Department
of Energy &
Climate Change

Performance and Impact of the Feed-in Tariff Scheme: Review of Evidence

Final Report

URN [15D/394]

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

Performance and Impact of the Feed-in Tariff Scheme: Review of Evidence

A Report by Dr Colin Nolden, Science Policy Research Unit, Sussex University

For the Department of Energy and Climate Change

Contents

1. Executive Summary

This review summarises evidence gathered to date on the performance of the Feed-in Tariff (FIT) scheme, looking over the 5 years of operation from 1 April 2010 until 31 March 2015. DECC commissioned this review in preparation for the periodic review of the Feed-in Tariff in 2015. Its objective is to assess, where information is available, the success of the FIT in achieving its objectives, which are to:

1) Encourage deployment of small-scale (up to 5MW) low-carbon electricity generation;
2) Empower people and give them a direct stake in the transition to a low-carbon economy;
3) Assist the public take-up of carbon reduction measures;
4) Foster behavioural change in energy use;
5) Help develop local supply chains and drive down energy costs.

The FIT has already succeeded in meeting the top three of its original objectives. The deployment of small-scale (<5 MW) low-carbon electricity generation under the FIT has exceeded projections in terms of numbers of installations (column 2 and 3, Table 1). In terms of cumulative capacity (indirectly specified in column 4 of Table 1) it is rapidly catching up with original projections, while actual generation appears on track to reach projected targets (column 5 and 6, Table 1).

	Cumulative number of FIT installations [2]	Cumulative number of domestic installations [3]	Generation per installation [4]	Total electricity generation [5]	Share of final UK electricity consumption [6]
2010 Impact Assessment	780,000 by 2020	450,000 by 2015	7.7 MWh/a in 2020	6,000 GWh in 2020	1.6% in 2020
Achievement	682,511 end of March 2015	640,344 end of March 2015	5.4 MWh/a in Year 4 (2013/14)	2,645 GWh in Year 4 (2013/14)	0.84% in Year 4 (2013/14)

Table 1: Achievement of the FIT compared to objectives laid out in the 2010 Impact Assessment

We can see that people have been directly empowered through the number of domestic installations (column 3, Table 1) in the FIT, especially <=4kW solar PV systems. Many more people have a direct stake in the transition to a low-carbon economy through participation in, and shared ownership of, school and community energy projects. 60MW of community and shared ownership is supported almost entirely by the FIT. Community energy projects are known to engender greater support for renewables. They may also support a quicker, cheaper passage through planning, thereby assisting the public take-up of carbon reduction measures and the diffusion of low carbon infrastructures.

Public take-up of carbon reduction measures has been encouraged through the FIT not only directly through the uptake of FIT supported technologies (column 2 and 3, Table 1), but also through increased energy awareness. Households with FIT-supported renewable energy installations reduce electricity use from the grid and are more likely to also have energy efficiency measures installed, although the properties involved are typically large, detached and between 30 and 70 years old. Evidence of the FIT directly fostering behavioural change is emerging but not clear. Research findings suggest that targeted, precise and timely information can encourage people to change their energy use behaviour. Successful recent examples indicate that certain domestic routines can be adapted to the availability of free solar power which reduces energy costs and has the potential to offer a financial buffer against fuel poverty.

The FIT's cumulative cost effectiveness per tonne of carbon is still above the projection for the FIT's overall carbon cost effectiveness (column 2, Table 2). However, taking the figure for 2013-14 (Year 4) by itself reveals that year-on-year carbon cost-effectiveness has already exceeded original projections (column 3, Table 2), which suggests that the FIT is on target for reaching original projections. If total FIT-supported electricity generation continues to grow (column 5, Table 1), and as long as the average carbon intensity of electricity generation does not rapidly decline, cumulative carbon savings from the FIT may exceed projections (column 6, Table 2).

	Carbon cost effectiveness (cumulative) (2)	**Carbon cost effectiveness (year on year)** (3)	**Resource cost** (4)	**Domestic bill impact** (5)	**Tonnes of carbon saved** (6)
2010 Impact Assessment	£460/tCO_2	£460/tCO_2	£200/MWh in 2020	£6.50 in 2015	7m to 2020
Achievement	£525.79/tCO_2 in 2013-14	£378.29/tCO_2 in 2013-14	£261/MWh in 2013-14	£9 in 2014	1.3m in 2013-14

Table 2: Achievement of the FIT compared to objectives laid out in the 2010 Impact Assessment

The development of local supply chains as a result of the FIT is not clear cut. For some scales of wind, hydro and anaerobic digestion deployment there appears to be strong UK supply chain development, if not technological leadership. For other scales of FIT-supported wind, hydro and anaerobic digestion deployment, and solar PV more generally, the UK share of the supply chain is primarily in labour and civil construction. Its value to the UK economy should not be underestimated, as solar PV alone directly supported over 15,000 jobs (2012/13) and renewable energy in general is more labour intensive than fossil-fuel generation. This labour intensity has particularly favourable job market effects in times of economic recovery.

The domestic bill impact of the FIT is exceeding original projections by nearly a third (fifth column of Table 2). Policies such as the FIT that encourage the diffusion of immature technologies and target emissions through levies on energy bills generally increase average household electricity bills as they are a form of regressive tax. Given the trajectory of improving carbon cost effectiveness (second and third column of Table 2), the resource cost is also likely to align with projections for 2020 (fourth column of Table 2), pushing the cost of FIT eligible renewable energy technologies ever closer to grid parity.

Emerging influences of the FIT that were not within the scope of original objectives are the diversification of electricity suppliers and the encouragement of business model innovation in terms of funding renewable installations and stimulating technological change. Solar PV plus battery stands out as a technology trend with significant diffusion potential in the long-term. Short-term gains are particularly noticeable in the lowest peak summer demand forecast for 2015 as a result of increasing levels of embedded FIT-supported electricity generation technology, which increases on-site electricity consumption and consequently reduces grid demand and transmission losses.

2. Introduction

2.1 Background to the UK Feed-in Tariff scheme.

The Department of Energy and Climate Change (DECC) introduced the Feed-In Tariff (FIT) scheme on 1 April 2010, under powers in the Energy Act 2008[1] in line with EU 2020 renewable energy targets[2] and UK 2050 decarbonisation targets[3]. Experiences with other policy measures (in particular the Renewables Obligation) suggested that businesses, organisations, communities and individuals outside the energy sector require a simple, accessible policy framework to encourage them to take up renewable electricity generation.

> *'The introduction of the feed-in tariffs will create a subsidy framework for small-scale low carbon technologies which is easily understood, offers more certain returns and covers a wide range of technologies. This will enable broad participation of individuals and communities, as well as energy professionals, in the 'big energy shift' to a low carbon economy'[4].*

HMG's Renewable Energy Strategy in 2009 stated that the FIT would increase public engagement and foster behaviour change by 'bringing renewable electricity generation into communities around the country'[5]. The FIT was specifically designed so that the tariff structure, which encourages the deployment of small-scale (up to and including 5MW), low-carbon electricity generation, represents an incentive for the uptake of small-scale renewable energy technologies[6]. The introduction of the FIT marked a new approach to the deployment of renewable energy technologies in the UK as it is explicitly not technologically neutral, in the sense that specific, less mature technologies, as well as smaller installations, enjoy a higher tariff compared to larger installations or technologies that are closer to grid parity (the point at which a technology can generate power at a levelised cost which is equal to the price of purchasing power from the electricity grid)[7].

The main objectives of the FIT are to:

- Encourage deployment of small-scale (up to and including 5MW) low-carbon electricity generation;
- Empower people and give them a direct stake in the transition to a low-carbon economy;
- Assist the public take-up of carbon reduction measures;

---

[1] UK Parliament, 2008, Energy Act 2008, Parliament of the United Kingdom, London.
[2] House of Lords, 2008, The EU's Target for Renewable Energy: 20% by 2020 – Volume I: Report, House of Lords, London.
[3] UK Parliament, 2008, Climate Change Act, Parliament of the United Kingdom, London.
[4] DECC, 2009, Summary: Intervention & Options URN: 09D/703 – Impact Assessment of Feed-in Tariffs for Small-Scale, Low Carbon, Electricity Generation, Department of Energy and Climate Change, London, p.1.
[5] HMG, 2009, The Renewable Energy Strategy, Her Majesty's Government, London.
[6] DECC, 2010, Feed-in Tariffs – Government's Response to the Summer 2009 Consultation, Department of Energy and Climate Change, London.
[7] Nolden, C., 2013, Regulating the diffusion of renewable energy technologies: Interactions between community energy and the feed-in tariff in the UK, PhD Thesis submitted to the University of Exeter, Exeter.

- Foster behavioural change in energy use;
- Help develop local supply chains and drive down energy costs.

However there are wider benefits, which are recognised but more difficult to quantify, which include consumer engagement (including greater energy awareness potentially leading to demand reduction), diversification of the energy mix, reduced dependence on (imported) fossil fuels, greater energy security at the small scale, business and employment opportunities in developing and deploying renewable energy technologies, avoidance of and reductions in losses through transmission/distribution networks, innovation benefits and potential reductions in technology costs as a result of technological deployment. These are discussed in the wider benefits section of this report.

The technologies supported under FIT are: solar photovoltaic (PV), onshore wind, hydropower, anaerobic digestion (AD) and micro combined heat and power (micro-CHP). Generation and export tariffs are paid for by suppliers and then passed on to consumers through electricity bills. Every technology has a range of tariff bands up to and including 5MW apart from micro-CHP[8]. For micro-CHP the FIT only applies to <=2kW installations.

Tariffs were set to give rates of return between 5-8%, encouraging investment but preventing overcompensation. This only partly succeeded in the case of solar PV and a fast-track review in 2011 and the introduction of quarterly degression were needed to reduce returns, in some cases from double to single digits[9]. Minimum energy efficiency standards (minimum Energy Performance Certificate band D to obtain the higher FIT tariff – below band D received the lower tariff) for the smallest installations (<=250kW) were also introduced to encourage improvements in energy efficiency in properties.

There are different tariff bands for each technology which account for the fact that economies of scale play a decreasing role the smaller the installation is. As a result, smaller installations receive significantly more per kWh of electricity generated than larger installations, in recognition of the greater proportional cost of installation.

Accreditation is also structured differently for different technologies. Wind and solar PV systems with a Declared Net Capacity (DNC) of up to and including 50kW (which are considered microgenerators) as well as micro-CHP installations with a DNC up to and including 2kW must be installed under the Microgeneration Certification Scheme (the MCS-FIT process) and applications should be submitted to a FIT Licensee (licensed electricity supplier with FIT participation status) for accreditation. For solar PV and wind installations with a DNC above 50kW and up to and including 5MW, as well as for all AD and hydro installations up to and including 5MW, applications need to be submitted to Ofgem for Renewables Obligation Order (ROO-FIT) accreditation[10].

---

[8] Current tariff tables available at https://www.ofgem.gov.uk/environmental-programmes/feed-tariff-fit-scheme/tariff-tables

[9] DECC, 2012, Feed-in Tariffs Scheme – Government response to Consultation on Comprehensive Review Phase 2A: Solar PV cost control, Department of Energy and Climate Change, London.

[10] Ofgem, 2015, Applying for the Feed-in-Tariff (FIT) scheme, < https://www.ofgem.gov.uk/environmental-programmes/feed-tariff-fit-scheme/applying-feed-tariff-fit-scheme >.

2.1.1 Methodology

This review summarises evidence gathered over the 5 years of the FIT's operation from 1 April 2010 until 31 March 2015:

Year 1: 1 April 2010 – 31 March 2011

Year 2: 1 April 2011 – 31 March 2012

Year 3: 1 April 2012 – 31 March 2013

Year 4: 1 April 2013 – 31 March 2014

Year 5: 1 April 2014 – 31 March 2015

The primary sources of information are the Department of Energy and Climate Change (DECC) and the Office of Gas and Electricity Markets (Ofgem), either in the form of official statistics, reports, evaluations, policy documents or internal communications. Figures on the number of FIT installations and cumulative capacity are sourced from DECC's statistics on monthly FIT commissioned installations, on which degression is based. These figures are based on the numbers and capacity of installations commissioned and registered on the MCS-FIT (Microgeneration Certification Scheme) and ROO-FIT (Renewables Obligation Order) databases.

Figures on total and average capacity, diversity of generators, electricity generation, carbon emissions and FIT payments budgets have been provided by Ofgem, which uses figures on installations confirmed on the Central Feed-in Tariff Register (CFR). DECC figures for commissioned installations are higher than Ofgem figures as there is a time lag between installations being commissioned and the details being entered by FIT Licensees on the databases and for Ofgem to check that they are eligible before confirming them on the CFR. Around 10% of commissioned installations fail to appear on the CFR as a result of owners not applying for the FIT or accreditation for the FIT being withheld. **DECC** and **Ofgem** statistics are marked in bold to avoid confusion throughout the review.

Further information was provided by relevant stakeholders such as technology providers, gathered through personal communication and collected using a systematic search of relevant databases. Other sources include academic journals and reports from research organisations and trade associations. Grey literature (publications not controlled by commercial publishing) was used in some cases where verified information was not available. Most of the information gathered covers the years 2009-2015, although relevant literature stretches back to 2005, when reports started pointing towards the potential of engagement in energy through the installation of small-scale generation fostering behavioural change. The most concise data is available for Year 1 through to Year 4. Figures from **DECC**'s monthly FIT commissioned installations and **Ofgem**'s CFR figures are available up until the end of Year 5. Other **Ofgem** statistics such as figures on electricity generation and FIT payments are only available up until the end of Year 4.

The quality of evidence was assessed by ensuring the methods used followed academic rigour and thoroughness. Evidence from grey literature, where the adherence to academic research practices cannot be guaranteed, is presented as such and must be assessed in its context. Some passages from the relevant literature have been quoted verbatim. This report does not guarantee that relevant passages have been marked appropriately and the author apologises in advance for shortfalls in accepted referencing practices.

3. Uptake of the FIT

This section provides an overview of the number of installations and the cumulative installed capacity. Broken down by individual tariff bands, it will become evident how certain scales of technological deployment are in much greater demand than others, while a small number of large installations can dwarf a very large number of small installations in terms of installed capacity. It also highlights how original projections failed to foresee the rapid uptake of domestic solar PV, due to the unexpectedly large reductions in module costs. The figures in this section are based on **DECC**'s MCS-FIT and ROO-FIT statistics. Figures on total and average capacity by technology type are based on **Ofgem**'s CFR statistics.

3.1 Number of installations and cumulative capacity

According to **DECC**'s MCS-FIT and ROO-FIT statistics, 682,511 installations with a cumulative capacity of 3,567MW were installed between Year 1 and Year 5 (1 April 2010 and 31 March 2015) of the FIT (see Table 3 and Figure 1).

	Cumulative Installed Capacity (MW)	Cumulative Number of Installations	Cumulative Installed Capacity in %	Cumulative Number of Installations in %
Solar PV	2,992.70	674,218	83.46%	98.75%
Hydro	70.5	644	2.00%	0.10%
Wind	398.2	6,839	11.47%	1.03%
AD	105.4	167	3.05%	0.03%
Micro CHP	0.7	643	0.02%	0.10%
Grand Total	**3,567.40**	**682,511**	**100.00%**	**100.00%**

Table 3: Cumulative installed capacity and cumulative number of installations up until 31 March 2015[11]

3,567MW of cumulative FIT capacity at the end of Year 5 represented around 13.5% of the total installed renewable electricity capacity of 26.4GW in the UK[12]. Figure 1 shows the total number of FIT installations (682,511) according to technology at the end of Year 5 of the FIT.

[11] DECC, 2015, FEED-IN TARIFFS: Commissioned Installations by Month (Up to and including April 2015), Department of Energy and Climate Change, London.
[12] DECC, 2015, Section 6 – Renewables – June 2015, Department of Energy and Climate Change, London.

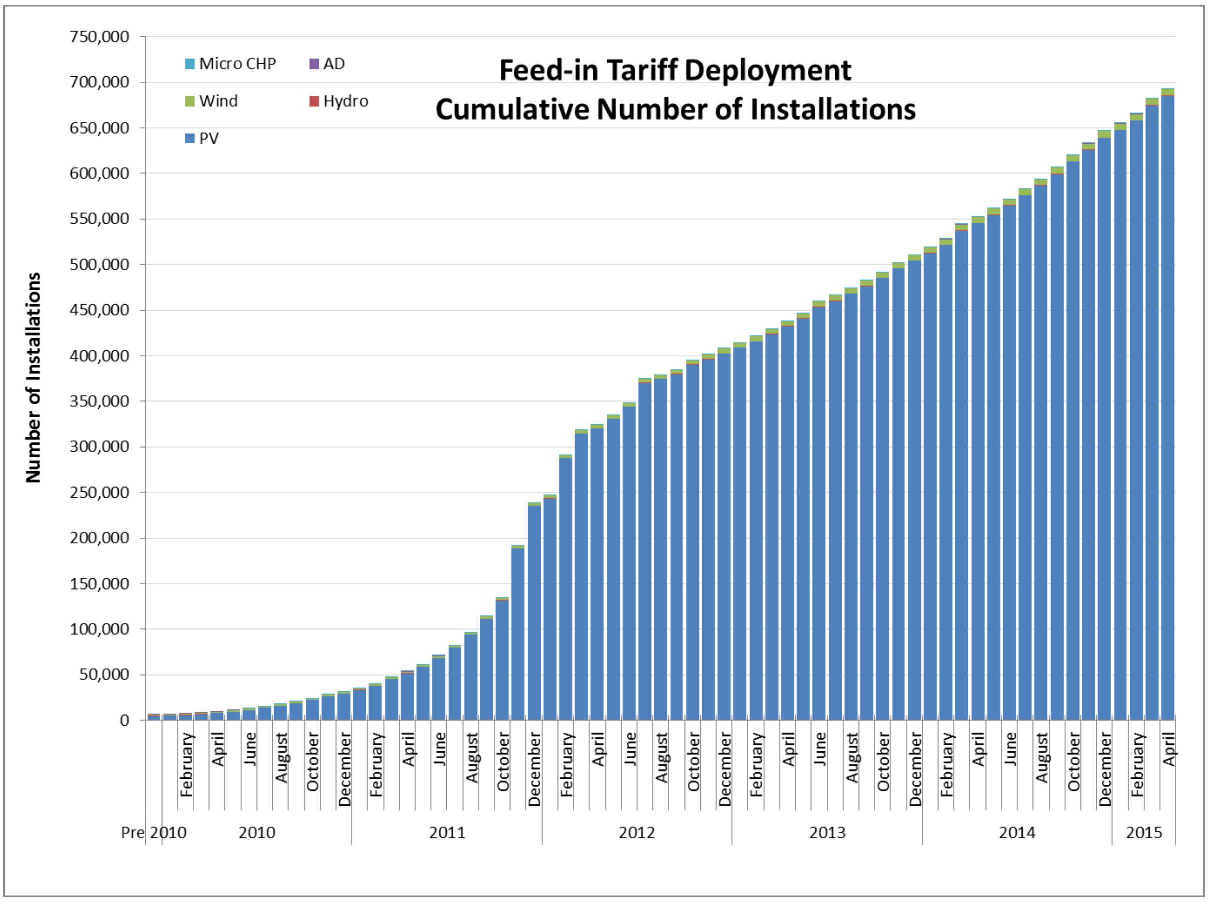


Figure 1: Cumulative number of FIT installations[13]

The 682,511 installations at the end of Year 5 (Figure 1) represent a 30% increase in cumulative installed FIT capacity (see Figure 2) compared to the end of Year 4 from a 25% increase in the number of installations. The discrepancy between the cumulative number of installations and cumulative installed capacity can be illustrated using the example of solar PV and wind. Sub-50kW (microgeneration) solar PV installations represent 99% (669,852) of the total number of solar PV installations, but only 82% (2,452MW) of total solar PV installed capacity. In contrast, wind represents only 1% (6,839) of installations but 11% (398MW) of total installed capacity. As the average capacity of individual wind installations is growing while the average capacity of individual solar PV installations is remaining fairly constant, the share of cumulative wind capacity is growing relative to solar PV[14] (see section on Total and average capacity by technology type). As a result, solar PV still dominates cumulative number of installations but wind and AD play a more notable role in cumulative installed capacity due to the relatively larger average size of installations (see subsections on Wind and AD below). Figure 2 on the cumulative capacity of FIT eligible installations also reflects more accurately electricity generation potential[15].

