6%
Large >10 kWp	£3,600	£8,599	8.2%	£9,349	9.3%
2015 investment scenarios	**Cost per kWp**	**Income FIT only: generation tariff + export tariff**		**Income generation tariff + export to supplier @6p**	
		Income	**IRR**	**Income**	**IRR**
Small <5kWp	£2,699	£6,507	8.3%	£7,121	9.4%
Medium 5-10 kWp	£2,699	£5,729	6.9%	£6,341	8.0%
Large >10 kWp	£2,420	£6,224	9.1%	£6,974	10.6%
2020 investment scenarios	**Cost per kWp**	**Income FIT only: generation tariff + export tariff**		**Income generation tariff + export to supplier @6p**	
		Income	**IRR**	**Income**	**IRR**
Small <5kWp	£1,726	£4,295	8.7%	£4,909	10.4%
Medium 5-10 kWp	£1,726	£3,813	7.3%	£4,425	9.1%
Large >10 kWp	£1,726	£4,149	8.3%	£4,899	10.4%

9. Externalities – areas outside scope of this study

9.1 This report has simply considered the extent to which the cost of Solar PV installations are covered by the income generated, with and without the subsidy element of the Feed-in Tariff.

9.2 There has been considerable debate about the cost-effectiveness of the Feed-in-Tariff as a means to achieve the UK's renewable energy targets.

9.3 George Monbiot has argued: "The only renewables policy that makes sense is to build big installations where the energy is – which means high ground, estuaries or the open sea – and deliver it by wire to where people live…Every pound spent on Solar PV is a pound not spent on a more effective technology. You need to spend £9 on solar to have the same impact as £1 spent on largescale wind or hydro."[13]

9.4 Prof David Mackay noted: "the present cost of installing such photovoltaic panels is about four times the cost of installing solar thermal panels, but they deliver only half as much energy, albeit high-grade energy (electricity)." He also noted "The energy yield ratio (the ratio of energy delivered by a system over its lifetime, to the energy required to make it) of a roof-mounted, grid-connected solar system in Central Northern Europe is 4, for a system with a lifetime of 20 years (Richards and Watt, 2007). Wind turbines with a lifetime of 20 years have an energy yield ratio of 80."

9.5 Although the above does show that, on current technologies, solar PV is not the most cost-effective means of promoting renewable energy, the position is expected to improve, due to rapid decreases in the cost of solar PV. It also shows that the view that manufacturing a solar panel consumes more energy than it will ever deliver is false; "An energy yield ratio bigger than one means that a system is A Good Thing, energy-wise." [14]

9.6 The arguments over the cost-effectiveness of the Feed-in Tariff for Solar PV assume greater weight given the current constraints upon public sector finances. Spain has had a subsidy policy that has led to massive growth in renewable energy over the last decade. Recently, the need for deficit reduction has led to cuts in its guaranteed prices

[13] Guardian.co.uk, Monday 1 March 2010, Friday 5 March 2010
[14] Sustainable Energy: Without the Hot Air, Professor David Mackay, pp40-41

for Solar PV energy of between 5% and 45%; controversially it is also trying to cut agreed tariffs for existing plants by 30%.[15]

9.7 Against the argument over cost-effectiveness, there is an argument that the Feed-in Tariff for domestic electricity generation will encourage behavioural change, and thus justifies the relatively high levels of payment.

9.8 The Government's Response to the Summer 2009 Consultation on Feed-in Tariffs is explicit that "Engaging more people in directly tackling climate change this way should help bring about greater acceptance of the behavioural changes that we need to make. I also believe that those who generate their own electricity, are likely to value it more and use it more responsibly and efficiently."

9.9 If, as expected, the Feed-in Tariff encourages greater take up of energy efficiency measures then the carbon and financial savings will be enhanced. The Sustainable Development Commission, in a small scale study, noted that "The visual presence of the technologies appears to provide a tangible reminder of free energy production ... which in turn leads residents to begin to differentiate between free and costly behaviours." [16]

9.10 The extent to which this takes place, and alters societal returns of the Feed-in Tariff is beyond the scope of this report. It is worth noting that domestic Solar PV panels seem to have the greatest level of consumer acceptance, and – if the hypothesis that domestic energy generation leads to greater energy efficiency is valid - are therefore most likely to lead to widespread changes in consumer behaviour.

9.11 Consideration has not been given within this report to the related environmental benefits the installation of Solar PV will deliver. The business case for investment in Solar PV by local authorities, however, may be improved by the consequent reductions in carbon dioxide emissions having a positive impact on the Carbon Reduction Commitment (CRC) Energy Efficiency Scheme.

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[15] Abstracted from Financial Times, http://tiny.cc./zybrz

[16] Seeing the light: the impact of micro-generation on the way we use energy, The Hub Research Consultants on behalf of the Sustainable Consumption Roundtable, October 2005

10. Conclusions

10.1 This report has established that, with the benefits of the Feed-in Tariffs, current solar PV installations can generate savings and income of £2.50 to £3.00 per £1.00 invested, with an Internal Rate of Return between 4.4% and 11.7%.

10.2 The operation of Solar PV technology is reasonably well understood, and it unlikely that annual outputs will alter significantly from 800 kWh per kWp installed in the UK. There is, however, widespread agreement that the costs of Solar PV will fall rapidly; prices have halved over the last decade, and are expected to do so again by 2020, or even earlier.

