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The feed-in tariff in the UK: A case study focus on domestic photovoltaic systems

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ABSTRACT

This paper explores the photovoltaic (PV) industry in the United Kingdom (UK) as experienced by those who are working with it directly and with consideration of current standards, module efficiencies and future environmental trends. The government's consultation on the comprehensive review for solar PV tariffs, proposes a reduction of the generation tariff for PV installations in the UK of more than 50%. The introduction of the Feed-In Tariffs scheme (FITs) has rapidly increased deployment of PV technologies at small scale since its introduction in April 2010. The central principle of FIT policies is to offer guaranteed prices for fixed periods to enable greater number of investors. A financial analysis was performed on two real-life installations in Cornwall, UK to determine the impact of proposed cuts to the FIT will make to a typical domestic PV system under 4 kW. The results show that a healthy Return on Investment (ROI) can still be made but that future installations should focus on off-setting electricity required from the national grid as a long term push for true sustainability rather than subsidised schemes. The profitability of future installations will have to be featured within in-service and end-of-service considerations such as the feed-in tariff, module efficiencies and the implications of costs associated with end-of-life disposal.

1. Introduction

As part of the United Kingdom (UK) Government's commitment to tackling climate change and ensuring energy security, a range of financial incentives have been put in place to encourage the deployment of renewable energy. The Renewable Energy Strategy suggests that by 2020 over 30% of electricity should come from renewable sources including 2% from small-scale sources [1]. The importance of small-scale renewable energy is highlighted in the UK's Microgeneration Strategy, which outlines the support provided to ensure that the sector meet these goals [2].

Microgeneration is defined in Section 82 of the UKs Energy Act (2004) as "the production of electricity or heat from a low-carbon source, at capacities of no more than 50 kWe or 45 kWth"[1] [3]. In the UK, microgeneration technologies are supported through several measures including; reduced VAT on microgeneration products, capital grants for householders and Government policies, such as the Renewables Obligation (RO) and the Feed-in Tariff (FIT) [2]. A range of renewable microgeneration technologies are available including; solar photovoltaic (PV) panels, solar thermal panels, and wind turbines. In particular, solar PV has shown strong significant growth at the domestic level over the past few years. Photovoltaic devices are increasingly recognised as an essential component of future energy generation and are seen as a well-developed technology that could be deployed on domestic properties [4]. Emerging research focusses on overcoming some of the limitations with current PV technology [5] which will be further discussed in section 1.2.2.

This paper offers an exploration of the FIT in the UK, focussing especially on PV and on the recent government decisions to cut the payment rates. This paper draws on a large array of sources including the analysis of two case studies to offer wider lessons for adding to current understanding of the real life industrial impact of FIT instruments. The case studies were taken from a random sample of well-located[2] sites in Cornwall, UK installed in May and August 2010.

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[1] The units defined in this act are the kWe (Kilowatt – electric) and kWth (Kilowatt – thermal).

[2] A well-located site should provide optimum output from a PV system; this depends on many factors such as orientation, pitch, shading and geographical location. More details of each system are provided in Section 2.2.

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1.1. Current legislation in the UK

"The 2009 Renewable Energy Directive sets a target for the UK to achieve 15% of its energy consumption from renewable sources by 2020" [6]. However, in 2010 the UK produced 6.5% of electricity from renewable sources, falling short of its 10% target and in 2011 only reached 9.6% [7]. Failure to meet the 2010 target raises concerns as to whether the UK will meet the legally binding EU target set for 2020.

1.1.1. Renewables Obligation (RO)

The Renewables Obligation (RO) is currently the primary mechanism to support deployment of renewable electricity generation. The original design imposed an obligation on energy suppliers to provide an increasing proportion of their supply from renewable sources [8]. Electricity suppliers can fulfil their obligation by delivering Renewable Obligation Certificates (ROCs) to the electricity regulator, paying the "buy-out" price or a combination of the two [9]. In 2009, the RO moved from a mechanism of single level support to a banded system varying by technology. Support levels for each technology are decided considering factors including their costs, relative maturity and potential for future deployment. On 9th November 2011, the Government published a banding review outlining the levels of banded support available for renewable electricity generation under the Renewables Obligation (RO) for the period 2013–17 [10]. Solar PV installations between 50 kW and 5 MW are currently supported at 2 ROCs/MWh within the RO [10]. On 30th September 2011, suppliers that fully complied with their renewable obligation received £14.32 for each ROC from the buy-out fund recycle payments [11].