[13] DECC, 2015, FEED-IN TARIFFS: Commissioned Installations by Month (Up to and including April 2015), Department of Energy and Climate Change, London.
[14] Ofgem, 2014, Feed-in Tariff – Annual Report 2013-14, Office of Gas and Electricity Markets, London.
[15] DECC, 2015, FEED-IN TARIFFS: Commissioned Installations by Month (Up to and including April 2015), Department of Energy and Climate Change, London.

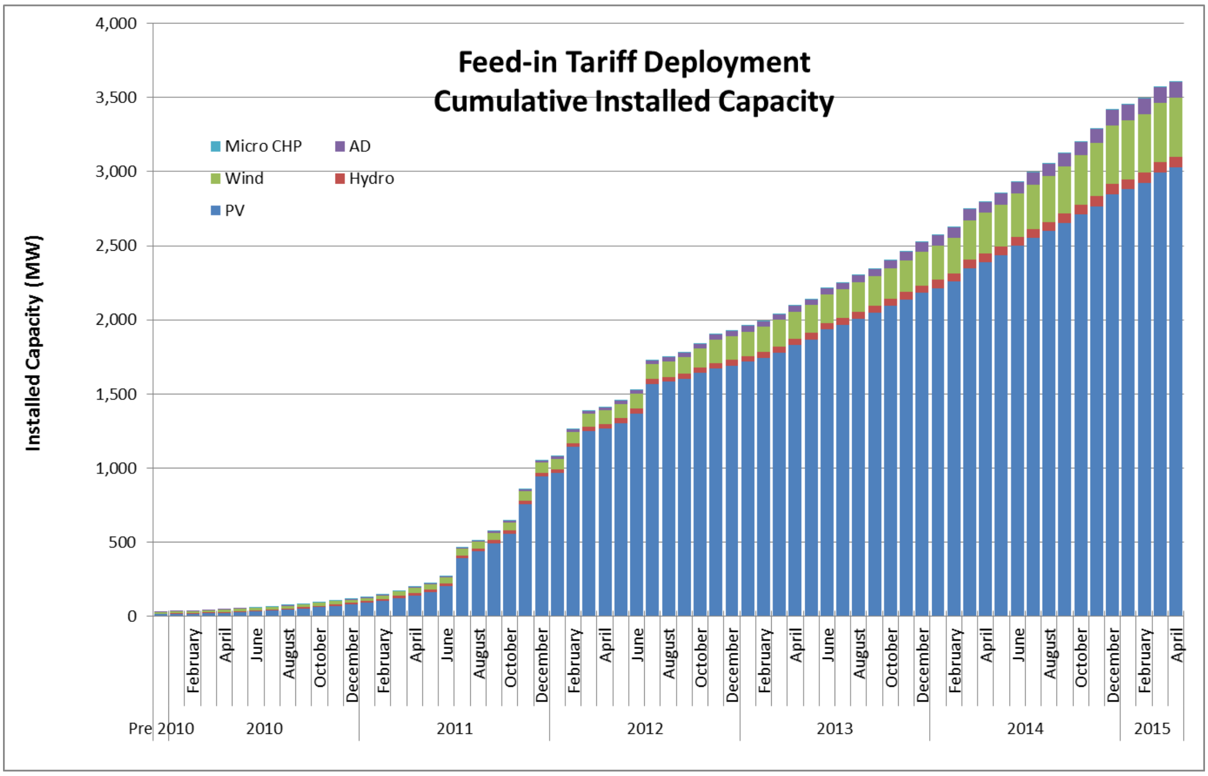


Figure 2: Cumulative installed FIT capacity[16]

The FIT's impact on the diffusion of eligible technologies is particularly evident for solar PV (see Figures 1 and 2). After an initial period of moderate growth in the number of FIT eligible installations in Year 1 (1 April 2010 – 31 March 2011), uptake of solar PV increased rapidly in the second half of Year 2 (1 April 2011 – 31 March 2012) as a result of unanticipated drops in the cost of solar PV systems[17]. According to DECC's Government response to the Consultation on Solar PV Cost control in 2012[18]:

> *'The market for solar PV has seen dramatic changes in recent years, with significant and swift reduction in global costs of the technology… The pace of change in the solar PV market has also exposed the limitations of the FITs scheme in its original form [and] highlighted the need to find a new way to enable solar PV tariffs to respond more nimbly to market developments'*

In 2012 more frequent tariff reductions ("baseline" degression) together with degression dependent on rates of deployment were introduced to enable DECC to better control the costs of the FIT scheme and take into account change in technology costs. Following the implementation of changes, growth in the cumulative number of installations slowed down from peaks of more than 25,000 installations a month (over 5,000 a week) to a more sustainable rate of around 10,000 installations a month, more in line with DECC predictions as demonstrated in Figure 3. Although in FITs Year 5, growth in installations often exceeded 10,000 a month.

[16] DECC, 2015, FEED-IN TARIFFS: Commissioned Installations by Month (Up to and including April 2015), Department of Energy and Climate Change, London.

[17] DECC, 2012, Feed-in Tariffs Scheme – Government response to Consultation on Comprehensive Review Phase 2A: Solar PV cost control, Department of Energy and Climate Change, London.

[18] DECC, 2012, Feed-in Tariffs Scheme – Government response to Consultation on Comprehensive Review Phase 2A: Solar PV cost control, Department of Energy and Climate Change, London.

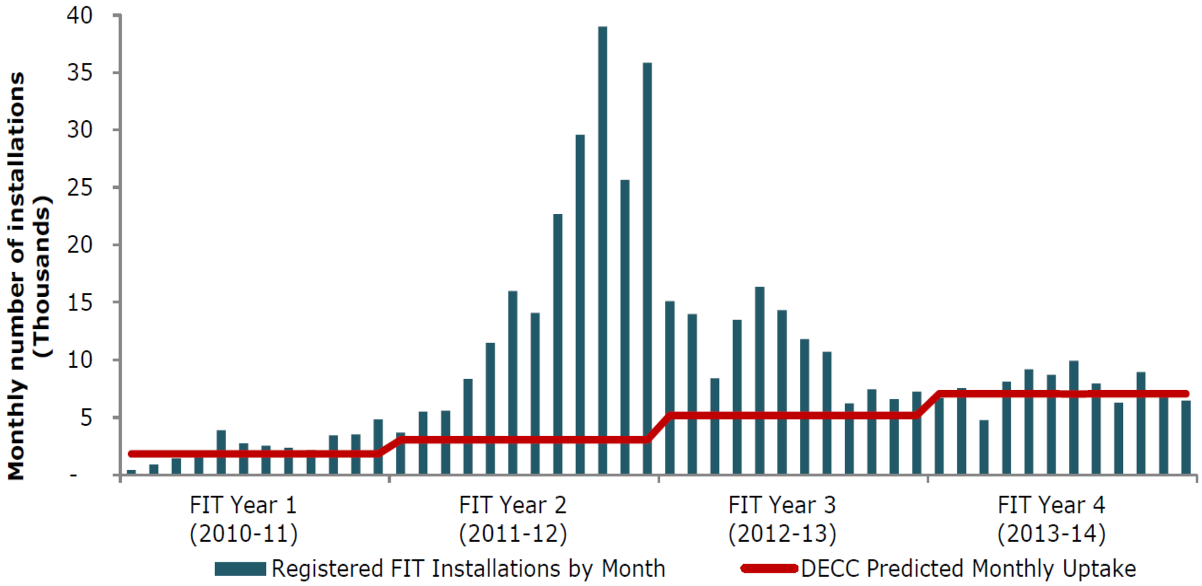


Figure 3: Monthly FIT accreditation compared to DECC predictions[19]

The amount of electricity generated (2,645 GWh in Year 4) is in line with DECC's original projections, although the number of installations is far greater than was forecast (see Figure 4).

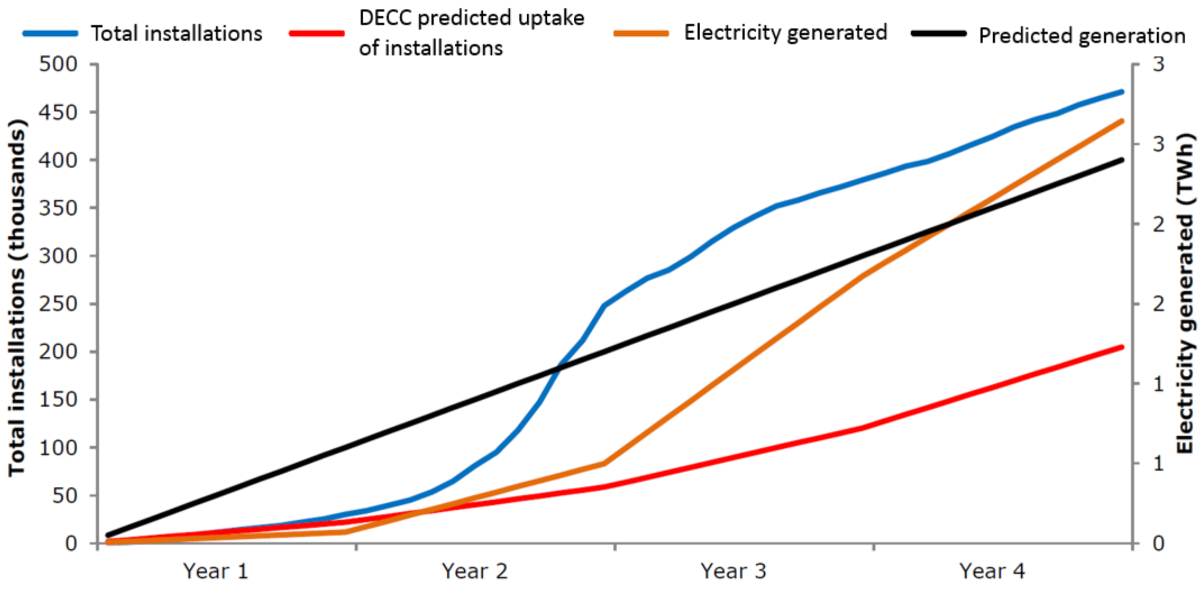


Figure 4: FIT uptake and generation compared to DECC predictions[20]

Figure 4 shows how original projections foresaw a relatively small number of FIT installations generating a relatively large amount of electricity. The reason behind the number of installations outstripping DECC predictions while the amount of electricity generated per installation is lagging behind is the unforeseen popularity of <=4kW domestic solar installations rather than non-domestic solar PV and other technologies with larger average load factors[21].

[19] Ofgem, 2014, Feed-in Tariff – Annual Report 2013-14, Office of Gas and Electricity Markets, London.
[20] Ofgem, 2014, Feed-in Tariff – Annual Report 2013-14, Office of Gas and Electricity Markets, London.
[21] Ofgem, 2014, Feed-in Tariff – Annual Report 2013-14, Office of Gas and Electricity Markets, London.

3.1.1 Uptake of Solar photovoltaic (Solar PV)

As is evident from Table 3 and Figure 1, Solar PV dominates FIT installations. 674,218 out of a total of 682,511 are solar PV installations, which represents a 99% share. Within that 99% share, domestic <= 4kW installations dominate with a share of 95% of all solar PV installations to date (see Figure 5, which shows both MCS-FIT and ROO-FIT installations). Commonly referred to as retrofit installations by Ofgem (although around 2% of <=4kW solar PV systems are installed on new build properties), the rapid uptake of <=4kW installations is the result of the relative simplicity of installing solar PV panels on roofs of privately owned dwellings (with 561,404 of a total of 591,600 solar PV installation confirmed on **Ofgem**'s CFR at the end of Year 5 registered as domestic installations)[22].

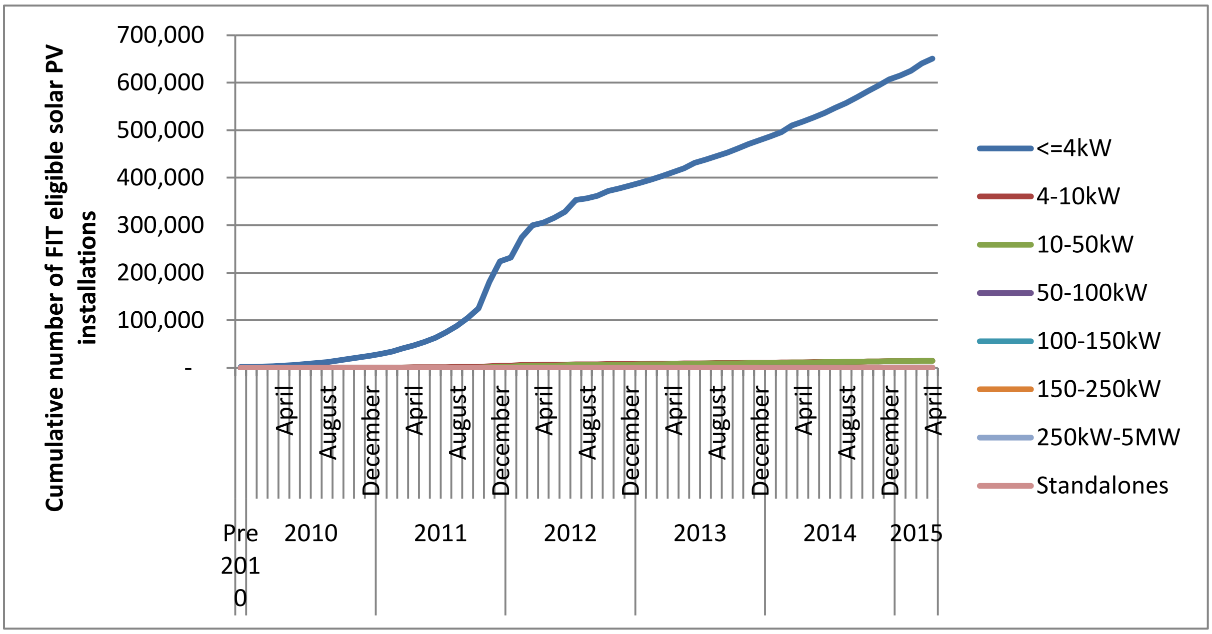


Figure 5: Cumulative number of FIT eligible solar PV installations[23]

The popularity of domestic PV installations is the result of a combination of generous tariffs for <=4kW installations (especially between 1 April 2010 and 3 March 2012 – see Annex 1) that continue for the duration of the 20 year (previously 25 year) Eligibility Period, the fact that 50% of electricity is deemed to be exported from installations (which increases the return of investment as the export tariff applies in addition to the generation tariff, even if all the electricity is used on site) and 'free' electricity in daylight hours. A study commissioned by Citizen's Advice[24] shows that the statement that the 'FIT represents a good investment' is supported by 74% of a sample of 501 domestic solar PV users that purchased their systems outright or on finance, although this figure declined from 80% of those installing pre-2013 to 58% of those installing 2013 or later.

Compared to the cumulative number of 95% of all solar PV installations, domestic <=4kW installations only represent 62% of cumulative installed capacity. Figure 6 shows that the 10-50kW band has the second largest share of cumulative installed capacity (16% of the total). The

[22] DECC, 2015, Monthly Central Feed-in Tariff Register Statistics (March 2015), Department of Energy and Climate Change, London.
[23] DECC, 2015, FEED-IN TARIFFS: Commissioned Installations by Month (Up to and including April 2015), Department of Energy and Climate Change, London.
[24] Flanagan, B., Wilkinson, T., 2015, Solar PV User Experience, Citizens Advice, London.

relatively small number of 250kW-5MW (70 in total) and Standalones (107 in total) have around three times the cumulative capacity of over 14,500 4-10kW systems[25].