10.3 These expectations have been factored in to the Feed-in Tariff, which has rates falling from 2011. Despite this, returns are expected to increase marginally.

10.4 The healthy returns, combined with the Government's decision to allow Local Authorities to sell electricity to the grid, also means that there is potential to treat the installation of Solar PV as a commercial investment. The long lifetimes of Solar PV mean that investment decisions will be significantly affected by expectations of future inflation and interest rates.

10.5 Many local authorities have significant estates with a range of civic and community buildings that may be appropriate for Solar PV. The introduction of the Feed-in Tariff means that the business justification for investing in solar technology has been significantly improved and that there are now a range options available for local authorities to consider including:

- Using existing capital budgets to pay for Solar PV installation, using income generated to create savings on revenue budgets.
- Using investment funds to pay for Solar PV installation, as an alternative to investment on the money markets.
- Installing Solar PV, using lease finance arranged through the provider, offset by savings and income from the Feed-in Tariff.
- Partnership arrangements with commercial installers, where income from Feed-in tariffs and electricity generated is split between the partners.

10.6 The relative benefits of each of these options will depend on a combination of the financial position of a local authority, the commercial opportunities available, an authority's view on the viability of Solar PV and future interest and inflation rates and the positive impact Solar PV technology could have in respect of the CRC Energy Efficiency Scheme.

10.7 However it must be acknowledged that the timing of investment decisions in Solar PV will be key, given the forecast reductions in both installation costs and Feed-in Tariff income. Consideration will also need to be given to the risk that the levels of Feed-in Tariff may be reduced at the first review of the scheme, due to take effect in 2013. The constrained nature of public finances means that questions over value for money will become more urgent, and the recent Spanish decision to reduce subsidy rates may be an indication of the future of the scheme.

Appendix A: Survey of Solar PV sites to establish actual outputs

Solar PV Performance										
Site	**Installer**	**Installation date**	**No months Operational**	**Size (kWp)**	**Output (as end Jan2010 kWh**	**Equivalent Monthly Output (kWh)**	**Equivalent Annual Output (kWh)**	**Equivalent monthly Output / kWp**	**Equivalent annual Output / kWp**	**Notes**
West Berks Council Offices, Newbury	Ardenham Energy	Dec-08		11	12,200	871	10,457	79	951	
Faringdon School, Faringdon	Ardenham Energy	Feb-09	12	10.4	10,940	912	10,940	88	1,052	As two separate arrays
Sheepdrove Farm, Lambourne	Ardenham Energy	Oct-08	16	5.44	5,985	374	4,489	69	825	
West Oxford Community Centre	Ardenham Energy	Apr-07	34	5	11,406	335	4,026	67	805	Some shading due to large trees to east.
Poringland Library, Poringland, Norfolk	Photon Energy	Feb-08	24	3.9	6,408	267	3,204	68	822	
QE School SRC, Wimborne	Photon Energy	Jun-09	8	2.268	1,383	173	2,075	76	915	
The Living Rainforest	Econergy	Mar-06	46	2.1	4,986	108	1,301	52	619	
Archers Farmhouse, Banbury, Oxon	Photon Energy	May-08	21	1.944	3,250	155	1,857	80	955	
Weyhanger, Farnham	Photon Energy	Jan-08	25	1.3	2,258	90	1,084	69	834	
Hesketh Hall, Broughton-in-Furness, Cumbria	Photon Energy	Mar-09	11	1.3	810	74	884	57	680	
Aeppel House, Tingewick	Photon Energy	May-08	21	0.5	860	41	491	82	983	

Appendix B: Feed-in Tariffs for Solar PV sites

Tariff level (p/kWh) for new installations in period ending:	Mar-11	Mar-12	Mar-13	Mar-14	Mar-15	Mar-16	Mar-17	Mar-18	Mar-19	Mar-20	Mar-21	Tariff lifetime (years)
Solar PV <4 kW (new build**)	36.1	36.1	33	30.2	27.6	25.1	22.9	20.8	19	17.2	15.7	25
Solar PV <4 kW (retrofit**)	41.3	41.3	37.8	34.6	31.6	28.8	26.2	23.8	21.7	19.7	18	25
Solar PV >4-10 kW	36.1	36.1	33	30.2	27.6	25.1	22.9	20.8	19	17.2	15.7	25
Solar PV >10-100 kW	31.4	31.4	28.7	26.3	24	21.9	19.9	18.1	16.5	15	13.6	25
Solar PV >100kW-5MW	29.3	29.3	26.8	24.5	22.4	20.4	18.6	16.9	15.4	14	12.7	25
Solar PV Stand alone system**	29.3	29.3	26.8	24.5	22.4	20.4	18.6	16.9	15.4	14	12.7	25