1.1.2. Feed-in tariffs scheme (FITs)

The FITs work alongside the RO and was introduced in April 2010 by the UK government to promote the deployment of small-scale renewable and low-carbon electricity generation technologies as part of their obligation to meet the Renewable Energy Directive. The scheme is applicable to a number of technologies including PV, Wind, Hydroelectric and Anaerobic Digestion (AD) up to a maximum total installed capacity (TIC) of 5 MW [12]. The main aim is to drive down the cost of those technologies by providing potential investors with the security to make long-term investments.

The FIT scheme provides three financial Incentives:

1. Generation tariff

The energy supplier will pay a set rate for each unit (kWh) of electricity generated. The level of tariff is dependent on the technology and size of installation [13]. Once registered, tariff levels are guaranteed and index- linked. This will be covered later in this section.

2. Export tariff

All technologies receive a further fixed rate for each unit of electricity supplied to the grid. Currently, it is estimated as 50% of the electricity generated [12].

3. Electricity bill savings

Electricity generated on-site will reduce the amount of electricity required from the grid resulting in reduced energy bills.

The scheme has been hugely successful in increasing the installed capacity generated from PV. Between 1st April 2010 and week ending 25th March 2012; 1.06 GW of PV capacity registered for Feed-in Tariffs. The majority of these installations (88%) were domestic installations less than 4 kW. However, the government announced a review of the FIT scheme in February 2011 and has since targeted PV technology due to the substantial increase in installations observed during the first year of the scheme. This has led to uncertainty within the PV market in the UK [14]. The UK government has committed to "improving the efficiency of FITs by finding £40 million of savings, around 10% of the projected spend in the 2014/15 financial year" [4] and as a result, the Department of Energy and Climate Change (DECC) are reviewing the FITs. On the 9th of June 2011, DECC announced reductions in FIT rates for PV systems with total installed capacity greater than 50 kW [15]. Table 1 below outlines the FIT rates for installations before and after the 1st August 2011.

Since the first comprehensive review, DECC have been monitoring the uptake of PV installations and have released proposals to further reduce the tariffs. Under the proposals the new tariffs will apply to all new solar PV installations with an eligibility date on or after 12th December 2011. This date was later brought forward to 1st April 2012. Table 2 outlines the FIT rates announced.

The announcement of plans to reduce the feed-in tariff has resulted in a rush to install PV systems before the deadline. On the 9th December 2011, the MCS website announced that the database has been successfully providing certificates for microgeneration certificates "between 6000–9000 each day this week, compared to volumes in the recent past of about 500 per day" [16]. Fig. 1 illustrates the large increase in installed capacity in the weeks before the deadlines (12th December 2011 and 1st April 2012) announced by the government.

On 24th May 2012, DECC announced further reductions in tariff for solar PV installations. From 1st August 2012, domestic installations will receive 16p/kWh with an increased export tariff from 3.2p/kWh to 4.5p/kWh. In addition to the new tariff bands, new rules require PV systems under 4 kWp to supply an Energy Performance Certificate (EPC) showing that the property has an EPC

Table 1
FIT tariff rates announced by DECC on 9th June 2011.

Band (kW)	Before 01.09.11 (p/kWh)	After 01.09.11 (p/kWh)	Reduction (%)
>50 kW ≥ 100 kW	32.9	19.0	42
>100 kW ≥ 150 kW	30.7	19.0	38
>150 kW ≥ 250 kW	30.7	15.0	51
>250 kW	30.7	8.5	72
Stand-alone	30.7	8.5	72

Information sourced from Ofgem website, feed-in tariff payment rate table for photovoltaic eligible installations, http://www.ofgem.gov.uk/Sustainability/Environment/fits/tariff-tables/Documents1/Tariff%20Table%201%20August%202012%20PV%20Only.pdf.