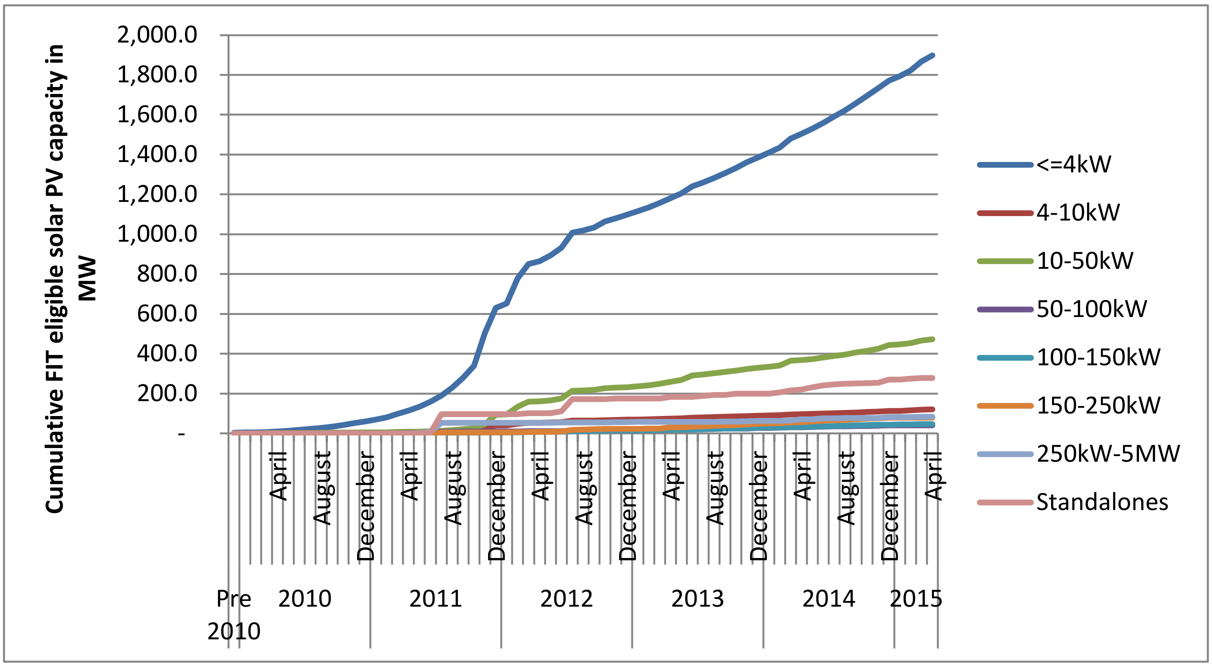


Figure 6: Cumulative installed FIT eligible solar PV capacity[26]

A closer look at ROO-FIT solar PV installations (>50kW, Figure 7) reveals a greater diversity in terms of number of installations according to tariff band, although smaller solar PV installations in general are more popular.

Standalones in Figure 7 refers to solar PV installations on ground-mounted arrays. They range in size, although there is a tendency for large (>1MW) ‘solar farm’ installations. Solar farms’ popularity, also as installations > 5MW which used to fall under the Renewables Obligation as opposed to the FIT, is linked to the absence of split incentives as the lease of land is easier to negotiate than the lease of a roof.

Split incentives, also known as landlord-tenant issues, arise from the occupiers of properties suitable for solar PV installation not owning the property. This causes problems regarding insurance of roof mounted solar PV systems and the distribution of FIT remuneration. At a domestic scale it refers to the difficulty of negotiating the installation of roof or wall mounted domestic solar PV systems if the main benefactor of the FIT (such as an investor) is not the owner or the occupier of the property on which the system is installed.

[25] DECC, 2015, FEED-IN TARIFFS: Commissioned Installations by Month (Up to and including April 2015), Department of Energy and Climate Change, London.
[26] DECC, 2015, FEED-IN TARIFFS: Commissioned Installations by Month (Up to and including April 2015), Department of Energy and Climate Change, London.

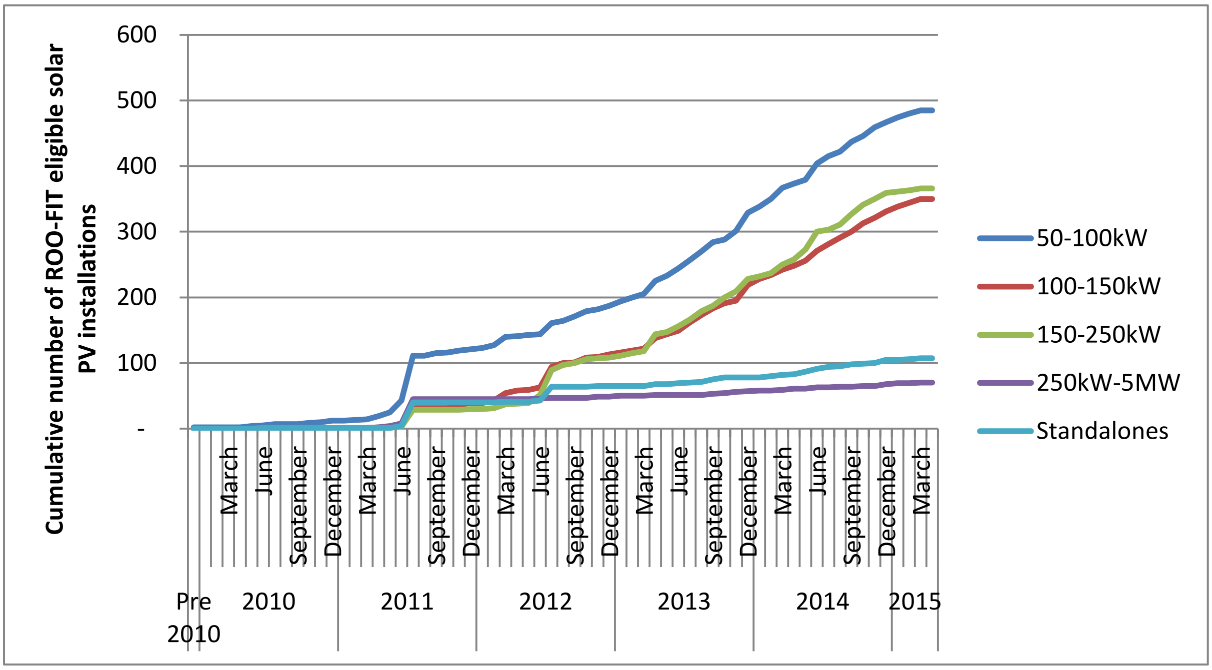


Figure 7: Cumulative number of ROO-FIT eligible solar PV installations[27]

As a result of the unexpected popularity of domestic installations, the number of solar PV installations is exceeding projections of the 2010 Impact Assessment. It was originally anticipated that 725,000 (IA 2010[28]) domestic systems would be installed by 2020 and, as of 31 March 2015, there are already 640,344 domestic solar PV systems installed.

[27] DECC, 2015, FEED-IN TARIFFS: Commissioned Installations by Month (Up to and including April 2015), Department of Energy and Climate Change, London.
[28] DECC, 2010, Impact Assessment of Feed-in Tariffs for Small-Scale, Low Carbon, Electricity Generation, Department of Energy and Climate Change, London.

3.1.2 Uptake of Wind

The total installed capacity of wind under the FIT increased in proportion from around 4% in Year 2 to 10% in Year 5[29]. Overall, the scalar diversity of wind turbines supported by the FIT is greater than the scalar diversity of solar PV (see Figure 8).

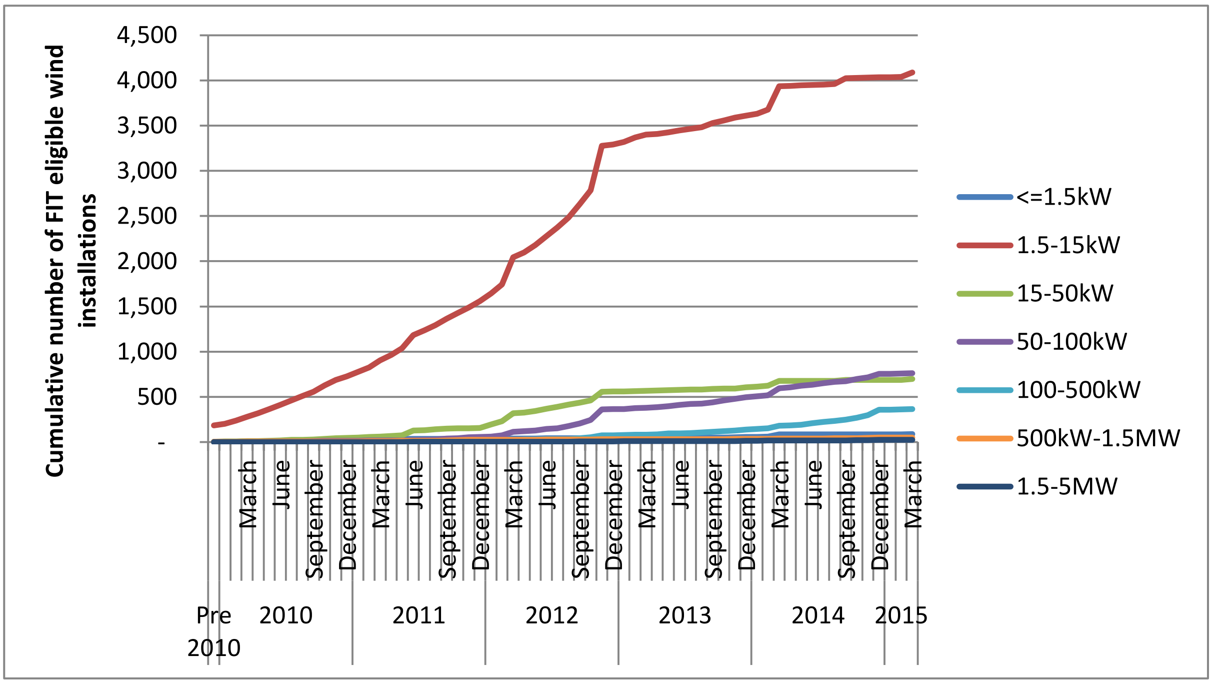


Figure 8: Cumulative number of all FIT eligible wind installations[30]

This diversity can be attributed to non-linear increases in spatial requirements for larger wind turbines (compared to solar PV). What is notable is the rapid increase in the number of 100-500kW turbines installed compared to wind turbines that fall into other tariff bands between December 2012 and December 2014. This has been linked to the practice of de-rating[31], which is the deliberate capping of the power output of wind turbines to a level less than that originally intended for a particular model of turbine. Since December 2014 the number of installations appears to be stagnating for most tariff bands except the 1.5-15kW tariff band. This is likely to be the result of most developers of >50kW installations having applied for pre-accreditation in December 2013, which gave them 12 months in which to build from the date of application to receive the fixed tariff and resulted in a rush to commission and accredit in the last quarter of 2014.

[29] DECC, 2015, FEED-IN TARIFFS: Commissioned Installations by Month (Up to and including April 2015), Department of Energy and Climate Change, London.
[30] DECC, 2015, FEED-IN TARIFFS: Commissioned Installations by Month (Up to and including April 2015), Department of Energy and Climate Change, London.
[31] IPPR, 2015, Feed-in Frenzy, Institute for Public Policy Research, London.

As with solar PV, larger wind installations above 50kW fall under ROO-FIT (see Figure 9). Compared to solar PV, however, wind turbines are only rarely roof or wall mounted as physical structures cause air turbulences, which limit their generation capacity. Wind turbines require careful siting to benefit from the local wind regime and to ensure a reasonable payback period. Microgeneration turbines (<50kW) play an important role in terms of numbers (Figure 8) but only a minor role in terms of cumulative capacity (see Figure 10). According to RenewableUK[32], the slowing uptake of microgeneration turbines is likely to be the result of tariff decreases far in excess of industry CAPEX and the introduction of a single band for all turbines under 100kW instead of separate bands for 0-1.5kW, 1.5-15kW and 15-100kW (see section on Impact of FIT on the economy).

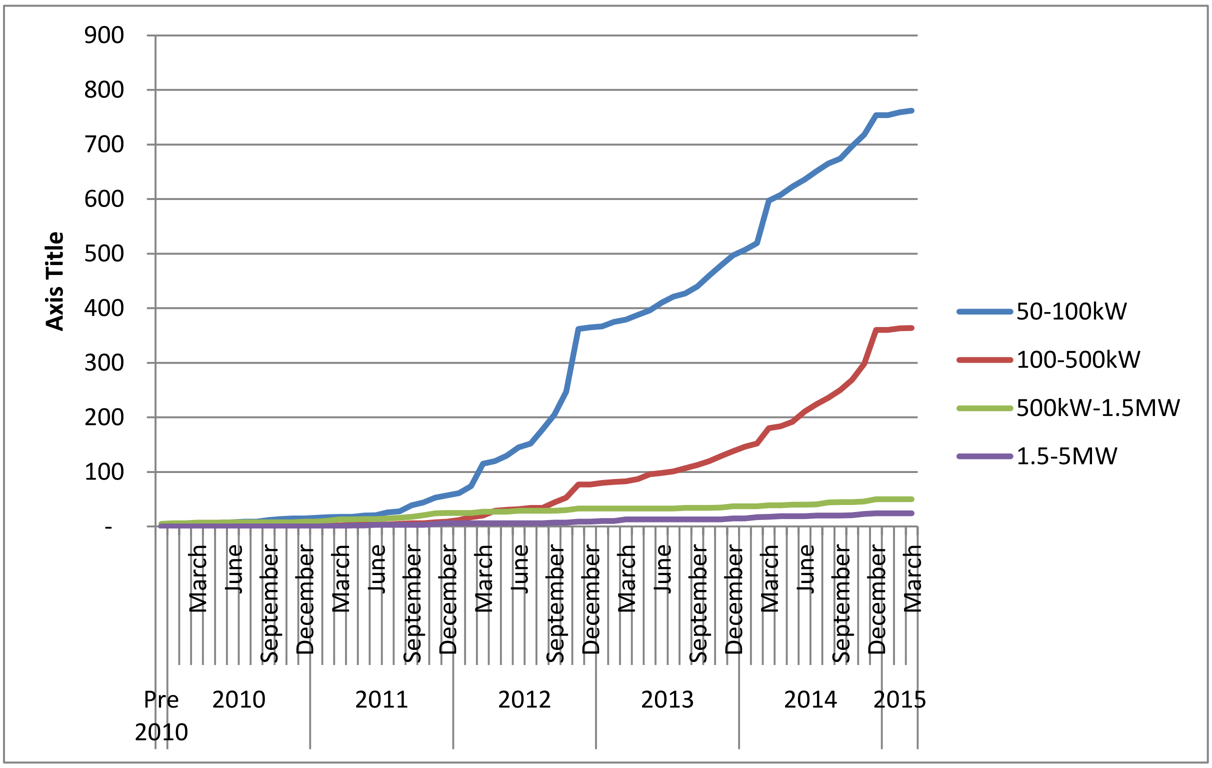


Figure 9: Cumulative number of ROO-FIT eligible wind installations[33]

The dangers of decreasing tariffs voiced by industry appear to have taken effect on the cumulative capacity of eligible wind installations. Figure 10 shows that growth of cumulative installed capacity across all tariff bands declined since December 2014. It also shows that cumulative wind capacity is spread fairly evenly across tariff bands and that 500kW-1.5MW

[32] RenewableUK, 2014, Small and Medium Wind Strategy, RenewableUK, London.

[33] DECC, 2015, FEED-IN TARIFFS: Commissioned Installations by Month (Up to and including April 2015), Department of Energy and Climate Change, London.

installations, which proved very popular in the first 2.5 years of the FIT, have been overtaken by the cumulative installed capacity under the comparatively small 100-500kW band[34].

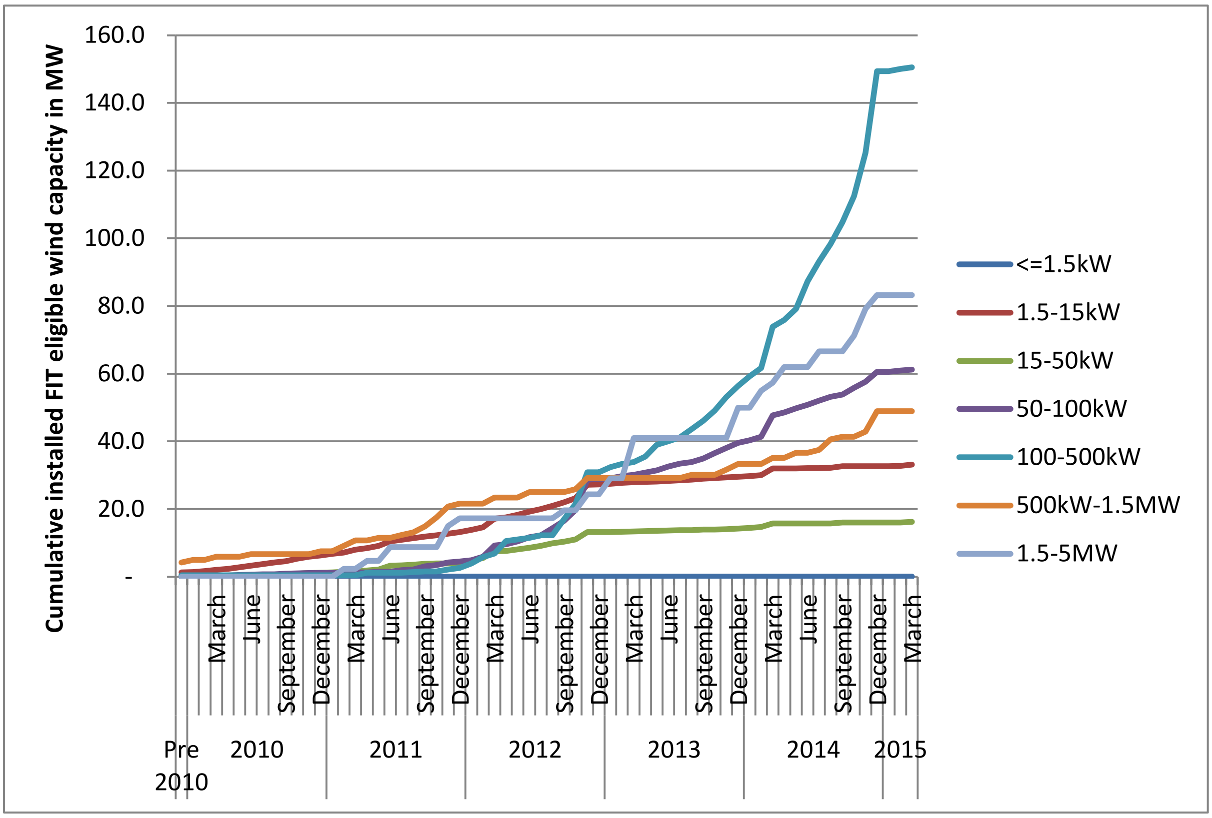


Figure 10: Cumulative installed FIT eligible wind capacity[35]

The larger 1.5-5MW tariff band experienced the second largest year-on-year growth in terms of number of installations, with 57% more installations by the end of December 2014 compared to December 2013. Cumulative installed capacity for the same band increased by 66% over the same period, indicating that within this tariff band, the average size of wind installation is growing. Since December 2014, however, no growth in cumulative capacity for this tariff band has been recorded. This decline is linked to the abovementioned impact of pre-accreditation.