Appendix C: Equivalent FIT subsidy for surveyed Solar PV sites

Site	Size (kWp)	Equivalent annual Output/kWp	Equivalent Annual Output (kWh)	Current 25 year subsidy	31/03/2011	25 year subsidy 2015	31/03/2016	25 year subsidy 2020	31/03/2021
Aeppel House, Tingewick	0.5	983	491	£5,075	£203	£3,550	£142	£2,200	£88
Hesketh Hall, Broughton-in-Furness, Cumbria	1.3	834	1,084	£11,200	£448	£7,800	£312	£4,875	£195
Weyhanger, Farnham	1.3	680	884	£9,125	£365	£6,350	£254	£3,975	£159
Archers Farmhouse, Banbury, Oxon	1.944	955	1,857	£19,175	£767	£13,375	£535	£8,350	£334
The Living Rainforest	2.1	619	1,301	£13,425	£537	£9,375	£375	£5,850	£234
QE School SRC, Wimborne	2.268	915	2,075	£21,425	£857	£14,925	£597	£9,325	£373
Poringland Library, Poringland, Norfolk	3.9	822	3,204	£33,075	£1,323	£23,075	£923	£14,425	£577
West Oxford Community Centre	5	805	4,026	£36,325	£1,453	£25,250	£1,010	£15,800	£632
Sheepdrove Farm, Lambourne	5.44	825	4,489	£40,500	£1,620	£28,175	£1,127	£17,625	£705
Faringdon School, Faringdon	10.4	1,052	10,940	£85,875	£3,435	£59,900	£2,396	£37,200	£1,488
West Berks Council Offices, Newbury	11	951	10,457	£82,100	£3,284	£57,250	£2,290	£35,550	£1,422
Mean of sites: Small < 5 kwp	1.90	830	1,556	£16,075	£643	£11,200	£448	£7,000	£280
Mean of sites: Medium 5-10 kwp	5.22	815	4,257	£38,425	£1,537	£26,725	£1,069	£16,700	£668
Mean of sites: Large >10 kwp	10.70	1,001	10,699	£83,975	£3,359	£58,575	£2,343	£36,375	£1,455

Appendix D: Calculation of annual cost saving from electricity generated by Solar PV

Calculation of annual cost saving from electricity generated				Price per kw/hr					
	Ave site size kWp	Annual Output per kWp	Annual Output (kWh)	£0.08	£0.10	£0.11	£0.12	£0.14	£0.16
Small < 5 kwp	1.9	830	1,556	£125	£156	£171	£187	£218	£249
Medium 5-10kwp	5.2	815	4,257	£341	£426	£468	£511	£596	£681
Large > 10 kwp	10.7	1,001	10,699	£856	£1,070	£1,177	£1,284	£1,498	£1,712

Appendix E: Lifetime incomes for surveyed sites, including impact of generation Feed-in tariff

Lifetime income for sites based on installation in 2010

Lifetime income: 2010 FIT + electricity cost reduction (calculated at varying p per kwh)	**Size (kWp)**	**Equivalent annual Output/kWp**	**Equivalent Annual Output (kWh)**	8p / kwh	10p / kwh	11p / kwh	12p / kwh	14p / kwh	16p / kwh
Aeppel House, Tingewick	0.5	983	491	£6,058	£6,304	£6,426	£6,549	£6,795	£7,041
Hesketh Hall, Broughton-in-Furness, Cumbria	1.3	834	1,084	£13,368	£13,910	£14,181	£14,452	£14,993	£15,535
Weyhanger, Farnham	1.3	680	884	£10,892	£11,334	£11,555	£11,776	£12,218	£12,660
Archers Farmhouse, Banbury, Oxon	1.944	955	1,857	£22,889	£23,818	£24,282	£24,746	£25,675	£26,604
The Living Rainforest	2.1	619	1,301	£16,026	£16,677	£17,002	£17,327	£17,977	£18,628
QE School SRC, Wimborne	2.268	915	2,075	£25,574	£26,611	£27,130	£27,649	£28,686	£29,723
Poringland Library, Poringland, Norfolk	3.9	822	3,204	£39,483	£41,085	£41,886	£42,687	£44,289	£45,891
West Oxford Community Centre	5	805	4,026	£44,376	£46,389	£47,396	£48,402	£50,415	£52,428
Sheepdrove Farm, Lambourne	5.44	825	4,489	£49,478	£51,722	£52,844	£53,966	£56,211	£58,455
Faringdon School, Faringdon	10.4	1,052	10,940	£107,755	£113,225	£115,960	£118,695	£124,165	£129,635
West Berks Council Offices, Newbury	11	951	10,457	£103,014	£108,243	£110,857	£113,471	£118,700	£123,929
Mean of sites: Small < 5 kwp	1.90	830	1,556	£19,184	£19,963	£20,352	£20,741	£21,519	£22,297
Mean of sites: Medium 5-10 kwp	5.22	815	4,257	£46,927	£49,055	£50,120	£51,184	£53,313	£55,441
Mean of sites: Large >10 kwp	10.70	1,001	10,699	£105,385	£110,734	£113,409	£116,083	£121,433	£126,782