Table 2
FIT tariff rates announced by DECC on 31st October 2011.

Band (kW)	Current tariff (p/kWh)	Proposed tariff (p/kWh)	Reduction (%)
≤4 kW (new build)	37.8	21.0	44
≤4 kW (retrofit)	43.3	21.0	52
>4 ≥ 10 kW	37.8	16.8	56
>10 ≥ 50 kW	32.9	15.2	54
>50 kW ≥ 100 kW	19.0	12.9	32
>100 kW ≥ 150 kW	19.0	12.9	32
>150 kW ≥ 250 kW	15.0	12.9	14

Information sourced from DECC website, Feed-in tariffs scheme: consultation on Comprehensive Review Phase 1 http://www.decc.gov.uk/assets/decc/11/consultation/fits-comp-review-p1/3364-fits-scheme-consultation-doc.pdf.

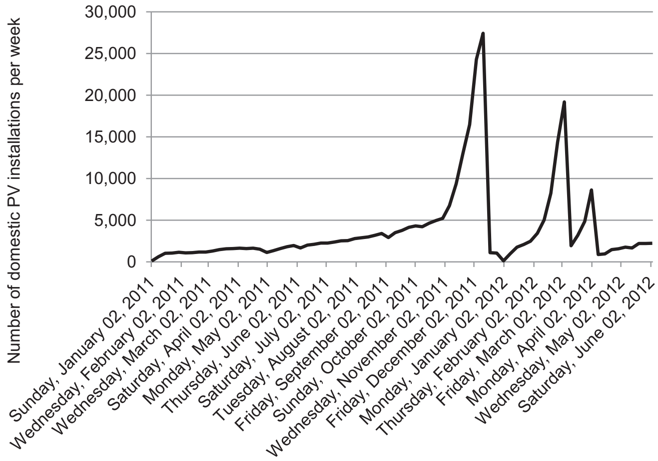

Fig. 1. Number of domestic PV installations per week, tariff band 0–4 kW sourced from the Energy Saving Trust website http://www.energysavingtrust.org.uk/Generate-your-own-energy/Financial-incentives/Energy-Performance-Certificates-and-the-Feed-in-Tariff.

band D or better at the time of application to qualify for the standard rate FIT; an additional cost of £50 to £100 plus Value Added Tax (VAT) [17].

1.2. A review of industry challenges

The introduction of the FIT in the UK in April 2010 has had a significant influence on the solar PV industry. The FIT scheme was designed to promote the uptake of low carbon electricity technologies by the public and communities in the UK. Section 1.1.2 outlines the success of the FIT for the domestic PV sector in the UK. However, the rapid increase in installations over the past few years has highlighted several issues observed by those who are working with it directly. Many of these issues are connected and may be beyond the control of actors within the UK market, but are areas that affect actors within the UK industry.

1.2.1. Cost reductions

According to the DECC consultation document "Global costs of installing solar PV have dramatically reduced since the FIT scheme began" [4]. When the scheme was introduced DECC included a digression of 9% per annum to account for the reduction in costs of installing a PV system. However, figures over the past year show the cost of installing PV systems has reduced significantly more than predicted by DECC [18]. The retail module price index dropped by 26% over the past year [18], this is illustrated in Fig. 2.[3]

The opportunities for cost reduction in PV systems are dependent on many factors including manufacturing cost, power electronic costs, battery costs and installation costs. PV modules represent 45–60% of the total installed system cost and therefore is the most important cost driver in the industry [19]. For example, analysis of the case studies 1 and 2 (outlined in section 2.5) show that the modules represent 48% and 55% respectively. Cost reductions in PV module prices are a key driver to enable development within the market. However, module costs are largely beyond the influence of the UK market and fluctuate depending on the world market [20]. The UK industry faces the challenge of predicting the future price of modules.

[3] These prices reflect the lowest price for solar PV modules and do not include sales tax using data from [18] Solarbuzz, Module Pricing, in, 2011.