[34] DECC, 2015, FEED-IN TARIFFS: Commissioned Installations by Month (Up to and including April 2015), Department of Energy and Climate Change, London.
[35] DECC, 2015, FEED-IN TARIFFS: Commissioned Installations by Month (Up to and including April 2015), Department of Energy and Climate Change, London.

3.1.3 Uptake of Hydroelectric

The diversity of hydroelectric (hydro) technology installed since April 2010 under the FIT (Figure 11) is even greater than the diversity of wind turbines (Figure 8). Small hydroelectric installations (<=15kW) dominate in terms of total numbers but medium size hydroelectric turbines (in excess of the <50kW microgeneration scale) are increasingly popular, with growth in the number of 50-100kW hydroelectric turbine installations outstripping the growth in smaller turbines[36]. Compared to the relative growth in <=15kW turbines, the cumulative number of larger turbines installed under the FIT is declining.

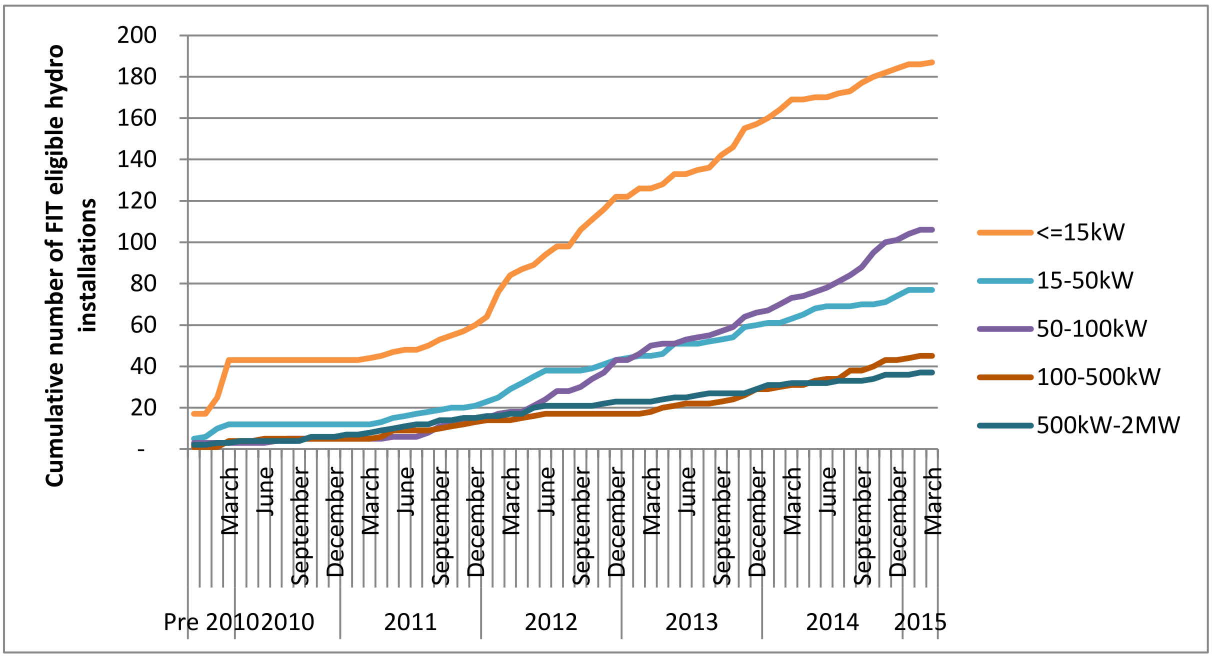


Figure 11: Cumulative number of FIT eligible hydro installations[37]

The cumulative capacity of hydro installations (Figure 12) is dominated by installations falling under the second highest tariff band (500kW- 2MW). **Ofgem**'s CFR registered the first two installations in this tariff band in Year 5. There is a noticeable relative increase in the number of 50-100kW installations since late 2011 (see Figure 11). In general, uptake of larger installations is slowing with a general trend towards smaller installations as a share of the overall number of hydro[38].

[36] DECC, 2015, FEED-IN TARIFFS: Commissioned Installations by Month (Up to and including April 2015), Department of Energy and Climate Change, London.
[37] DECC, 2015, FEED-IN TARIFFS: Commissioned Installations by Month (Up to and including April 2015), Department of Energy and Climate Change, London.
[38] Ofgem, 2014, Feed-in Tariff – Annual Report 2013-14, Office of Gas and Electricity Markets, London.

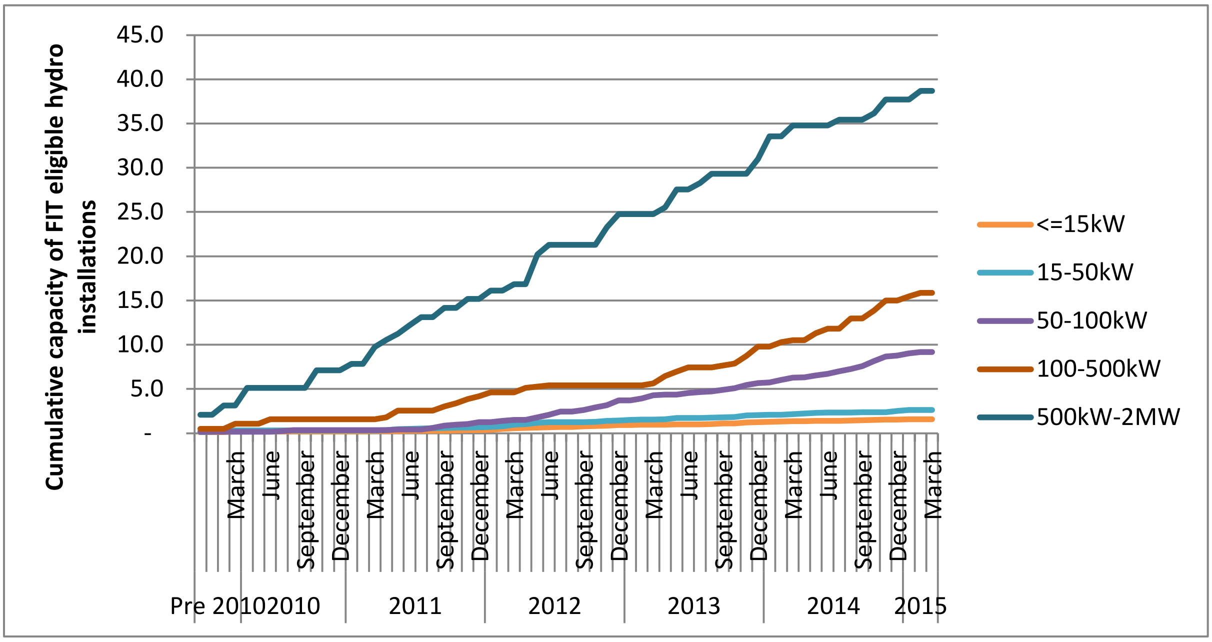


Figure 12: Cumulative capacity of FIT eligible hydro installations[39]

The downturn of hydro's average capacity per installation following a peak in Year Two (1 April 2011 – 31 March 2012), despite relatively constant numbers of installations registered over the years, may partly be attributed to geographical limitations as there are only a finite number of locations suitable for hydro installations and those sites that can offer larger capacities are likely to have been chosen first for installation[40].

The British Hydropower Association[41] points to degression as one of the main reasons for slowing growth (see Impact of FIT on the economy), as only 60MW of small-scale hydroelectric potential been exploited to date using the FIT[42] despite a potential for 1-2.5GW of small-scale hydro in England and Wales alone[43].

[39] DECC, 2015, FEED-IN TARIFFS: Commissioned Installations by Month (Up to and including April 2015), Department of Energy and Climate Change, London.

[40] DECC, 2015, FEED-IN TARIFFS: Commissioned Installations by Month (Up to and including April 2015), Department of Energy and Climate Change, London.

[41] British Hydropower Association, 2015, Small-scale hydro – An integral part of the UK renewable energy mix, Presentation for a meeting with Amber Rudd, 11 March, 2015.

[42] DECC & HMG, 2015, Delivering UK Energy Investment: Low Carbon Energy, Department of Energy and Climate Change & Her Majesty's Government, London.

[43] EA, 2010, Mapping Hydropower Opportunities and Sensitivities in England and Wales, Environment Agency, London.

3.1.4 Uptake of Anaerobic Digestion (AD)

The cumulative installed capacity of AD increased in proportion from around 1% of the FIT total in Year 2 to 3% in Year 5[44]. For AD, the FIT only distinguishes between three different tariff bands. Unlike other technologies, the highest band (500kW-5MW) experienced rapid uptake and even outstripped the number of installations under other tariff bands on two occasions, November 2012 and January 2013 (see section on Impact of FIT on the economy for more information). Since then, however, the number of installations that fall under the <=250kW and 250-500kW tariff bands has grown considerably faster (see Figure 13)[45].

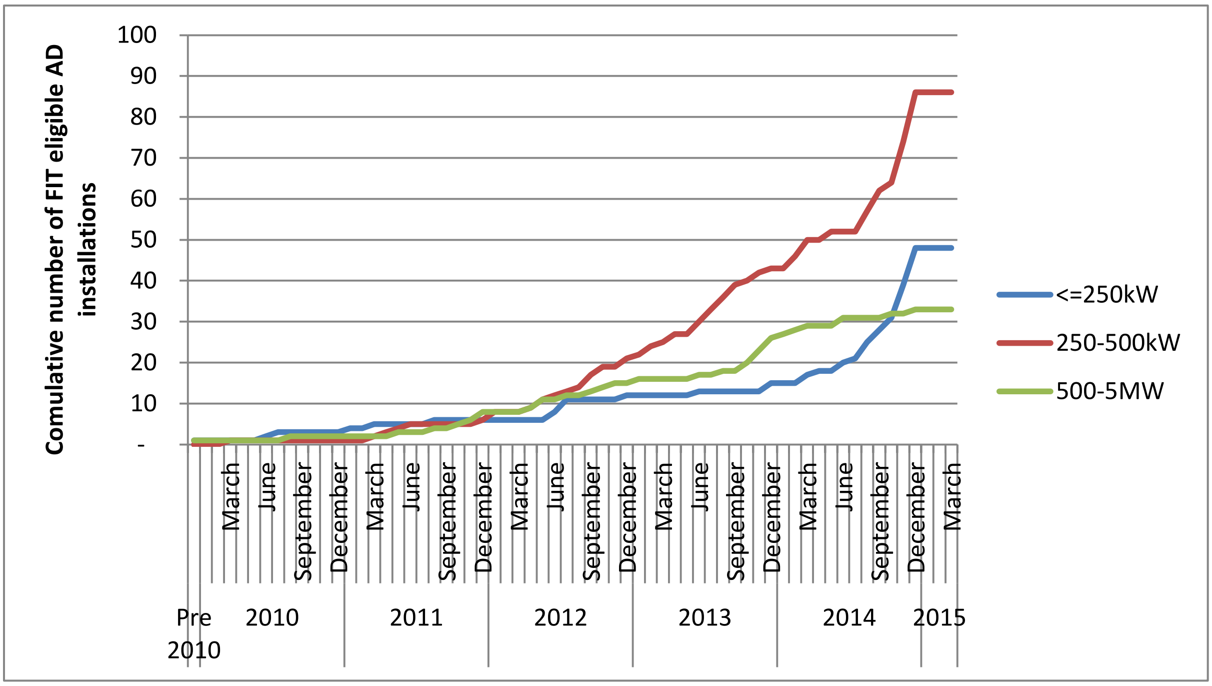


Figure 13: Cumulative number of FIT eligible AD installations[46]

In contrast to other FIT eligible technologies, the purpose of AD plants is principally for waste management and the scale of AD plants is generally determined by the availability of waste. Waste-fed plants (e.g. where municipal, commercial and industrial wastes contribute over 50% towards the total feedstock requirement) tend to be larger (>1MW) and based on collections from a wider area. Farm-fed plants (e.g. where manure, slurry, energy crops and crop wastes contribute over 50% towards the total feedstock requirement) tend to be much smaller (<1MW)[47]. The smallest tariff band (<=250kW) is the most likely to be farm-waste-fed, given the restriction on transporting farm wastes. The growth in smaller installations compared to larger waste-fed plants is attributed by Ofgem[48] to the increasing awareness among commercial property owners (farmers) of the long-term benefits of the FIT. It has also coincided with the

[44] Ofgem, 2014, Feed-in Tariff – Annual Report 2013-14, Office of Gas and Electricity Markets, London.
[45] DECC, 2015, FEED-IN TARIFFS: Commissioned Installations by Month (Up to and including April 2015), Department of Energy and Climate Change, London.
[46] DECC, 2015, FEED-IN TARIFFS: Commissioned Installations by Month (Up to and including April 2015), Department of Energy and Climate Change, London.
[47] NNFCC, 2015, DC15-04 AD Deployment Update for DECC – January 2015, York.
[48] Ofgem, 2014, Feed-in Tariff – Annual Report 2013-14, Office of Gas and Electricity Markets, London.

actions from the Anaerobic Digestion Strategy and Action Plan[49] reducing barriers to the farm sector, for instance by establishing the Anaerobic Digestion web portal[50].

Industry claims that different FIT tariff levels in different bands combined with a low degression trigger tend to push AD plants to favour lower-cost, high quality crops over farm wastes. This is exacerbated by the fact that the degression band at 500kW is not aligned with the <=250kW and 250-500kW tariff bands, so an increase in larger 250-500kW AD installations has a disproportionate impact on the smallest scale AD.

Figure 14 shows that on average, in terms of installed capacity, AD plants are larger than other technologies supported by the FIT. Large-scale 500kW-5MW installations dominate cumulative installed capacity despite a rapid increase in deployment of <500kW AD plants in late 2014.

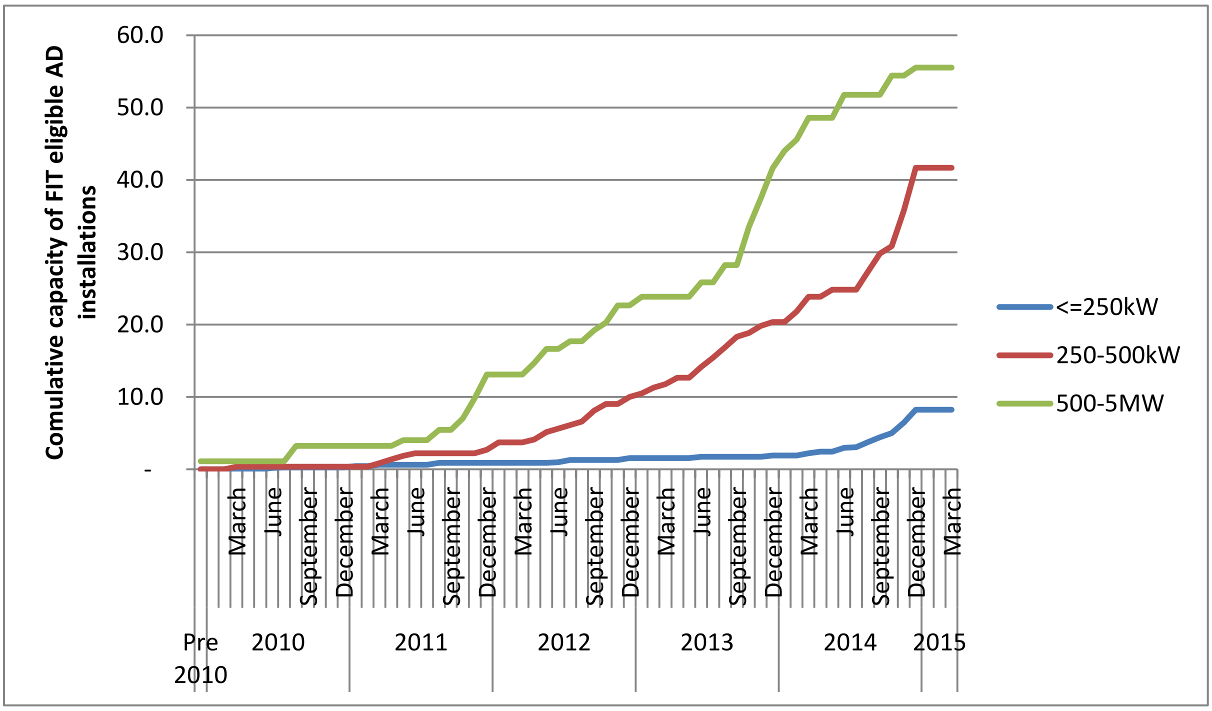


Figure 14: Cumulative capacity of FIT eligible AD installations[51]

[49] DECC & Defra, 2011, Anaerobic Digestion Strategy and Action Plan, Department of Energy and Climate Change and Department for Environment, Food and Rural Affairs, London.

[50] http://www.biogas-info.co.uk/

[51] DECC, 2015, FEED-IN TARIFFS: Commissioned Installations by Month (Up to and including April 2015), Department of Energy and Climate Change, London.

3.1.5 Uptake of Micro-CHP

Unlike other FIT-eligible technologies, only <=2kW micro-CHP is supported under the FIT, as it is not necessarily a renewable energy technology and its FIT is intended as a trial (it is referred to as the Micro-CHP pilot in the FIT Impact Assessment). The number of micro-CHP installations trebled in 2011 before growth considerably slowed down (Figure 15). With less than 700 installations it is far from reaching the 30,000 projected installations by 2030[52] that would be supported by the FIT or the threshold of 12,000 installations that would have triggered a review of tariffs[53]. Total installed capacity is around 0.7 MW.