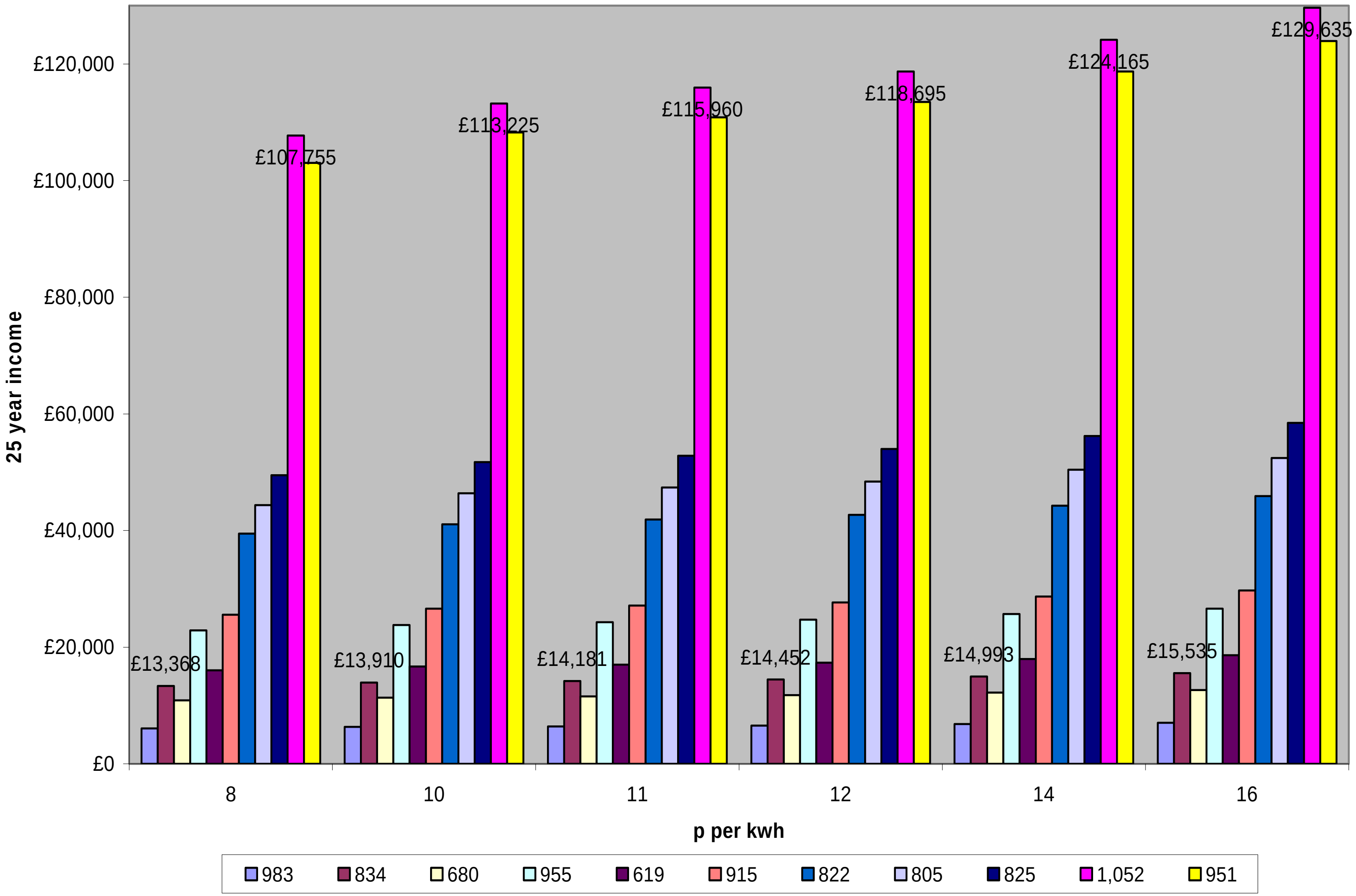
Lifetime income for sites based on installation in 2015

Lifetime income: 2015 FIT + electricity cost reduction (calculated at varying p per kwh)	Size (kWp)	Equivalent annual Output/kWp	Equivalent Annual Output (kWh)	8p / kwh	10p / kwh	11p / kwh	12p / kwh	14p / kwh	16p / kwh
Aeppel House, Tingewick	0.5	983	491	£4,533	£4,779	£4,901	£5,024	£5,270	£5,516
Hesketh Hall, Broughton-in-Furness, Cumbria	1.3	834	1,084	£9,968	£10,510	£10,781	£11,052	£11,593	£12,135
Weyhanger, Farnham	1.3	680	884	£8,117	£8,559	£8,780	£9,001	£9,443	£9,885
Archers Farmhouse, Banbury, Oxon	1.944	955	1,857	£17,089	£18,018	£18,482	£18,946	£19,875	£20,804
The Living Rainforest	2.1	619	1,301	£11,976	£12,627	£12,952	£13,277	£13,927	£14,578
QE School SRC, Wimborne	2.268	915	2,075	£19,074	£20,111	£20,630	£21,149	£22,186	£23,223
Poringland Library, Poringland, Norfolk	3.9	822	3,204	£29,483	£31,085	£31,886	£32,687	£34,289	£35,891
West Oxford Community Centre	5	805	4,026	£33,301	£35,314	£36,321	£37,327	£39,340	£41,353
Sheepdrove Farm, Lambourne	5.44	825	4,489	£37,153	£39,397	£40,519	£41,641	£43,886	£46,130
Faringdon School, Faringdon	10.4	1,052	10,940	£81,780	£87,250	£89,985	£92,720	£98,190	£103,660
West Berks Council Offices, Newbury	11	951	10,457	£78,164	£83,393	£86,007	£88,621	£93,850	£99,079
Mean of sites: Small < 5 kwp	1.90	830	1,556	£14,320	£15,098	£15,487	£15,877	£16,655	£17,433
Mean of sites: Medium 5-10 kwp	5.22	815	4,257	£35,227	£37,355	£38,420	£39,484	£41,613	£43,741
Mean of sites: Large >10 kwp	10.70	1,001	10,699	£79,972	£85,321	£87,996	£90,671	£96,020	£101,369