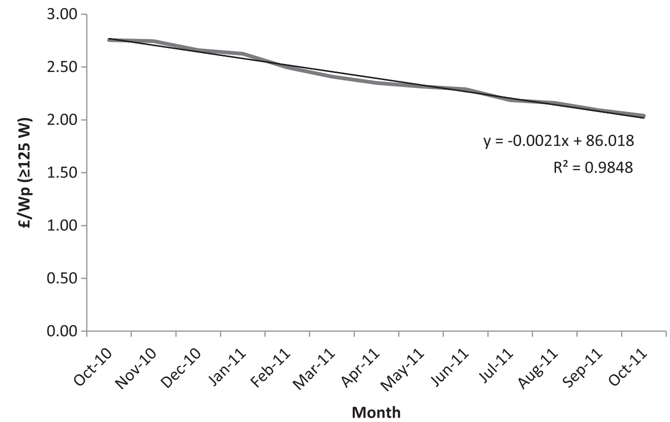

Fig. 2. Price reduction of photovoltaic panels Information sourced from solarbuzz, module Pricing in 2011 http://www.solarbuzz.com/facts-and-figures/retail-price-environment/module-prices.

1.2.2. Module efficiency

The dramatic development of PV is still strongly influenced by the FIT. The growth of the market has enabled the cost reduction of PV modules, either as a result of decreasing manufacturing cost or as an improvement in module efficiency [21]. A study on the effects of the FIT for small roof-top solar PV systems in Germany found that "reductions in total system costs are primary driven by global learning in PV module production" [22].

Research has found that PV modules with higher efficiency lead to systems with lower levelised costs [23]. The main aim for the solar industry in the future is to further reduce production costs through technological innovations and improvements and increasing the performance ratio of PV [24]. The International Energy Agency (IEA) has set efficiency targets for crystalline silicon technologies up until 2050, as shown in Table 3 [25]. Crystalline silicon technologies 2010–2015 2015–2020 2020–2030/2050.

The evolution of silicon PV cell efficiencies has developed significantly since the 1940's with the rapid progress of silicon technology allowing the production of silicon cells with 15% efficiency. In the 1970's efficiencies of 17% were reached due to the achievements in microelectronics. The most significant results have been obtained over the past 20 years where silicon cell efficiencies close to 25% have been achieved [26]. A report on the impact of silicon feedstock on the PV module cost found that the module cost is dependent on cell efficiency. If the cell efficiency is reduced by 10% (in relative values), the module cost increase by 11% [27]. The industry faces challenges to improve module efficiency with the overall aim to reduce module cost.

1.2.3. End-of-life modules

Policy instruments used to promote RETs are motivated by environmental issues (e.g., reducing global climate change, a desire to reduce dependence on imported fossil fuels, increased portfolio diversity, local economic development, etc.) [28]. Since PV is one of the technologies targeted by such policies, it is important to

Table 3
Efficiency targets for crystalline silicon technologies.

Efficiency targets (commercial modules)		
2010–2015	2015–2020	2020–2030/2050
Single-crystalline: 21% Multi-crystalline: 17%	Single-crystalline: 23% Multi-crystalline: 19%	Single-crystalline: 25% Multi-crystalline: 21%

Information sourced from a report from Solar Technologies FZE on Costs and Competitiveness in 2008 http://www.solartechnologies.net/sg_part4.html.

consider how to minimise the environmental impact of PV over the life of the technology.

The expansion of the PV market is contained by the availability of materials used within the supply chain. Recently, there has been concern that the increasing demand could create a shortfall if supply is unable to meet demand. Research conducted by Candelise et al. [29] revealed that PV technologies may be constrained by the availability of key materials, hampering their growth potential and their ability to sustain cost reduction trends in the future. Therefore, the reduction of waste and recycling end-of-life products can have a significant impact on increasing the supply of critical materials [30].