According to the Combined Heat and Power Association (CHPA) in 2012, tariff levels were too low to sustain growth in micro-CHP deployment, despite the UK's current world leadership in the development of green technology micro-CHP[54]. Despite DECC following up the CHPA's suggestion to increase the tariff on 16 March 2013, albeit at a slightly lower level (13.45p/kWh) than the CHPA proposal (to 15p/kWh), market growth continued to decline. Current year-on-year increase of around 4% is an indication that this increase in tariff was not sufficient to trigger sustained market growth. Considering the very slow growth in micro-CHP deployment it is questionable whether a slightly higher tariff (15p/kWh instead of 13.45p/kWh) would trigger significant market growth. It is possible that the introduction of the Renewable Heat Incentive shifted interest from micro-CHP towards heat generating technologies. Online commentaries also point out that there is a distinct lack of trustworthy information on the advantages and disadvantages of micro-CHP[55] as claims on cost reductions and competitiveness in 2010 never materialised.

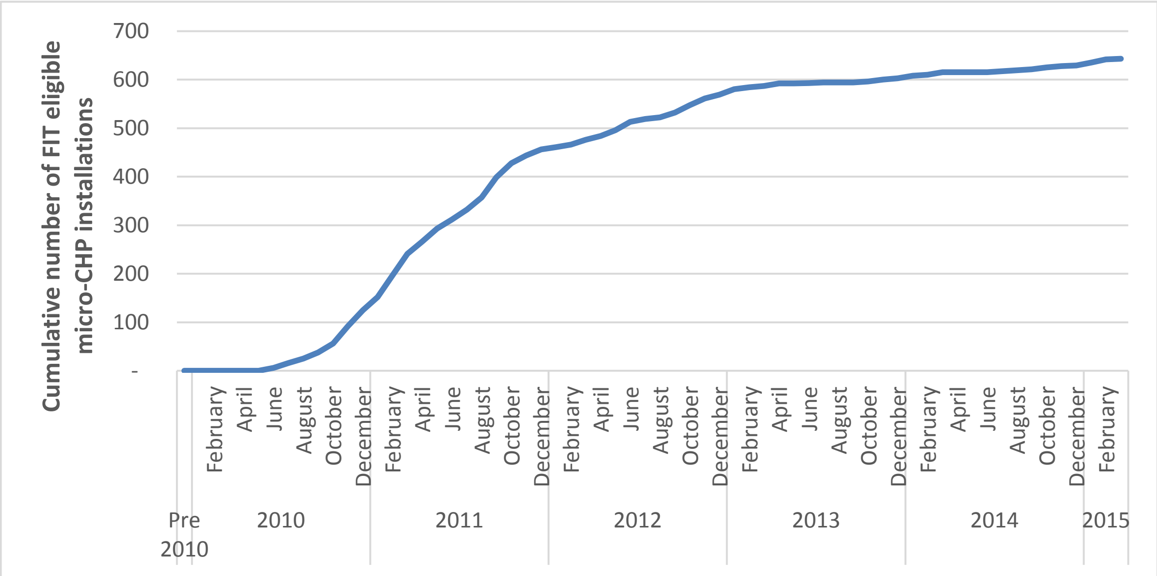


Figure 15: Cumulative number of FIT eligible micro-CHP installations[56]

---

[52] DECC, 2010, Impact Assessment of Feed-in Tariffs for Small-Scale, Low Carbon, Electricity Generation, Department of Energy and Climate Change, London.

[53] DECC, 2010, Feed-in Tariffs – Government's Response to the Summer 2009 Consultation, Department of Energy and Climate Change, London.

[54] CHPA, 2012, CHPA response to 'Feed-in Tariff Comprehensive Review Phase 2B' Consultation, Combined Heat and Power Association, London.

[55] Fixter, S., 2011, Is domestic CHP dead and buried?, YouGen blog, < http://www.yougen.co.uk/blog-entry/1660/Is+domestic+CHP+dead+and+buried%273F/ >.

[56] DECC, 2015, FEED-IN TARIFFS: Commissioned Installations by Month (Up to and including April 2015), Department of Energy and Climate Change, London.

3.2 Total and average capacity by technology type

According to **Ofgem**'s CFR registry[57], the share of solar PV as a share of total installed capacity has continued to fall from 94% in Year 2 to 79% in Year 4 (Figure 16). The percentage of installed capacity of wind, on the other hand, has increased from 4% in Year 2 to 14% in Year 4. Similarly, AD increased its proportion from 1% in Year 2 to 5% in Year 4. Figures from Year 1 do not reflect the trend as the share of wind and hydro installations transferred from the RO outnumbered installations registered outright on the CFR in Year 1. Recent CFR statistics indicate that installed wind capacity in Year 5 is in the range of 10-15% of total installed capacity, AD is 3-4% while solar PV stands at around 80-85%[58].

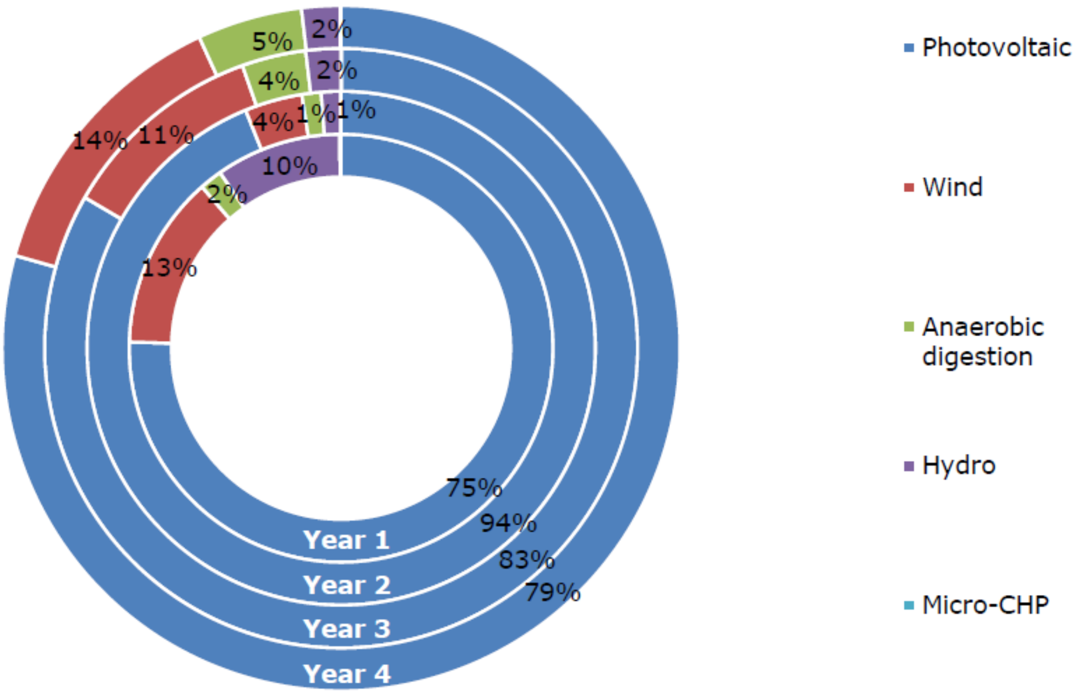


Figure 16: Total installed capacity by technology type[59]

What is interesting, and not immediately obvious by looking at Figure 16, is the changes in average capacity by technology. Figure 17 shows the change in average capacity by technology type between Year 1 and 4. Figures for Year 5 suggest that the average capacity of wind installations has jumped to 154kW/installation, solar PV has remained constant at 5.36kW/installation, Micro CHP remains unchanged, AD has declined to 680kW/installation while hydro has seen a remarkable increase to 207kW/installation. If the two 2-5MW installations that appear on the **Ofgem**'s CFR register (but not on **DECC**'s deployment statistics) are excluded, this figure drops to 174kW/installation[60].

[57] Ofgem, 2014, Feed-in Tariff – Annual Report 2013-14, Office of Gas and Electricity Markets, London.
[58] DECC, March 2015 Monthly Central Feed-in Tariff Register Statistics, Department of Energy and Climate Change, London.

[59] Ofgem, 2014, Feed-in Tariff – Annual Report 2013-14, Office of Gas and Electricity Markets, London.
[60] DECC, March 2015 Monthly Central Feed-in Tariff Register Statistics, Department of Energy and Climate Change, London.

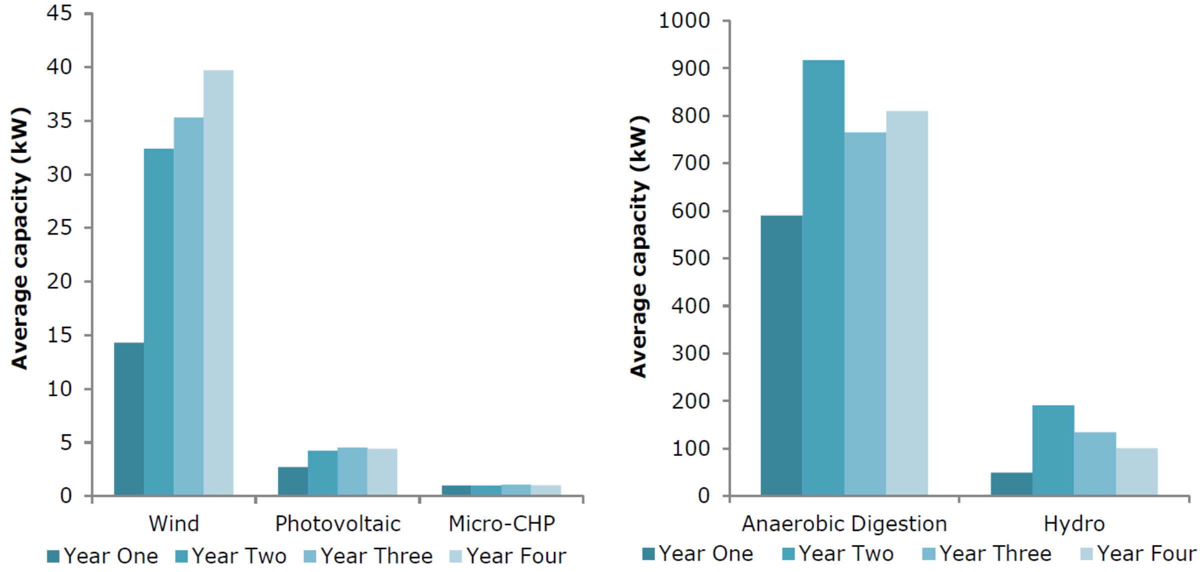


Figure 17: Total installed capacity by technology type[61]

Figure 18 compares unverified information on the monthly number of installations by technology type compared to the monthly installed capacity of solar PV, wind, hydro and AD.

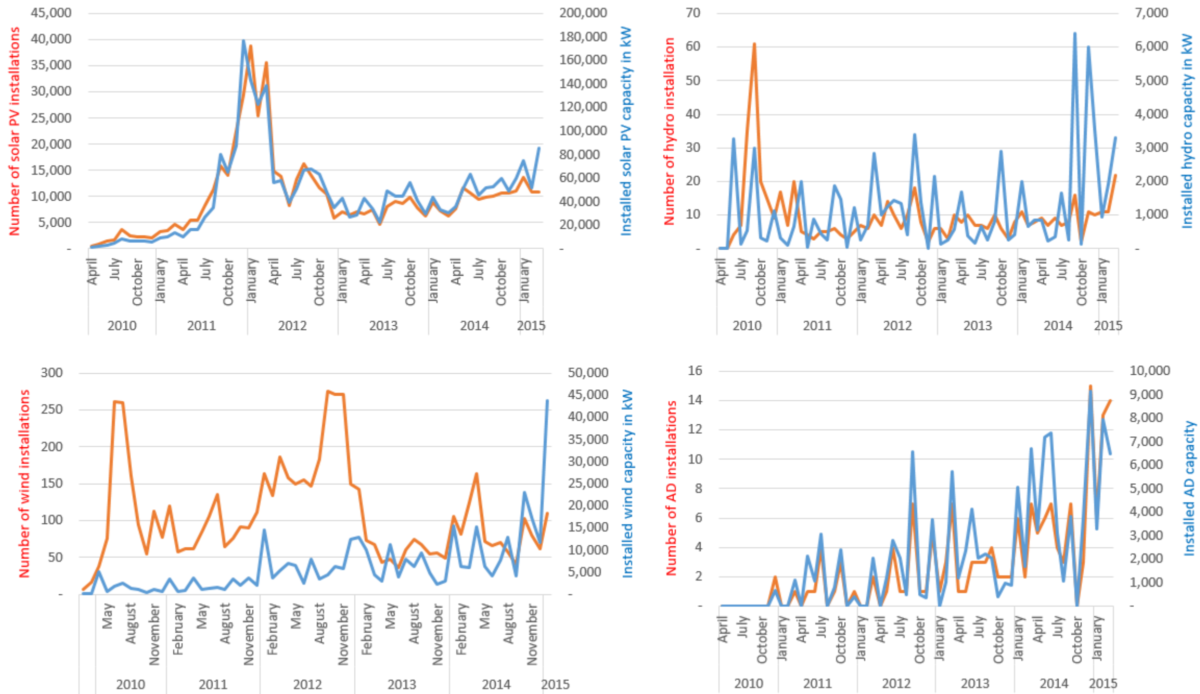


Figure 18: Monthly number of installations and installed capacity by technology type[62]

The average capacity of wind installations has increased continuously (Figure 17 and 18). The significant increase in average installed wind capacity in Year 5 is likely to be an anomaly

[61] Ofgem, 2014, Feed-in Tariff – Annual Report 2013-14, Office of Gas and Electricity Markets, London.
[62] DECC, March 2015 Monthly Central Feed-in Tariff Register Statistics, Department of Energy and Climate Change, London.

although the continuous trend towards larger installations (Figure 18) has been attributed to reductions in costs of wind energy technology and developers becoming increasingly aware about exploiting economies of scale[63] and partly the result of changing tariff banding (see section on Impact of FIT on the economy). The growing share of commercial as opposed to domestic installations (see following section) is also responsible for these trends as they have larger average installed capacities.

Summary

Cumulative FIT installations outstripped DECC predictions. The amount of electricity generated per installation remained below forecasts due to the unforeseen popularity of <=4kW domestic solar PV installations, rather than larger non-domestic solar PV and other technologies with larger average load factors.

As the average capacity of individual wind installations is growing, while the average capacity of individual solar PV installations is remaining fairly constant, wind's share of cumulative capacity is growing relative to solar PV. Solar PV still dominates cumulative number of installations but wind and AD play a more notable role in cumulative installed capacity, due to the relatively larger size of average installations.

Uptake of solar PV increased rapidly in the second half of Year 2 as a result of unanticipated drops in the cost of solar PV systems. Following the implementation of changes to the FIT in 2012, growth in the cumulative number of installations slowed down to a more sustainable rate more in line with DECC predictions.

The total installed capacity of wind under the FIT increased in proportion from around 4% of the FIT total in Year 2 to 10% in Year 5. The 1.5-5MW wind tariff band experienced 82% growth in Year 5. Cumulative wind capacity increased by 74% in Year 5 from an increase of 19% in cumulative number of installations. These figures show the average size of wind installation is growing.

Small hydroelectric installations (<=15kW) dominate in terms of total hydro numbers but medium size turbines (in excess of the <50kW microgeneration scale) are increasingly popular, with growth in the number of 50-100kW turbine installations outstripping the growth in smaller turbines. The first two 2-5MW hydroelectric turbines were installed under the FIT in Year 5 despite fears of degression reducing the number of water extraction concessions in 2015, especially in Scotland.

The total installed capacity of Anaerobic Digestion (AD) increased in proportion from around 1% of the FIT total in Year 2 to 5% of total installed capacity in Year 4. Strong growth in Year 5 was recorded for <500kW installations, which has reduced the proportion of AD in terms of total installed capacity to 3% in Year 5. Many of these installations are farm AD plants and their increasing diffusion is linked to the reduction of barriers to the farming sector as part of the Anaerobic Digestion Strategy and Action Plan.

Current micro-CHP growth stands at only 4% year on year in Year 5. An increase in the tariff in March 2013 failed to stimulate the market. The RHI may have shifted interest from micro-CHP towards heat technologies.

[63] Ofgem, 2014, Feed-in Tariff – Annual Report 2013-14, Office of Gas and Electricity Markets, London.

3.3 Diversity of generators

Ofgem figures show how average capacity by installer type has changed between Year 1 and 4 of the FIT (Figure 19).

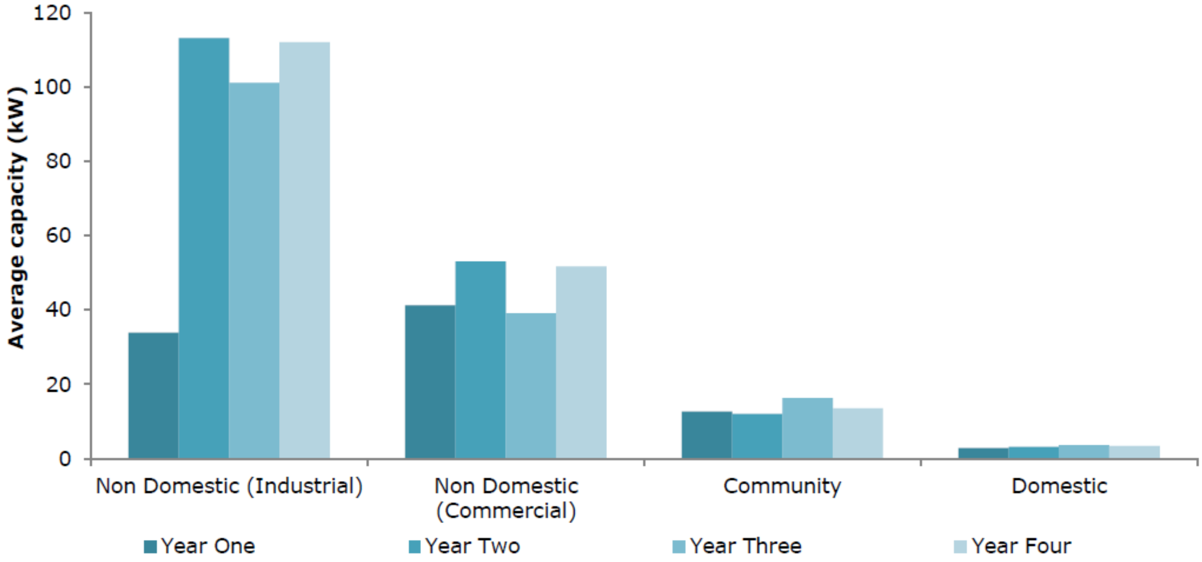


Figure 19: Average capacity by installer type Year 1-Year 4[64]

Average capacity by installer type in Years 1 – 5 can be derived from **Ofgem**'s CFR (Tables 4 and 5). Table 4 provides the cumulative number of FIT installations according to installation type. Table 5 provides the cumulative installed capacity according to installation type and technology type (Table 5).