Lifetime income for sites based on installation in 2020

Lifetime income: 2020 FIT + electricity cost reduction (calculated at varying p per kwh)	**Size (kWp)**	**Equivalent annual Output/kWp**	**Equivalent Annual Output (kWh)**	8p / kwh	10p / kwh	11p / kwh	12p / kwh	14p / kwh	16p / kwh
Aeppel House, Tingewick	0.5	983	491	£3,183	£3,429	£3,551	£3,674	£3,920	£4,166
Hesketh Hall, Broughton-in-Furness, Cumbria	1.3	834	1,084	£7,043	£7,585	£7,856	£8,127	£8,668	£9,210
Weyhanger, Farnham	1.3	680	884	£5,742	£6,184	£6,405	£6,626	£7,068	£7,510
Archers Farmhouse, Banbury, Oxon	1.944	955	1,857	£12,064	£12,993	£13,457	£13,921	£14,850	£15,779
The Living Rainforest	2.1	619	1,301	£8,451	£9,102	£9,427	£9,752	£10,402	£11,053
QE School SRC, Wimborne	2.268	915	2,075	£13,474	£14,511	£15,030	£15,549	£16,586	£17,623
Poringland Library, Poringland, Norfolk	3.9	822	3,204	£20,833	£22,435	£23,236	£24,037	£25,639	£27,241
West Oxford Community Centre	5	805	4,026	£23,851	£25,864	£26,871	£27,877	£29,890	£31,903
Sheepdrove Farm, Lambourne	5.44	825	4,489	£26,603	£28,847	£29,969	£31,091	£33,336	£35,580
Faringdon School, Faringdon	10.4	1,052	10,940	£59,080	£64,550	£67,285	£70,020	£75,490	£80,960
West Berks Council Offices, Newbury	11	951	10,457	£56,464	£61,693	£64,307	£66,921	£72,150	£77,379
Mean of sites: Small < 5 kwp	1.90	830	1,556	£10,113	£10,891	£11,280	£11,669	£12,448	£13,226
Mean of sites: Medium 5-10 kwp	5.22	815	4,257	£25,227	£27,355	£28,420	£29,484	£31,613	£33,741
Mean of sites: Large >10 kwp	10.70	1,001	10,699	£57,772	£63,121	£65,796	£68,471	£73,820	£79,169

Impact of electricity prices on lifetime income for current Solar PV sites, with Feed-in Tariff



Appendix F:

Forecast technology costs, extracted from Element Energy's report for DECC

2009: Current technology costs			
System size/type	**Fixed cost (per site)**	**Marginal cost (£/kW)**	**Annual maintenance cost**
New build domestic (2.5kWe)	£1,500	£3,983	£110
Retrofit (2.5kWe)	£2,000	£4,500	£110
New build (4-10kW)	£4,800 per kW		£24.00 per kWe
Retrofit (4-10kW)	£4,800 per kW		£24.00 per kWe
New build (10–100kWe)	£4,300 per kW		£22.00 per kWe
Retrofit (10–100kWe)	£4,300 per kW		£22.00 per kWe
New build (100–5,000kWe)	£4,000 per kW		£20.00 per kWe
Retrofit (100–5,000kWe)	£4,000 per kW		£20.00 per kWe
Stand alone system	£4,000 per kW		£20.00 per kWe

2015 technology costs			
System size/type	**Fixed cost (per site)**	**Marginal cost (£/kW)**	**Annual maintenance cost**
New build (<10kWe)	£1,500	£2,240	£110
Retrofit (<10kWe)	£2,000	£2,530	£110
New build (4-10kW)	£2,699 per kW		£16.00 per kWe
Retrofit (4-10kW)	£2,699 per kW		£16.00 per kWe
New build (10–100kWe)	£2,420 per kW		£15.00 per kWe
Retrofit (10–100kWe)	£2,420 per kW		£15.00 per kWe
New build (100–5,000kWe)	£2,250 per kW		£14.00 per kWe
Retrofit (100–5,000kWe)	£2,250 per kW		£14.00 per kWe
Stand alone system	£2,250 per kW		£14.00 per kWe

2020 technology costs			
System size/type	**Fixed cost (per site)**	**Marginal cost (£/kW)**	**Annual maintenance cost**
New build (<10kWe)	£1,500	£1,759	£110
Retrofit (<10kWe)	£2,000	£1,987	£110
New build (4-10kW)	£2,120 per kW		£15.00 per kWe
Retrofit (4-10kW)	£2,120 per kW		£15.00 per kWe
New build (10–100kWe)	£1,900 per kW		£14.00 per kWe
Retrofit (10–100kWe)	£1,900 per kW		£14.00 per kWe
New build (100–5,000kWe)	£1,765 per kW		£13.00 per kWe
Retrofit (100–5,000kWe)	£1,765 per kW		£13.00 per kWe
Stand alone system	£1,765 per kW		£13.00 per kWe