The waste electrical and electronic equipment (WEEE) directive 2002/96/EC [31] was developed to reduce the amount of electrical and electronic equipment being produced and encourage reuse, recycling and recovery. The directive places producers and distributers responsible for the associated costs of collection, treatment, recycling and recovery. In December 2008 the European Commission proposed to recast the directive, with a potential extension to include photovoltaic panels [32]. Some companies have undertaken a collection and recycling program, setting aside funds required to collect modules once they are decommissioned and recycle module to recover valuable materials [33]. The increasing amount of photovoltaic installations in the UK is estimated to generate substantial quantities of waste after a life expectancy of 25 years [34]. It is predicted that there will be 22,384 tonnes[4] of PV panels reaching end-of-life in 2035. It is clear that recycling PV panels to recover valuable materials has potential to contribute to future material supply and is an area which requires further study to ensure that the industry can meet material demands in the future. In January 2012, after three years of negotiations; European policy makers agreed upon a recast of the WEEE [31]. The directive will now apply to PV panels representing an important challenge for the European solar industry.

1.2.4. Employment

"According to REAL Assurance data an estimated 25,000 UK jobs have been created as a direct result of the feed-in tariff (FIT)". Many of the businesses within the sector are small and medium enterprises (SMEs), who will find it difficult to adjust to the change in legislation within such a short time frame. In a House of Commons debate on 23rd November 2011, Caroline Flint argued that the Government's cuts to feed-in tariffs "will hit jobs and growth in the solar industry, undermine confidence in the Green Deal and deter investment in the wider green economy" [35]. A survey by the Renewable Energy Association (REA) and Solar Trade Association (STA) industry survey reports that the likely impact of the proposed cuts to UK solar FITs may result in employment levels falling by 42% and 33% of companies fear they may be forced to close [36]. The industry faces the challenge of adapting to these changes without creating job losses.

2. Methodology

Two case studies were randomly selected from systems installed in Cornwall in 2010, when the FIT was introduced. The future uptake of solar PV within the UK domestic sector will be influenced by the financial incentives for home owners to invest in the technology [37]. A financial analysis was performed to determine the effect a reduction in the FIT will have on the overall economics of the systems. When the FIT was introduced, the government set them at a level to deliver a ROI of 5% for well-located solar PV installations [4]. Cornwall is the location of Great Britain's most southerly point and, as a result, the average annual solar radiation in Cornwall is the highest in the UK with 1300 kWh (Kilowatt-hours) per square metre [38]. The case studies were selected from this area for this reason, as representative of 'well-located' PV systems in the UK.

This analysis uses data supplied by industry to provide insight into how systems are performing in-situ. The results of which will compared to the impact assessment for small-scale installations undertaken by DECC in 2010 which assumed a 2 kWp reference installation, producing 850 kWh/kWp/year at a capital cost of £11,000.

2.1. Choice of method

When the FITs scheme was launched, the tariffs for solar PV were intended to provide a Return on Investment (ROI) of 5% for well-located installations. In order to address the question "What is the future market considerations for domestic solar PV in the UK?" the ROI and payback time was chosen as basic parameters in which purchasers can compare when considering microgeneration installations. In carrying out this analysis, it is recognised that economic payback time and return on investment are not the only factor that influence the decision to invest in microgeneration technology. However, the method has been used as a basis for setting future tariffs within UK government policy [39] and therefore can be considered as a factor that may influence purchasers. The ROI and payback time have been calculated on two selected case studies to determine the economic attractiveness of domestic PV systems under the tariffs set by the UK government in three different scenarios:

1. A system installed before 1st April 2012 that qualifies for the tariff level of 43.3p/kWh
2. A system installed after 1st April 2012 that qualifies for the tariff level of 21.0p/kWh
3. A system installed after 1st August 2012 that qualifies for the tariff level of 16.0p/kWh (including an increased export rate of 4.5p/kWh)

2.2. System details

The details of each system are outlined in Table 4; including the modules and inverters installed, system orientation and installation date.

Table 4
System details.