Row Labels	Community	Domestic	Non Domestic (Commercial)	Non Domestic (Industrial)	Grand Total
Anaerobic digestion		1	124	42	167
Hydro	22	296	226	28	572
Micro CHP	1	477	8		486
Photovoltaic	2205	572427	15933	1035	591600
Wind	153	4152	1985	84	6374
Grand Total	2381	577353	18276	1189	599199

Table 4: Cumulative number of FIT installations by installation type and technology type[65]

Sum of Installed Capacity (MW)	Community	Domestic	Non Domestic (Commercial)	Non Domestic (Industrial)	Grand Total
Anaerobic digestion		0.00	92.60	31.86	124.46
Hydro	1.01	3.90	62.32	4.46	71.69
Micro CHP	0.00	0.49	0.01		0.50
Photovoltaic	30.63	1,955.12	671.12	80.63	2,737.50
Wind	11.71	41.48	299.60	20.74	373.53
Grand Total	43	2,001	1,126	138	3,308

Table 5: Cumulative installed FIT capacity in MW by installation type and technology type[66]

[64] Ofgem, 2014, Feed-in Tariff – Annual Report 2013-14, Office of Gas and Electricity Markets, London.
[65] Ofgem, 2015, FIT Installation report 31 March 2015 < https://www.ofgem.gov.uk/publications-and-updates/feed-tariff-installation-report-31-march-2015 >.

Figure 20 suggests that the average capacity of domestic installations (3-4kW) has changed little between Year 1 and Year 4. The average capacity in Year 5 appears to be constant as the Year 1 – 5 average (Table 4 and 5) has remained constant at 3.5kW/domestic installation. The average size of community installations changed very little between Year 1 and 4 (12-14kW, Figure 20). Given that the average between Year 1 – 5 is 18kW, the average size of community installations must have increased significantly in Year 5 (Tables 4 and 5). The average size of industrial installations increased from less than 40kW in Year 1 to 113kW in Year 2. It dropped to 103kW in Year 3 before returning to a similar level in Year 4 (112kW). The Year 1 – 5 average of 116kW suggests that the average size of industrial installation increased slightly in Year 5 (Tables 4 and 5). The average size of commercial installations remained relatively constant between Year 2 (53kW), 3 (39kW) and 4 (52kW) before increasing significantly in Year 5 as the Year 1 – 5 average stands at 62kW (Table 4 and 5)[67&68].

Aside from changes in the average capacity, the share of installed capacities of domestic, community, commercial and industrial installations has also changed over the years. The most noticeable trend is the increase in proportional capacity of commercial installations from 18% in Year 1 to 39% in Year 4 (Figure 20).

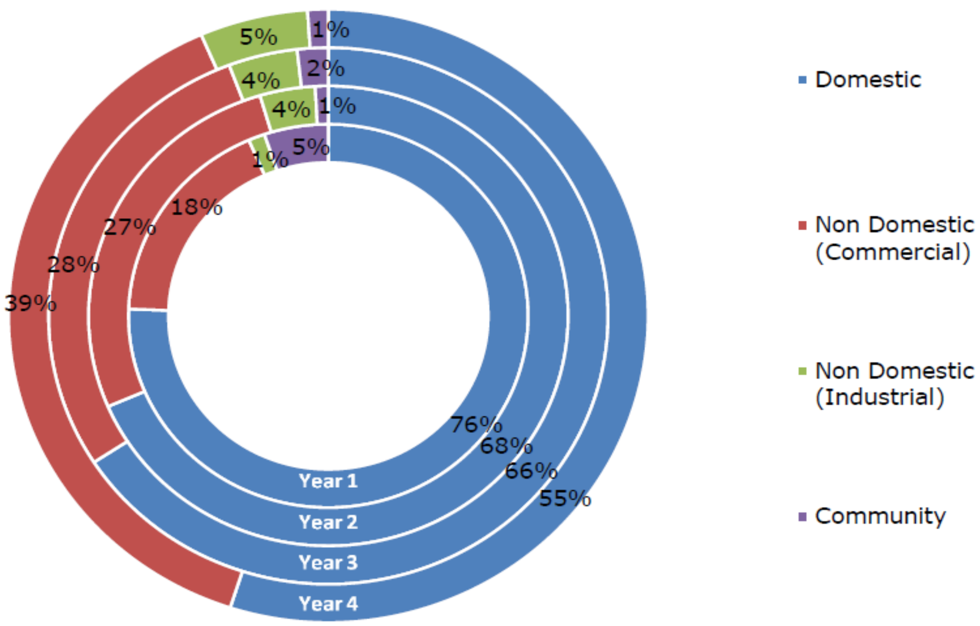


Figure 20: Changing share of installed capacities between Year 1 and Year 4[69]

Figure 20 also reveals a growing share of industrial installed capacity. The increase in commercial and industrial installations as a share of total installed capacity is likely to be the result of commercial property owners becoming more aware of the long-term investment opportunities of FITs. According to **Ofgem**[70], this also correlates with increases in wind and AD

---

[66] Ofgem, 2015, FIT Installation report 31 March 2015 < https://www.ofgem.gov.uk/publications-and-updates/feed-tariff-installation-report-31-march-2015 >.

[67] Ofgem, 2014, Feed-in Tariff – Annual Report 2013-14, Office of Gas and Electricity Markets, London.

[68] Ofgem, 2015, FIT Installation report 31 March 2015 < https://www.ofgem.gov.uk/publications-and-updates/feed-tariff-installation-report-31-march-2015 >.

[69] Ofgem, 2014, Feed-in Tariff – Annual Report 2013-14, Office of Gas and Electricity Markets, London.

[70] Ofgem, 2014, Feed-in Tariff – Annual Report 2013-14, Office of Gas and Electricity Markets, London.

markets, which are typically associated with non-domestic properties. The trend of domestic installations representing a decreasing share of total capacity is continuing in Year 5 with domestic installations dropping from 65%[71] in Year 4 to 60% in Year 5 (see Table 5)[72].

3.3.1 Communities and schools

Community and school installations are currently grouped together under one category because Ofgem provides specific guidance documents for community energy and school installations[73], with the underlying assumption that the process of developing community energy and school installations is similar, as is often their ambition in terms of size and type of technology.

Specific conditions for community organisations and education providers apply to solar PV installations with an eligibility date on or after 1 December 2012. These include a 'tariff guarantee' for energy installations with a Declared Net Capacity of <50kW (to ensure that business plans can be maintained, even if tariffs are reduced or degression is triggered) and a relaxation of the current minimum energy efficiency requirement by reducing it from an EPC band D to band G and above in order to allow FIT eligible community energy and school installations to receive the higher generation tariff rate[74]. Communities and schools also benefit from the extension of preliminary accreditation validity by 6 months for all technologies[75].

A community energy installation is defined in the FIT Order as 'an eligible installation – which is wired to provide electricity to a building which is not a dwelling; and in relation to which the FIT generator is a community organisation'[76]. A community organisation is defined as 'any of the following which has 50 or fewer employees: a charity; a subsidiary wholly owned by a charity; a community benefit or co-operative society; or a community interest company'[77].

Figures from the Community Energy Strategy[78] suggest that at least 60MW of community-owned renewable electricity generation is currently in operation in the UK[79]. A report by the Energy Saving Trust in 2015 for the Scottish Government (up to June 2014) on community and locally owned renewable energy in Scotland[80] shows that 202MW of electricity generating capacity, which is expected to generate approximately 470 GWh of electricity per year, can be attributed to community groups, local authorities, housing associations, other Scottish public bodies, charities (including faith organisations), further and higher education establishments,

---

[71] Ofgem, 2014, Feed-in Tariff – Annual Report 2013-14, Office of Gas and Electricity Markets, London.

[72] Ofgem, 2015, FIT Installation report 31 March 2015 < https://www.ofgem.gov.uk/publications-and-updates/feed-tariff-installation-report-31-march-2015 >.

[73] Ofgem, 2015, Feed-in Tariff: Guidance for Community Energy and School Installations (Version 2), Office for Gas and Electricity Markets, < https://www.ofgem.gov.uk/ofgem-publications/94298/communityenergyandschoolguidanceversion2-pdf >.

[74] Ofgem, 2013, Feed-in Tariff: Guidance for Community Energy and School Installations (Version 1), Ofgem E-Serve, London.

[75] DECC, 2015, Community Energy Strategy Update, Department of Energy and Climate Change, London.

[76] Ofgem, 2015, Feed-in Tariff: Guidance for Community Energy and School Installations (Version 2), Ofgem E-Serve, London.

[77] Ofgem, 2015, Feed-in Tariff: Guidance for Community Energy and School Installations (Version 2), Ofgem E-Serve, London.

[78] DECC, 2014, Community Energy Strategy: Full Report, Department of Energy and Climate Change, London.

[79] Harnmeijer, J., Parsons, M., Julian, C., 2013, The Community Renewables Economy – Starting up, scaling up and spinning out, ResPublica, Newland, Lincoln.

[80] EST, 2015, Community and locally owned renewable energy in Scotland at June 2014 – A report by the Energy Saving Trust for the Scottish Government, March 2015, Energy Saving Trust, Edinburgh.

local Scottish business and Scottish farms and estates. It is not clear whether all these community energy installations fall under the FIT but it is highly likely that they do[81].

DECC[82] published data on communities and schools show that the number of community energy installations granted full accreditation is much lower than the number granted preliminary accreditation. One of the reasons for this is the difficulty of bringing projects to fruition, which has been recognised by DECC by extending the preliminary accreditation validity period by 6 months for community groups.

DECC's statistics for community and school installations[83] are incomplete because unless a community group or school identifies itself in the process of applying for one of the specific benefits detailed above it is not necessary for them to record the information when applying for the FIT. As a result, the information on **Ofgem**'s CFR paints an incomplete picture of their engagement with the FIT. On the other hand, some groups of schools club together and apply as a community organisation, thus skewing the data in the opposite direction.

DECC's Community Energy Strategy[84], identifies that the FIT is a key source of income for community energy projects as it represents one the few means of securing long-term sources of income. Prior to the introduction of the FIT, most community and school projects did not have a reliable source of income on which to build a business case.

Community energy projects can be more effective than other actors (such as national government, energy suppliers and private sector organisations) in engaging and motivating local communities, although they should be viewed as complementary to business and government, rather than a substitute for them (see Behavioural change and public perception). More precise data collection is required to analyse the uptake of community and school installations and to evaluate their wider benefits, such as their role in community education and impact on behavioural change within the community.

3.3.2 Farming sector

According to RenewableUK[85], over a third of farms use renewable energy on-site and around 10% of farms have installed wind turbines. Solar PV is also very popular on farms. Moleenergy, part of Mole Valley Farmers, installed 23,000 panels on 308 farms across the Southwest in 2011-2012 alone. Solar PV alone has accounted for £78m of the £90m Moleenergy members are estimated to earn from all government incentives for renewables[86].

Data published by the Waste and Resource Action Programme (WRAP) in February 2015 shows that 62 of the 153 operational AD sites in the UK are located on-farm, which represents around 41MW out of a total output capacity of 145MW[87] (see also the Anaerobic Digestion section of the Impact of the FIT on the economy).

[81] Nolden, C., 2013, Regulating the diffusion of renewable energy technologies: Interactions between community energy and the feed-in tariff in the UK, PhD Thesis submitted to the University of Exeter, Exeter.

[82] DECC, 2015, FEED IN TARIFFS: COMMUNITIES & SCHOOLS INSTALLATIONS, Department of Energy and Climate Change, London.

[83] DECC, 2015, FEED IN TARIFFS: COMMUNITIES & SCHOOLS INSTALLATIONS, Department of Energy and Climate Change, London.

[84] DECC, 2014, Community Energy Strategy: Full Report, Department of Energy and Climate Change, London.

[85] RenewableUK, 2014, Small and Medium Wind Strategy, RenewableUK, London.

[86] RegenSW,

[87] WRAP, 2015, Operational AD sites, < http://www.wrap.org.uk/content/operational-ad-sites >.

In the event that all current AD pipeline projects are deployed[88], we would be likely to see a significant increase in the processing of farm waste, but in addition, a significant increase in the use of crops. For example, the total capacity of AD, if all current pipeline projects are deployed, could increase to 470MW, of which 30% of this installed capacity would be on-farm, and 6% would be crop only plants[89]. The AD industry propose that conditions under the FIT scheme should be improved for small farm-fed AD systems which are likely to use a high proportion of wastes. They claim that insufficient tariffs for <= 250kW plants, combined with a degression trigger that is set at too low a level, means that small-scale AD is not able to deploy effectively under the scheme. This is exacerbated by the fact that the degression band at 500kW is not aligned with the tariff bands, so an increase in larger AD installations between 250kW and 500kW has a disproportionate impact on the smallest scale AD. The Renewable Energy Planning Database identified 76 installations between 400kW and 500kW with planning permission that have not yet been commissioned, so it is possible that further degression could occur, disproportionately affecting the smallest AD.

Summary

The average capacity installed by each installer type has remained fairly constant between Year 2 and 5, except for commercial and community installations where Year 5 saw an increase in average capacities.

The share of registered industrial and commercial installations as a share of the cumulative number of FIT installations is continuously growing.

Industrial installations increased their share of cumulative installed capacity from 1% in Year 1 to 5% in Year 4 and commercial installations increased from 18% to 39%. This is likely to be due to the increasing commercial awareness of the benefits of the FIT.

The share of cumulative installed capacity for domestic installations is continuously declining (from 76% in Year 1 to 55% in Year 4).

There is at least 60MW of community-owned renewable electricity generation in the UK. FITs are a key source of income for community energy projects as they represent one the few means of securing long-term sources of income. Prior to the introduction of the FITs, most community and school projects did not have a reliable source of income on which to build a business case. The share of registered community installations has remained stable (1-2%) although there is uncertainty regarding registration data.

Industry claims that 10% of farms have installed (primarily FIT-supported) wind turbines. 62 of the 153 operational AD sites in the UK are located on-farm, which represents around 41MW out of a total AD output capacity of 145MW. Solar PV is also very popular in the farming sector with 23,000 panels installed on 308 farms in the Southwest in 2011-2012 alone.

---

[88] NNFCC estimate that based on recent trends only 30 – 50% of planned plants go ahead, and WRAP ASORI survey recently suggests only 80% of installed waste treatment capacity is actually utilised (in terms of feedstock tonnage), reducing to 77% in farm-plants.

[89] DECC submission to Greg Barker in May 2013

4. Electricity generation

4.1 Load factors and electricity generation

Load factors are the ratio between average load (the amount of load and the amount of time the system is operating) and rated load (as stated by the manufacturer and verified according to industry standards) for a given period of time, usually calculated over a year and expressed as a percentage[90]. For non-dispatchable renewable energy technologies, such as solar PV and wind, the load factor is much lower due to the intermittency of sunshine and wind. For dispatchable technologies (fossil-fuels and biomass) in general, load factors are higher. The result is that impressive-sounding figures for cumulative installed capacities of non-dispatchable renewable energy technologies (such as wind turbines with rated loads of 900kW and a 33% average load of ~300kW) may result in comparatively low actual generation (equivalent of a gas turbine with a rated load of 400kW and a 75% average load of ~ 300kW).

Meter readings obtained by **DECC** in 2013[91] from the electricity suppliers for each FIT installation in GB for the first 3 years (up to 31 March 2013) of the FIT scheme are the result of electricity suppliers collecting over 1.5 million meter readings. Analysis of meter readings was only carried out for FIT Years 2 and 3 as Year 1 did not yield sufficient data of installations running the whole year. The figures need to be treated as provisional as data, particularly for large schemes, has a bigger impact on the weighted mean load factor and these need to be analysed in more detail. Further analysis of load factors has not been conducted since 2013. Table 6 shows the median load factors and associated percentiles for each technology.

FIT Year 2 (2011/12)				Percentile				
Technology	Count	Coverage (%)	Weighted mean	5th	25th	50th	75th	95th
Hydro	87	38	25	4.6	15.9	29.6	45.5	92.9
MicroCHP	48	26	13.6	5	9.4	11.2	14.1	29.6
Solar PV	12,165	31	10.3	6.7	9.3	10.5	11.5	13.1
Wind	560	35	18.3	4.3	10.1	15.9	24.7	37.4

FIT Year 3 (2012/13)				Percentile				
Technology	Count	Coverage (%)	Weighted mean	5th	25th	50th	75th	95th
Hydro	127	39	46.1	6.7	26.5	43.1	57.5	72.9
MicroCHP	80	21	16.1	4.2	10.4	14.9	19.4	32.3
Solar PV	107,829	37	9.2	6	8.6	9.6	10.5	11.9
Wind	1,443	47	22.3	5.1	10.1	16.3	24.4	38.6

Table 6: Provisional annual load factor by technology for Year 2 and Year 3[92]

The second column in Table 6 shows how many installations were used for the analysis of FIT generation data, the third column gives the percentage of all installations by technology type that were included in the analysis and the fourth column shows the median load factor. Due to

[90] RAENG, 2014, Wind Energy – implications of large-scale deployment on the GB electricity system, Royal Academy of Engineering, London.
[91] DECC, 2014, Analysis of Feed-in Tariff generation data, Department of Energy and Climate Change, London.
[92] DECC, 2014, Analysis of Feed-in Tariff generation data, Department of Energy and Climate Change, London.

the small number of AD installations they are not included in this analysis but their (weighted mean) median load factor in 2012/13 was 59.3%.

The smaller average (weighted mean) load factor of solar PV in 2012/13 (9.2%) compared to 2011/12 (10.3%) is the result of weather conditions, as the number of sun hours per day was 4.5 in Year 2 compared to 3.7 in Year 3[93]. Long periods of high pressure are responsible for lower wind load factors in 2011/12 compared to 2012/13, while higher than average rainfall is responsible for higher hydro load factors in 2012/13 compared to 2011/12.