Appendix G: Payback periods for Solar PV sites, without subsidy

Calculation of years to payback, without subsidy

Cost / KWp		8p / kwh	10p / kwh	11p / kwh	12p / kwh	14p / kwh	16p / kwh
£5,500	Current high end >10 kwp	69	55	50	46	39	34
£3,600	Current low end >10 kwp	45	36	33	30	26	22
£2,420	2015 DECC estimate >10 kwp	30	24	22	20	17	15
£1,900	2020 DECC estimate >10 kwp	24	19	17	16	14	12
£1,726	2020 UKSolar PV estimate >10 kwp	22	17	16	14	12	11
£5,500	Current high end 5-10 kwp	84	67	61	56	48	42
£3,800	Current low end 5-10 kwp	58	47	42	39	33	29
£2,699	2015 DECC estimate 5-10 kwp	41	33	30	28	24	21
£2,120	2020 DECC estimate 5-10 kwp	33	26	24	22	19	16
£1,726	2020 UKSolar PV estimate 5-10 kwp	26	21	19	18	15	13
£6,000	Current high end 1.3 kWp	90	72	66	60	52	45
£5,000	Current high end 3 kWp	75	60	55	50	43	38
£4,000	Current low end < 5 kwp	60	48	44	40	34	30
£2,699	2015 DECC estimate < 5 kwp	41	33	30	27	23	20
£2,120	2020 DECC estimate < 5 kwp	32	26	23	21	18	16
£1,726	2020 UKSolar PV estimate< 5 kwp	26	21	19	17	15	13

Appendix H: Payback periods for solar PV sites with Feed-in Tariff

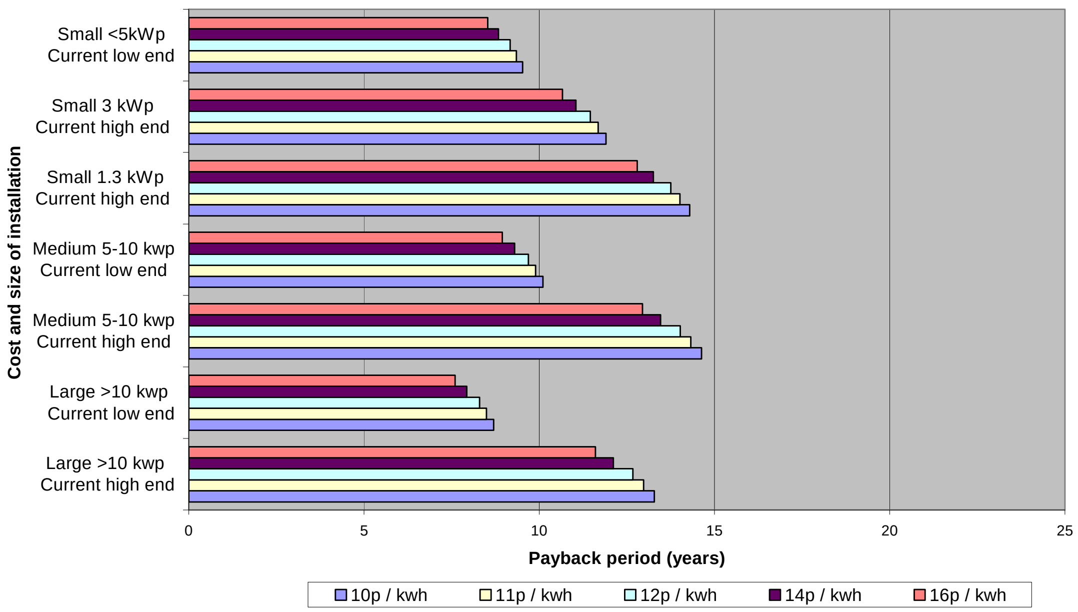
The following table has used the data gathered to calculate the payback period for current Solar PV installations. Income will be generated beyond the payback period until twenty-five years, which is assumed to be the end of the installation's useful life.

Payback periods for current solar PV sites

Size of site and cost scenario	Cost / KWp	Ave size kwP	Years to payback at electricity cost of:				
			10p / kwh	11p / kwh	12p / kwh	14p / kwh	16p / kwh
Large >10 kwp Current high end	£5,500	10.70	13	13	13	12	12
Large >10 kwp Current low end	£3,600	10.70	9	8	8	8	8
Medium 5-10 kwp Current high end	£5,500	5.22	15	14	14	13	13
Medium 5-10 kwp Current low end	£3,800	5.22	10	10	10	9	9
Small 1.3 kWp Current high end	£6,000	1.90	14	14	14	13	13
Small 3 kWp Current high end	£5,000	1.90	12	12	11	11	11
Small <5kWp Current low end	£4,000	1.90	10	9	9	9	9

This table is represented graphically below, on a 25 year axis to represent the assumed life of a Solar PV installation.