	Case study 1	Case study 2
Module manufacturer	Romag	Sanyo
Module model	Powerglaz® SMT 6(48)P	HIT 240 HDE4
Total module area	18.3 m^2 14 modules – 7 by 2 in portrait	12.5 m^2 9 modules – 5 by 2 in portrait, less 1 module
Peak power output	2.52 kWp	2.16 kWp
Inverter manufacturer	SMA	SMA
Inverter model	SB1200 × 2	SB2500
Fixing method	Slate roof hooks and rails	Slate roof hooks and rails
Orientation and shading	Array faces south west, is tilted 20° and has modest shading	Array faces south–south east, is tilted 30° and has no or very little shading
Date of installation	August 2010	May 2010
Installation cost	£12,992	£12,552
Energy production over the first year	2478 kWh	2403 kWh

[4] This number is based on 9.5 million tonnes of end-of-life waste in Europe, 68,000 MW (Monier, 2011) installed capacity of PV and 160.23 MW installed capacity of PV in England Scotland and Wales.

2.3. Assumptions

A financial analysis of the two case studies (outlined in section 3) was performed to determine the effect a reduction in the FIT will have on the overall economics of the systems. The equations below present a simple method to determine the Return on Investment (ROI) and Payback time.

Return on investment (%) = Net profit (£)/Investment (£) × 100.

Payback Time (years) = Annual Profit (£)/Investment (£)

Where; Annual Profit (£) = FIT (£) + Export rate (£) + savings on electricity (£).

However, the annual profit changes year-on-year due to change in the Retail Price Index (RPI), electricity prices and PV panel efficiency. For this study, the payback time is considered to be the number of years before the system begins to generate profit.

The following assumptions have been made concerning the FIT:

1. Feed-in tariff rate is valid for 25 years.
2. Import electricity cost of 13.18p/kWh [40]; this figure is based on the average UK price of electricity in 2010.
3. Export rate of 3.1p/kWh (with the exception of the FIT rate of 16p/kWh, which assumes and increased export rate of 4.5p/kWh)

The following assumptions have been made to estimate the future revenue from the system:

1. 50% of the generated energy is used on-site by the client

Electricity exports are currently not metered; domestic FIT installations are deemed to export 50% of the total electricity generated, regardless of the amount actually exported [39].

2. An inflation rate (RPI) of 3% per year for the next 25 years.

According to figures published on the National Statistics website, the average RPI between 2001 and 2011 was 3%.

3. Electricity price increase of 8% per year for the next 25 years

According to data published by DECC the annual percentage movement in domestic electricity prices in the UK has increased by an average of 8% between 2002 and 2010 [41].

4. A panel efficiency loss of 0.5% per year for the next 25 years

The installed panels have a 10 year performance guarantee for 90% of the originally measure output and a 25 year performance guarantee for 80% of the originally measured output from the manufacturer. A study on the reliability of photovoltaic modules concluded that "the yearly degradation rate must be less than 0.5% in order to provide the present 25-year power warranties" [42].

5. Digression of 12.5% per annum to account for the reduction in total installed cost

According to DECC "the costs of purchasing and installing solar PV have reduced dramatically, falling in real terms by at least 30%" [4]. Therefore, the analysis assumes a 30% decrease in total installed cost between a system installed in April 2010 (with a FIT rate or 43.3p/kWh) and April 2012 (with a FIT rate of 21.0p/kWh). Most of this reduction is attributed to a falling cost in module price and therefore is likely to plateau at some stage. However, for the purpose of this study, it is assumed that the total installed price will continue to fall at the same rate until the end of 2012, as discussed in section 1.2.1.

6. No costs associated with end-of-life disposal

This factor is likely to change and will need to be built into next generation performance costing.

3. Results

Results of the financial analysis at the three tariff levels of 43.4p/kWh, 21.0p/kWh and 16.0p/kWh are outlined in Table 5. The analysis shows that domestic PV can still achieve a healthy ROI, even with a reduced FIT rate. The systems installed in 2010, receiving the initial tariff rate of 43.3p/kWh, have experienced a 9–10% ROI. Considering the reduced panel costs, current installations receiving 21.0p/kWh should experience an 8–9% ROI which will fall to approximately 7% ROI when the 16.0p/kWh is introduced in August 2012. Fig. 3 and Fig. 4 illustrate the rate in which the

Table 5
Results from the financial analysis of the case studies.