A **DECC** publication, which deals specifically with electricity generation from the FIT scheme[94], contains figures from Year 1 and 2 (ending 31 March 2012; note that these figures are estimates, as data from suppliers is incomplete, with gaps in the data requiring filling in using load factors calculated from incomplete data). In Year 1, 68.6 GWh was generated from 21,705 installations. In Year 2, 498.2 GWh from 206,851 installations was reported as being generated under the FIT, which is around eight times more than in Year 1. Of total generation, solar PV generated 52% (34.5% from <=4 kW retrofit installations), wind 19%, AD 14% and hydro 10%. Around 1/5th (104.4 GWh) of generation was exported under the FIT's export tariff and the remaining 393.8 GWh was either consumed onsite or exported under other arrangements. Solar PV contributed 79% of all electricity exported under the FIT export tariff, mainly from <=4kW retrofit installations[95], although this figure may not represent the true situation.

Another **DECC** publication[96] estimates that during Q3 2013 installations confirmed under the FIT scheme accounted for 633 GWh of generation with 458 GWh from solar PV, 77 GWh from wind, 69 GWh from AD, 30 GWh from hydro and 0.2 GWh from micro CHP. This represented 6.1% of all renewable energy generation (10.3TWh - from 11% of all UK renewable electricity capacity) and 0.8% of total generation (78.2TWh) (Figure 21).

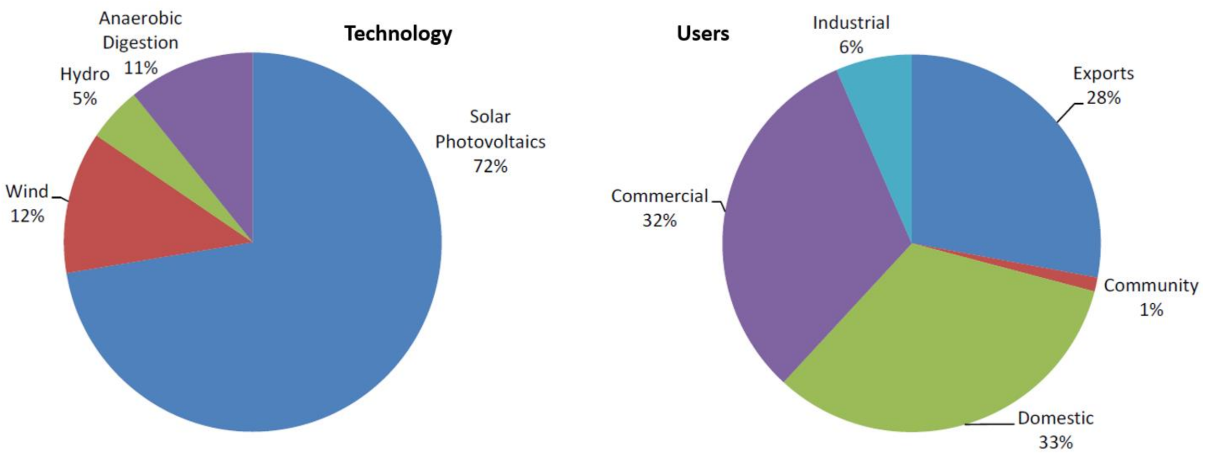


Figure 21: FIT generation by technology and user in Q3 2013[97]

[93] DECC, 2014, Analysis of Feed-in Tariff generation data, Department of Energy and Climate Change, London.
[94] DECC, 2012, 5 Electricity – Table 5.7. Feed in Tariff generation, Department of Energy and Climate Change, London.
[95] DECC, 2012, 5 Electricity – Table 5.7. Feed in Tariff generation, Department of Energy and Climate Change, London.
[96] DECC, 2013, Estimating generation from Feed in Tariff installations, Department of Energy and Climate Change, London.
[97] DECC, 2013, Estimating generation from Feed in Tariff installations, Department of Energy and Climate Change, London.

Figures from **Ofgem**[98] show that FIT installations generated a total of 2,645 GWh during Year 4 of the FIT (figures for Year 5 are not available). Total electricity generated from renewables at the end of 2013 Q4 stood at 16.8 TWh for the previous year. Based on these figures, total FIT generation represented around 14-15% of all renewable electricity generation. In Year 2, FIT generation represented 0.14% of 363 TWh of total electricity generation. In Year 4, FIT generation represented 0.74% of 359 TWh of total electricity generation[99], 0.84% of 317 TWh of final UK electricity consumption and around 0.9% of 295 TWh of final GB electricity consumption[100]. The 2010 Impact Assessment estimated that the FIT would deliver around 1.6% of final electricity consumption in 2020[101] (i.e. approx. 8 TWh in total) compared to 0.6-0.8% under a business as usual scenario[102]. Given the tendency towards larger installations (see Figure 17 and 18 in Total average capacity by technology type) it is realistic to assume that the figure of 1.6% of final electricity consumption by 2020 can be achieved.

Summary

Average load factors for non-dispatchable technologies such as solar PV, wind and hydro vary according to annual weather variations. The amount of electricity generated varies accordingly. In August 2013 wind represented 8% of cumulative installed capacity but 12% of FIT electricity generation in Q3 2013. The same figures for AD are 2% and 11% and for hydro 2% and 5% respectively. Solar PV only generated 72% of FIT electricity from 88% of cumulative installed capacity.

Total electricity generated from FIT installations in Year 4 amounted to 2,645 GWh, which represented 0.74% of 359 TWh of total UK electricity generation, 0.84% of 317 TWh of UK final electricity consumption and around 0.9% of 295 TWh of total GB electricity consumption. Original DECC projections were approx. 6,000 GWh/a (or 1.6%) of final UK electricity consumption in 2020. Under the 2010 Impact Assessment's Business as Usual (BAU) scenario we are currently where we would have expected to be in 2020 under BAU.

[98] Ofgem, 2014, Feed-in Tariff – Annual Report 2013-14, Office of Gas and Electricity Markets, London.

[99] DECC, 2014, Electricity: chapter 5, Digest of United Kingdom energy statistics (DUKES), Department of Energy and Climate Change, London.

[100] Electricity used within the energy industry and losses account for the difference between total electricity generation (demand) and final energy consumption. In 2013, 29 TWh (8%) was used within the energy industry and 27 TWh (7%) was accounted for by losses (DECC, 2014, Electricity: chapter 5, Digest of United Kingdom energy statistics (DUKES), Department of Energy and Climate Change, London). Final GB electricity consumption is the electricity consumption of England, Wales and Scotland.

[101] DECC, 2010, Impact Assessment of Feed-in Tariffs for Small-Scale, Low Carbon, Electricity Generation, Department of Energy and Climate Change, London.

[102] DECC, 2009, Summary: Intervention& Options URN: 09D/703 – Impact Assessment of Feed-in Tariffs for Small-Scale, Low Carbon, Electricity Generation, Department of Energy and Climate Change, London, p.1.

5. Carbon emission reductions and climate change mitigation

The current cost of carbon savings per £ spent will make the FIT appear prohibitively expensive (see Table 7) but the high cost of the FIT in terms of climate change policy cost-effectiveness was recognised in the 2010 Impact Assessment[103]. The point of a FIT scheme is not to support the cheapest form of carbon mitigation but to diversify the electricity generation landscape, engage communities and to nudge nascent and promising technologies toward grid parity. The decline in technology cost, as well as the decline in cost per tonne of CO_2 saved, is a more appropriate measure for the success of any FIT, as opposed to current contribution to carbon savings[104]. The 2010 Impact Assessment estimates the FIT's cost per tonne of carbon saved at £460/tCO_2[105], significantly more than the estimate of £269/tCO_2 in the 2009 Impact Assessment[106]. The period 1 April 2013 - 31 March 2014 was the first year that the cost of carbon saved by the FIT from installations accredited that year has reduced from the previous year (Table 7 and Figure 22).

FIT Year	Annual cost per tCO_2e for all FIT eligible installations	Annual cost per tCO_2e for installations accredited that year
Year 1	-	-
Year 2	£615.17	£650.81
Year 3	£613.00	£612.95
Year 4	£525.79	£378.29

Table 7: Annual cost per tCO_2e for all FIT eligible installations and for installations accredited that year[107]

Figures in Table 7 indicate that the cost-effectiveness of the FIT in terms of £/t CO_2 has improved significantly in Year 4 of the FIT. This is the result of more large-scale and more cost effective technologies installed since Year 2, such as +500kW wind and +500kW standalone solar PV (see section on Total and average capacity by technology type). The FIT remains less cost-effective than its original projections but changing technological application (diversifying from domestic solar PV towards other technologies and greater scales of application at lower tariff bands) are continuing the trend of increasing cost effectiveness (Table 7) to the extent that

[103] DECC, 2010, Impact Assessment of Feed-in Tariffs for Small-Scale, Low Carbon, Electricity Generation, Department of Energy and Climate Change, London.

[104] Ofgem, 2014, Feed-in Tariff – Annual Report 2013-14, Office of Gas and Electricity Markets, London.

[105] DECC, 2010, Impact Assessment of Feed-in Tariffs for Small-Scale, Low Carbon, Electricity Generation, Department of Energy and Climate Change, London.

[106] DECC, 2009, Summary: Intervention& Options URN: 09D/703 – Impact Assessment of Feed-in Tariffs for Small-Scale, Low Carbon, Electricity Generation, Department of Energy and Climate Change, London, p.1.

[107] Ofgem, 2014, Feed-in Tariff – Annual Report 2013-14, Office of Gas and Electricity Markets, London.

the cost per tonne of CO_2 of installations accredited in Year 4 is below the average cost effectiveness estimate of £460/t CO_2 from the 2010 Impact Assessment of the FIT by 2020[108].

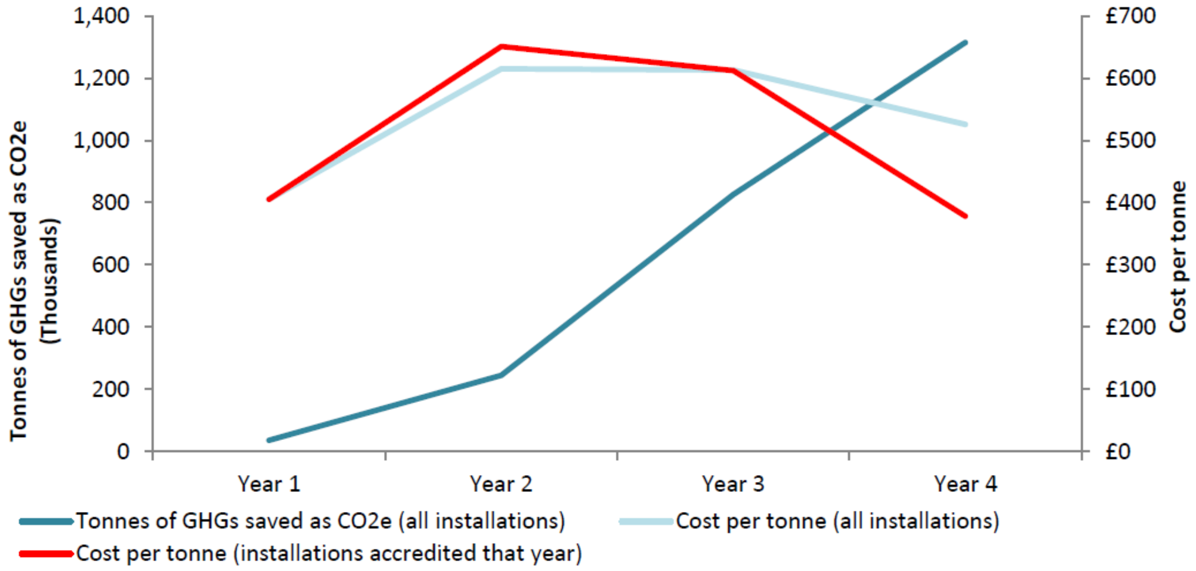


Figure 22: Tonnes of CO_2e saved (non-cumulative) and cost per tonne by year[109]

The GHG conversion factor for UK electricity in 2013-14 is 0.497 $kgCO_2e/kWh$. Multiplying 49.6 TWh of renewable generation under the RO in that year gives an approximate saving of GHG emissions of 24.6m tCO_2e in 2013-14, an increase of 42.7% from 17.3m tCO_2e over the same period the previous year (2012/13). The cost of GHG emissions saved by the RO in 2013-14 was £105.38/tCO_2e, around £10/t (i.e. nearly 10%) less than the previous year[110].

Applying the same process to the FIT (2.645 TWh multiplied by 0.497) gives a GHG saving of 1.3m tCO_2e in Year 4. The cost of GHG emissions saved by the FIT in Year 4 was £525.79/tCO_2e, £87.21 (i.e. around 16%) less than was spent per tCO_2e saved in Year 3[111]. In terms of generation per installation, 2.645 TWh of Year 4 FIT generation divided by the average number of installations of 488,939 in Year 4 equals 5.4 MWh/installation/annum. Original projections for 2020 were for 6 TWh from 780,000 installations (7.7 MWh/installation/annum)[112]. Given the growing share of non-domestic installations (Figure 19 and 20; Table 4 and 5) and the increases in the average size of wind installations[113] the cost effectiveness of the FIT is likely to have improved further in Year 5.

The cost per tCO_2e saved and the resource cost of the FIT appears a lot higher compared to conventional technology, such as nuclear at Hinkley Point C. Between Year 2 and Year 4 the

[108] DECC, 2010, Impact Assessment of Feed-in Tariffs for Small-Scale, Low Carbon, Electricity Generation, Department of Energy and Climate Change, London.

[109] Ofgem, 2014, Feed-in Tariff – Annual Report 2013-14, Office of Gas and Electricity Markets, London.

[110] Ofgem, 2015, Renewables Obligation – Annual Report 2013-14, Ofgem e-serve, London.

[111] Ofgem, 2014, Feed-in Tariff – Annual Report 2013-14, Office of Gas and Electricity Markets, London.

[112] DECC, 2010, Impact Assessment of Feed-in Tariffs for Small-Scale, Low Carbon, Electricity Generation, Department of Energy and Climate Change, London.

[113] DECC, March 2015 Monthly Central Feed-in Tariff Register Statistics, Department of Energy and Climate Change, London.

cost per kWh of electricity generated from FIT schemes declined from 27.2p to 26.1p/kWh[114]in 2012 prices, while Hinkley Point C will receive a strike price of around 9p//kWh[115] in 2012 prices (around 1/3 of the current FIT cost), guaranteed over 35 years. However, the falling technology costs for renewables is likely to reduce the cost of new renewable energy per £ spent, ultimately making policies such as the FIT unnecessary[116], while the economics of nuclear appear less certain [117,118]. It is important to analyse the trend over time as the FIT, if applied appropriately, encourages the cost of technology to fall as the FIT-subsidised market strives for economies of scale. The figures above indicate that this trend is emerging in relation to the FIT in the UK.

Summary

The point of a FIT is not to support the cheapest form of carbon mitigation but to diversify the electricity generation landscape, engage communities and to nudge nascent and promising technologies toward grid parity. The decline in technology cost as well as the decline in cost per tonne of CO_2 saved is a more appropriate measure for the success of any FIT, as opposed to current cost of carbon savings per £ spent.

The FIT has saved around 1.3m tonnes of greenhouse gases up until the end of Year 4. Its cumulative cost effectiveness in terms of £/t CO_2 has improved significantly from £615.17/t CO_2 in Year 2 to £525.79/t CO_2 in Year 4. This is the result of more large-scale and more cost effective technologies installed since Year 2, such as +500kW wind and +500kW standalone solar PV.

The cost per tonne of CO_2 of installations accredited in Year 4 (£378.29/t CO_2) is below the average cost effectiveness estimate of £460/t CO_2 from the 2010 Impact Assessment of the FIT by 2020.

[114] Ofgem, 2014, Feed-in Tariff – Annual Report 2013-14, Office of Gas and Electricity Markets, London.

[115] UK Government, 2013, Initial agreement reached on new nuclear power station at Hinkley, Press release on 21 October 2013, < www.gov.uk/government/news/initial-agreement-reached-on-new-nuclear-power-station-at-hinkley >.

[116] FS-UNEP Collaborating Centre/BNEF, 2015, Global Trends in Renewable Energy Investment 2015, Frankfurt School, FS-UNEP Collaborating Centre for Climate and Sustainable Energy Finance and Bloomberg New Energy Finance, Frankfurt am Main.

[117] Thomas, S., Bradford, P., Froggatt, A., Milborrow, D., 2007, The economics of nuclear power, Report prepared for Greenpeace International, London.

[118] The Economist, 2012, The dream that failed, Special Report Nuclear Energy, March 10 2012, London.

6. FIT payments

Ofgem's Feed-in Tariff Annual Levelisation Process for Year 4 reconciled all payments made as part of the quarterly process within the fourth year of the FIT scheme. The total Levelisation Fund was calculated to be £690,991,282.96 (Table 8 and 9). This figure represents the cost of the scheme including Total Generation Payments, Deemed Export Payments, and Qualifying (administration) Costs, minus the Value of Deemed Export to licensed electricity suppliers[119]. The figure is likely to be around £850,000,000 for 2014/15.

£701,791,067.06 in payments was reported by FIT Licensees as having been made to installations registered under the scheme (includes payments for both generation and export). £19,961,772.66 was paid into and subsequently redistributed from the Levelisation Fund by Licensed Electricity Suppliers[120].

Cost	Total	Description
FIT generation payments **(A)**	£685,973,264	The total cost in payments made to accredited generators, for on-site generation.
Total deemed export payments **(B)**	£21,302,774	The total payments made to accredited generators for electricity that is deemed to have been exported to the grid.
Qualifying FIT costs **(C)**	£9,264,770	The total administration costs allocated to FIT licensees. The administration costs are determined annually by the Secretary of State[11].
Value of net deemed export **(D)**	£25,549,525	The total value of net deemed export is defined as the amount of electricity deemed to have been exported by all accredited installations multiplied by the System Sell Price (SSP) for the annual period. This is the equivalent wholesale market price.
Levelisation fund **(=A+B+C-D)**	£690,991,283	This figure represents the cost of the scheme over the year.