Current payback periods for Solar PV



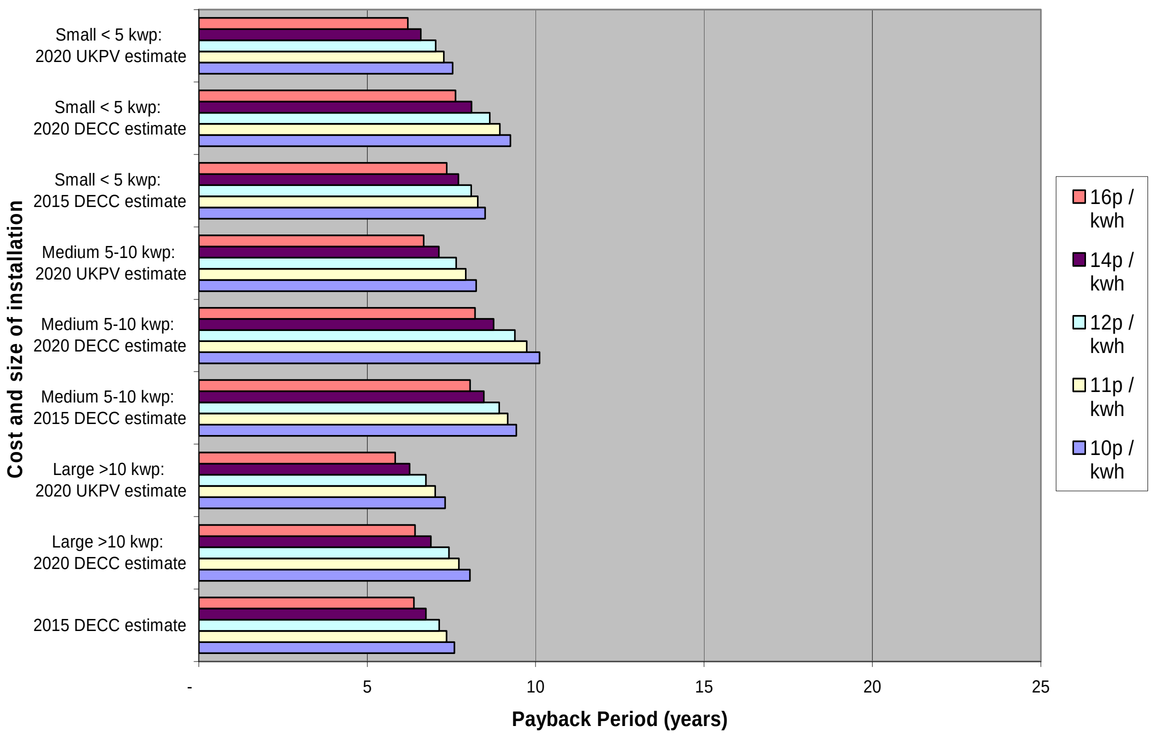
The table and graph show payback periods ranging from eight to fifteen years; given an assumed life of 25 years, solar PV currently installed will generate significant savings in energy cost over their lifetime.

The next section shows the same calculations for solar PV sites installed in 2015, when both costs and levels of Feed-in Tariff will have fallen, and in 2020, when both costs and levels of Feed-in Tariff will have fallen even further.

Payback periods for solar PV sites in 2015

Size of site and cost scenario	Cost / KWp	Ave size kwP	Years to payback at electricity cost of:				
			10p / kwh	11p / kwh	12p / kwh	14p / kwh	16p / kwh
Large >10 kwp: DECC estimate	£2,420	10.70	8	7	7	7	6
Medium 5-10 kwp: DECC estimate	£2,699	5.22	9	9	9	8	8
Small < 5 kwp: DECC estimate	£2,699	1.90	8	8	8	8	7

Payback periods for solar PV in 2015 and 2020



Payback periods for solar PV sites in 2020

Size of site and cost scenario	Cost / KWp	Ave size kwP	Years to payback at electricity cost of:				
			10p / kwh	11p / kwh	12p / kwh	14p / kwh	16p / kwh
Large >10 kwp: DECC estimate	£1,900	10.70	8	8	7	7	6
Large >10 kwp: UKSolar PV estimate	£1,726	10.70	7	7	7	6	6
Medium 5-10 kwp: DECC estimate	£2,120	5.22	10	10	9	9	8
Medium 5-10 kwp: UKSolar PV estimate	£1,726	5.22	8	8	8	7	7
Small < 5 kwp: DECC estimate	£2,120	1.90	9	9	9	8	8
Small < 5 kwp: UKSolar PV estimate	£1,726	1.90	8	7	7	7	6

The payback periods are represented graphically overleaf, on a 25 year axis to represent the assumed life of a Solar PV installation.

This graph demonstrates that payback periods have reduced further by 2015, and that there is less variability between size of sites and future installations.

Alternative ways of expressing the above information are on the payback periods for different sizes of installations over time:

Payback periods for large solar PV sites with Feed-in Tariff

Large >10 kwp	Cost / KWp	8p / kwh	10p / kwh	11p / kwh	12p / kwh	14p / kwh	16p / kwh
Current high end	£5,500	22	20	19	19	17	16
Current low end	£3,600	14	13	13	12	11	11
2015 DECC estimate	£2,420	9	9	8	8	8	7
2020 DECC estimate	£1,900	7	7	7	6	6	6
2020 UKSolar PV estimate	£1,726	7	6	6	6	5	5

Payback periods for medium solar PV sites with Feed-in Tariff

Medium 5-10 kwp	Cost / KWp	8p / kwh	10p / kwh	11p / kwh	12p / kwh	14p / kwh	16p / kwh
Current high end	£5,500	24	22	22	21	20	19
Current low end	£3,800	17	15	15	14	14	13
2015 DECC estimate	£2,699	12	11	11	10	10	9
2020 DECC estimate	£2,120	9	9	8	8	8	7
2020 UKSolar PV estimate	£1,726	8	7	7	7	6	6