	Case study 1 (2403 kWh/year)			Case study 2 (2478 kWh/year)		
FIT rate (p/kWh)	43.3	21.0	16.0	43.3	21.0	16.0
ROI (%)	9	8	7	10	9	7
Payback time (years)	10	12	12	9	11	12
Net profit £	30,738	17,741	14,440	32,543	18,886	15,451

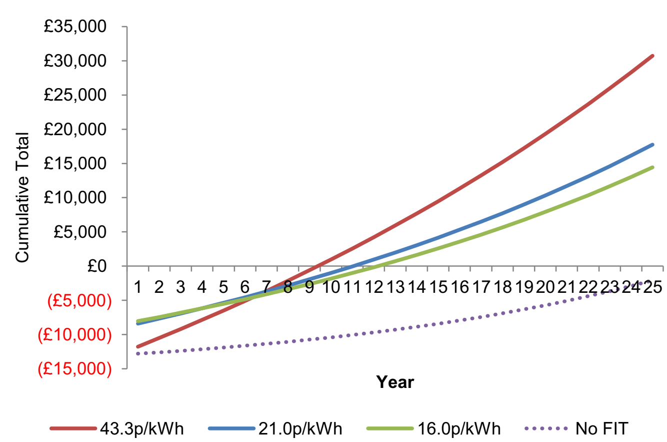

Fig. 3. Annual cumulative total of case study 1.

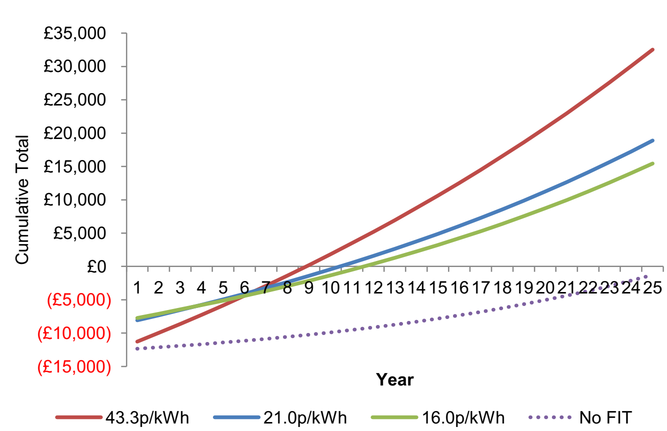

Fig. 4. Annual cumulative total of case study 2.

projects generate income from the three tariff levels. The dotted line represents a hypothetic 'bad' case where no financial support is received for energy generation and the system does not generate enough profit to pay back the initial investment.

4. Conclusions

The cost of purchasing and installing solar PV technology has reduced dramatically since the introduction of the FIT. However, without the financial support from government, solar PV technology cannot currently compete with grid electricity generated from fossil fuels. The reductions in solar PV tariffs recommended by the UK government are expected to delay grid parity and extend the need for financial support of PV installations.

The results from the real-life economic analysis shows that, given the price reduction of installing PV systems, a cut in the FIT will still result in a healthy return on investment (between 6 and 8%). However, property owners should be encouraged to invest in PV systems as a method of off-setting electricity required from the national grid, rather than an economic opportunity. As FIT rates decrease, the industry will observe a reduction in the number of installations under 4 kW and may observe a shift toward larger systems (between 50 kW and 5 MW) taking advantage of the support provided by the RO.

The UK government has reinforced its commitment to "improve energy efficiency, energy security and enable low-carbon technologies" [43]. This is demonstrated by the introduction of new rules which require PV systems under 4 kWp to supply an EPC showing that the property has an EPC band D or better to qualify for the standard rate FIT. These changes hint to the Governments transition from current subsidised schemes to a technologically and economically sustainable scheme in-line with environmental targets. The new framework proposes to consider improvements to the overall energy efficiency of the property [43]. However, as with PV systems installed under the FIT [44] the energy savings of such a scheme may be difficult to monitor. Future economic models will also need to consider any financial implications attached in decommissioning as a result of end-of-life legislation, however the push to sustainable schemes remains high on the agenda.

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