Payback periods for small solar PV sites with Feed-in Tariff

Small < 5 kwp	Cost / KWp	8p / kwh	10p / kwh	11p / kwh	12p / kwh	14p / kwh	16p / kwh
Current high end 1.3 kWp	£6,000	24	22	22	21	20	19
Current high end 3 kWp	£5,000	20	18	18	17	16	16
Current low end	£4,000	16	15	14	14	13	13
2015 DECC estimate	£2,699	11	10	10	9	9	8
2020 DECC estimate	£2,120	8	8	8	7	7	7
2020 UKSolar PV estimate	£1,726	7	6	6	6	6	5

The above tables allow decisions to be made on the likely profitability of a site now and in the future, given no change in the subsidy regime of the Generation Feed-in Tariff.

Appendix I: The impact of RPI and discount rates on investment decisions

The table below shows the impact that altering the RPI or discount rate can have. All figures have been based on an investment generating a return of £50 over 25 years (ie £2 per year for 25 years).

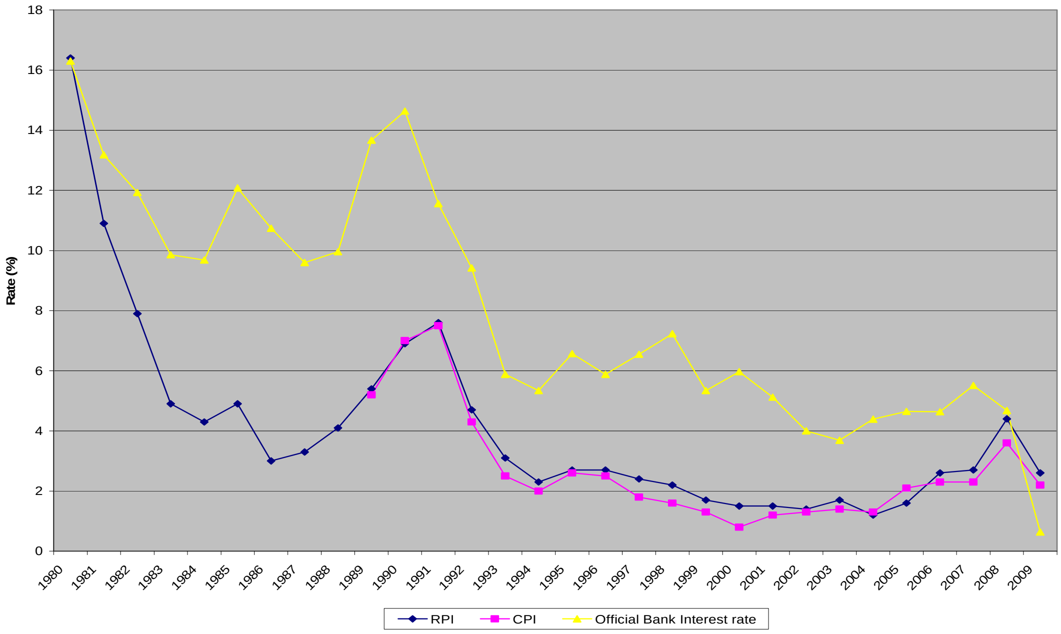
Impact of varying RPI and Discount rates

Discount rate	RPI (retail price index) rate						
	2.0%	2.5%	3.0%	3.5%	4.0%	4.5%	5.0%
0%	£65.34	£70.02	£75.11	£80.63	£86.62	£93.14	£100.23
2%	£50.00	£53.31	£56.90	£60.78	£64.99	£69.55	£74.49
3%	£44.15	£46.96	£50.00	£53.28	£56.83	£60.67	£64.82
4%	£39.23	£41.62	£44.21	£46.99	£50.00	£53.25	£56.76
5%	£35.06	£37.11	£39.32	£41.69	£44.26	£47.02	£50.00
6%	£31.50	£33.27	£35.17	£37.21	£39.40	£41.76	£44.31

It can be seen that, undiscounted, 2.5% RPI increases the income to £70.02, while using a discount rate of 4% would reduce this income to £41.62. Where the discount rate equals RPI the net effect is to restore the investment to a return of £50.

Given that solar PV has a long lifetime, assumptions about inflation rates and the interest rates charged on investments will have a significant impact

Average Annual Inflation and Interest Rates, 1980-2009



The graph overleaf shows the annual average of rates of inflation (both the Retail Price Index and the more recent Consumer Price Index) and official Bank rate over a thirty year period. It clearly shows the difficulty in forecasting over a 25 year period; even over the period of greatest stability, as rates have varied considerably. [17] The calculations of rates of return will be affected by changes in rates; as these uncertainties apply to all long-term investment decisions, organisations should have models which can be applied to a decision to invest in Solar PV.

[17] Between 1984 and 2008, the variance for the Retail Price Index is 2.925 and the standard deviation is 1.7101, while the variance for the Official Bank rate is 10.207 and the standard deviation is 3.195.
Inflation rate data sourced from Office of National Statistics, Official Bank rate data sourced from Bank of England.