Table 8: Total payments by payment type in Year 4[121]

	Year 1	Year 2	Year 3	Year 4
FIT generation payments	12,487,029	135,937,391	504,272,611	685,973,264
Total FIT export payments	448,251	3,529,269	14,619,298	21,302,774
Qualifying FIT costs	2,044,560	15,827,255	6,085,200	9,264,770
Value of net deemed export	453,717	4,146,229	13,839,372	25,549,525
Levelisation fund	14,526,123	151,147,686	511,137,737	690,991,283

Table 9: Annual breakdown of scheme costs[122]

119 Ofgem, 2014, Feed-in Tariff – Annual Report 2013-14, Office of Gas and Electricity Markets, London.

120 Ofgem, 2014, Feed-in Tariff – Annual Report 2013-14, Office of Gas and Electricity Markets, London.

121 Ofgem, 2014, Feed-in Tariff – Annual Report 2013-14, Office of Gas and Electricity Markets, London.

The rapid uptake of solar PV under the FIT scheme implies that spending exceeded its forecast. The projection for 2014-2015 was originally £446m and the 2013 National Audit Office forecast for 2014-2015 is £817m[123], compared to the DECC forecast of around £700m[124]. FIT spending is covered by the Levy Control Framework (LCF)[125], which sets an annual budget for projected costs of all DECC's low carbon electricity levy-funded schemes until 2020/21, and includes the FIT, Contracts for Difference and the Renewables Obligation.

The latest projections of spend under the LCF are now forecast to be £9.1bn[126] in 2020/2021 (2011/12 prices) because of greater than expected uptake of the Government's renewable energy schemes, combined with lower wholesale electricity prices and accelerated developments in technology efficiency.

The impact of the FIT on annual energy bills is estimated at around £9 per household in 2014. This figure is expected to increase to £14 in 2020[127], which is significantly higher than the 2010 Impact Assessment estimated average increase in annual household electricity bills of approximately £8.50 over the period 2011-2030[128].

Summary

Spending on the FIT has exceeded its previous forecast as a result of rapid uptake of solar PV in Year 2 but DECC forecasts and spending remains within the headroom of the LCF cap.

The 2010 Impact Assessment's estimate annual costs for households of £8.50 over the period 2011-2030 have been exceeded with the impact of the FIT on annual household energy bills in 2014 estimated at £9 and current projections of £14 in 2020.

---

122 Ofgem, 2014, Feed-in Tariff – Annual Report 2013-14, Office of Gas and Electricity Markets, London.

123 NAO, 2013, The Levy Control Framework, National Audit Office, London.

124 DECC, 2014, Annual Energy Statement 2014, Department of Energy and Climate Change, London.

125 NAO, 2013, The Levy Control Framework, National Audit Office, London.

126 OBR, July 2015, Economic and Fiscal Outlook. Office of Budgetary Responsibility, London. Table 2.7. http://cdn.budgetresponsibility.independent.gov.uk/fiscal_supplementary_tables_2015

127 DECC, 2014, Estimated impacts of energy and climate change policies on energy prices and bills, Department of Energy and Climate Change, London.

128 DECC, 2010, Impact Assessment of Feed-in Tariffs for Small-Scale, Low Carbon, Electricity Generation, Department of Energy and Climate Change, London.

7. Impact of FIT on the economy

7.1 Employment, growth and supply chain development

According to the CBI[129], which uses the Department of Business, Innovation and Skills' definition of 'low-carbon and environmental goods and services' for green business, over a third of UK economic growth in 2011-12 could be attributed to green business. According to the Renewable Energy View 2014[130] published by REA, Innovas and PwC, almost £30bn has been invested by the private sector in renewable electricity, heating and transport fuels between 2010-2014, supporting over 100,000 jobs. Figures on direct growth effects of the FIT on the economy are not currently available but Figure 23 compares rapid rates of business creation in the UK power sector and the UK economy as a whole[131]. Since the introduction of the FIT in 2010, business birth rates in the UK power sector have increased significantly.

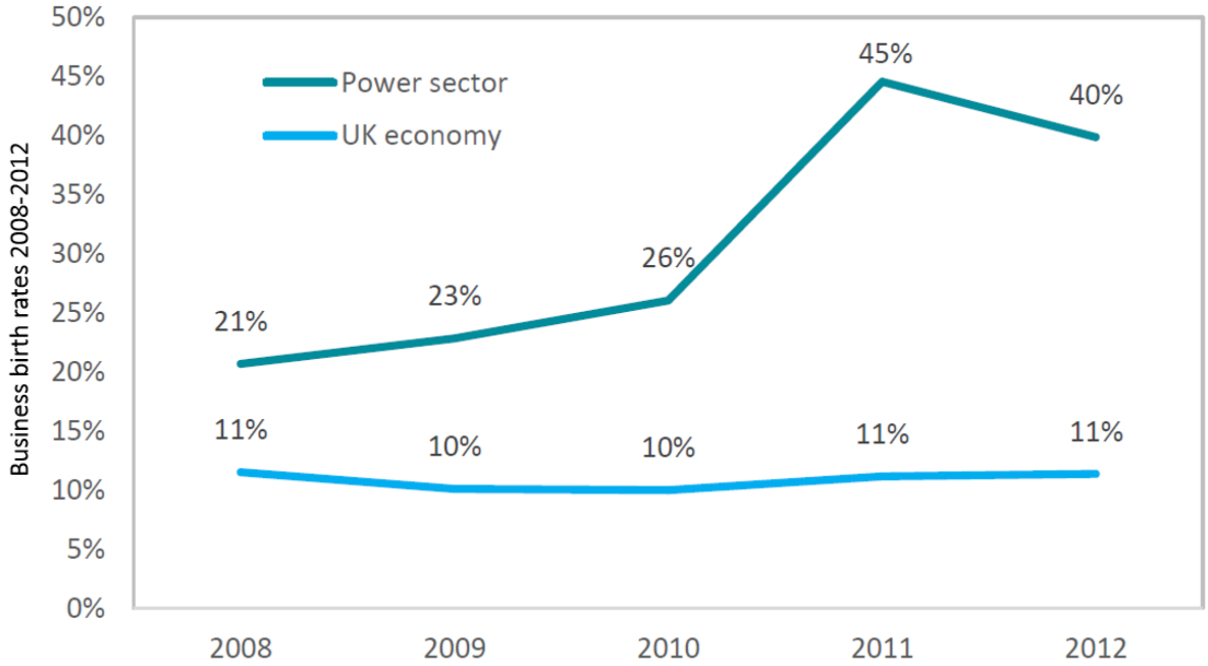


Figure 23: Job breakdown between manufacturing, installation and Operation & Maintenance (O&M)[132]

A literature review as part of UK Energy Research Centre's (UKERC) assessment of direct job creation resulting from policies supporting/relating to energy efficiency and renewable energy[133] suggests that renewable energy is more labour-intensive than either coal- or gas-fired power

[129] CBI, 2012, The colour of growth – Maximising the potential of green business, Confederation of British Industry, London.

[130] REA, Innovas and PwC, 2014, Renewable Energy View 2014, Renewable Energy Association, London.

[131] Centre for Economics and Business Research, 2014, Solar powered growth in the UK – The macroeconomic benefits for the UK of investment in solar PV, Solar Trade Association, London.

[132] Centre for Economics and Business Research, 2014, Solar powered growth in the UK – The macroeconomic benefits for the UK of investment in solar PV, Solar Trade Association, London.

[133] UKERC, 2014, Low carbon jobs: The evidence for net job creation from policy support for energy efficiency and renewable energy, UK Energy Research Centre, London.

plants. In the short term, building new renewable generation capacity is more likely to create more jobs than investing in an equivalent level of fossil-fuel-fired generation. The magnitude of difference is of the order of 1 job per annual GWh produced. This implies that 1 job more is created per GWh of new renewable electricity generation than for every GWh of new nuclear or fossil fuel generation.

Given the average employment intensity for the UK electricity sector as a whole of around 0.4 jobs/annual GWh (375 TWh/136,000 jobs), a marginal increase in labour intensity of 1 job per annual GWh is substantial (1.4 job/annual GWh compared to 0.4 job/annual GWh). In the longer term, however, impacts depend on how investments ripple through the economy and how support measures such as the FIT impact disposable household incomes. Fiscal and monetary stimuli such as the FIT may do more harm than good during periods of full employment as they have negative impact on productivity (see figure on 1.4 vs 0.4 job/annual GWh) but this is not an issue in the near to mid-term given slowly decreasing unemployment rates and uneven economic growth.

The following table (Table 10) from the UKERC report provides an indication (for all OECD countries) of the job intensity between manufacturing, installation and O&M for wind and solar PV. The first three columns provide an indication of short-term jobs for manufacturing and installation presented in terms of ‘job-years/MW’ and for O&M in ‘jobs/MW’ extending over the plant lifetime. The final three columns convert these figures into a common unit, ‘jobs/annual GWh’.

	Manf	Inst	O&M	Manf	Inst	O&M	Total
	job-yrs/MW	job-yrs/MW	jobs/MW	Jobs/annual GWh			
Wind							
Min	2.7	0.5	0.1	0.05	0.01	0.04	0.10
Median	3.9	1.3	0.2	0.07	0.02	0.08	0.18
Max	12.5	6.1	0.6	0.24	0.12	0.23	0.58
Solar PV							
Min	6	7	0.1	0.09	0.11	0.04	0.24
Median	16.8	13.2	0.3	0.26	0.20	0.11	0.57
Max	34.5	33	0.7	0.53	0.50	0.27	1.29

Table 10: Job breakdown between manufacturing, installation and O&M[134]

Table 10 shows that solar PV requires considerably more labour for the installation phase per unit than wind. Given the dominant, although declining, share of <=4kW solar PV installations as a share of the total number of FIT installations, the UKERC report suggests that more jobs/annual GWh have been created as a result of the FIT compared to equivalent investments in fossil fuel-fired generation in the absence of the FIT. As the UK has been in recession, and is still continuing to recover from it, the FIT as a form of fiscal and monetary stimulus has been, and is, contributing to job creation. In the longer-term context, however, labour intensity on its own is not economically advantageous, as it implies lower levels of labour productivity. Rather than the number of jobs created per unit of investment, the focus needs to shift towards the contribution of investment towards an economically efficient future energy system.

Given the decline of the utility business model in line with technological advancements surrounding solar PV and storage[135], it is not unreasonable to assume that the next equilibrium

[134] UKERC, 2014, Low carbon jobs: The evidence for net job creation from policy support for energy efficiency and renewable energy, UK Energy Research Centre, London.

in the business cycle will be at least partially supported by technological development and diffusion (e.g. energy storage) along with social innovation (e.g. community ownership and different business models for funding installations) currently enabled by supporting policies such as the FIT.

7.1.1 Solar Photovoltaic (PV)

According to the UK Solar Photovoltaic Roadmap – A Strategy for 2020 by the Knowledge Transfer Network[136], the UK was sixth globally for the number of solar PV installations during the first six months of 2013. Solar PV module manufacturing, which had a UK capacity in 2013 in the region of 600MW/a, has ceased with the closure of Sharp Solar's module factory in Wrexham although Romag in Consett, County Durham, still specialises in building-integrated solar PV modules at a smaller scale.

As a result, employment is dominated by installation rather than manufacturing. DECC's Impact Assessment[137] suggested that 10,000 – 30,000 jobs would be associated with solar PV for all installations in 2014/15 (Table 11).

	2012/13	2013/14	2014/15	Total 2012-2014
New installations between 2012-2014	140,000 - 250,000	170,000 - 340,000	170,000 - 330,000	480,000 - 910,000
FTE jobs for all installations between 2012-2014	10,000 - 20,000	10,000 - 30,000	10,000 - 30,000	30,000 - 70,000

Table 11: Estimated FTE jobs associated with solar PV for new installations projected between Year 3 and Year 5[138]

According to the Renewable Energy View 2014[139] the solar PV industry directly supported 15,620 UK jobs in 2,200 enterprises across the UK supply chain during 2012/13, which is around 15% of total jobs in renewable energy industries and a third of all renewables companies in the UK. A report by BIS suggests that 34,400 people were employed in the wider solar PV sector and its supply chain in 2013, which is likely to include companies that have an involvement in the solar sector without solar being their core business[140]. The BIS report also

[135] Mitchell, C., Froggatt, A., Hoggett, R., 2014, Governance and disruptive energy system change, Conference Paper, International Workshop on Incumbent – Challenger Interactions in Energy Transitions, 22-23 September 2014, Stuttgart, Germany.

[136] KTN, 2013, UK Solar Photovoltaic Roadmap – A Strategy for 2020, Knowledge Transfer Network, London.

[137] DECC, 2012, Impact Assessment – Government Response to Consultation on Feed-in Tariffs Comprehensive Review Phase 2A: solar PV Tariffs and Cost Control, Department of Energy and Climate Change, London.

[138] DECC, 2012, Impact Assessment – Government Response to Consultation on Feed-in Tariffs Comprehensive Review Phase 2A: solar PV Tariffs and Cost Control, Department of Energy and Climate Change, London.

[139] REA, Innovas and PwC, 2014, Renewable Energy View 2014, Renewable Energy Association, London.

[140] BIS, 2015, The Size and Performance of the UK Low Carbon Economy, Department for Business, Innovation and Skills, London.

identified compound annual growth rates in the sector of 20.8% from 2010 to 2013, although the number people employed actually declined from its peak of 35,600 in 2012.

The BIS report also estimates that the gross value added, including supply chain, of solar PV has increased from £2.7bn to £33.3bn (2010-13). Both the BIS report and the Renewable Energy View 2014 point towards the large business creation potential for the solar PV industry. The latter claims it is around twice as high as for other renewable technologies with more than twice the number of companies supported per £1m of investment. Figure 24 compares the 10 largest UK renewables sectors, by turnover, identified by the Centre for Economics and Business Research.

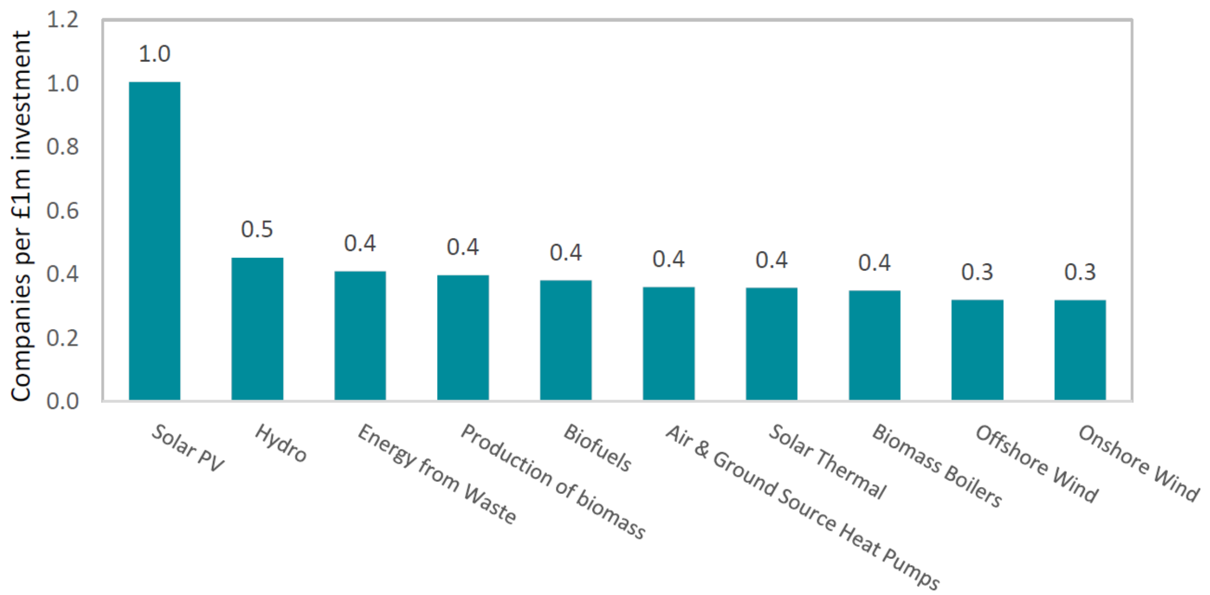


Figure 24: Number of companies supported per £1 of investment[141]

A study by the Building Research Establishment's National Solar Centre (NSC)[142] commissioned by DECC established that domestic solar PV installations support around 20 FTEs (full time equivalent jobs) /MW installed capacity compared to 7 FTEs/MW for ground-mounted projects. The Centre for Economics and Business Research (Cebr)[143], who were commissioned to undertake market research by the Solar Trade Association (STA), assumes that the number of jobs supported by rooftop installations will decrease to 16 FTEs/MW and the number for ground-mounted to 5.6 FTEs/MW by 2030 as a result of Cebr's forecast for rising output per worker across the economy.

According to the STA[144], inverters and solar PV modules are sourced from outside the UK as well as around 80% of mounting systems. Labour and operational expenditures are fully UK based. The total UK supply chain content (capital, labour and operational expenditures) is probably around 56%. This percentage is similar for both domestic and commercial installations.

Engineering, legal and financial expertise, rather than materials, are the UK's key export opportunities although there is manufacturing potential for specialised modules (building and roof integrated) by companies such as Romag, GB-Sol and Viridian that could be developed

[141] Centre for Economics and Business Research, 2014, Solar powered growth in the UK – The macroeconomic benefits for the UK of investment in solar PV, Solar Trade Association, London.

[142] BRE Group, 2014, BRE National Solar Centre measures job growth in the solar sector, < http://www.bre.co.uk/news/BRE-National-Solar-Centre-measures-job-growth-in-the-solar-sector-965.html >.

[143] Centre for Economics and Business Research, 2014, Solar powered growth in the UK – The macroeconomic benefits for the UK of investment in solar PV, Solar Trade Association, London.

[144] Personal communication with a representative from the Solar Trade Association.

further. Non-specialist mounting systems, cables, switchgear, meters etc. are also made in the UK and some of this is likely to be exported[145]. According to the Knowledge Transfer Network[146], the UK has the opportunity to establish higher levels of manufacturing capability at all stages of the supply chain, with significant strength and expertise being identified in instrumentation, new devices and in-line production tools.

There is also considerable inward investment linked to both ground-mounted installations and aggregated installations at a domestic level. SunEdison, for example, is a company establishing a supply-chain presence in the UK market by both setting up offices and investing in building solar farms, commercial rooftop and domestic installations while Enphase is investing in supply chains[147].

7.1.2 Wind

According to RenewableUK:

> *The small wind market is not a product of the FIT, but a market that was able to utilise the incentive scheme in order to increase deployment and achieve economies of scale.*[148]

Figures from RenewableUK suggest that in 2013 less than £1 of the average annual household energy bill went towards supporting <500kW wind via the FIT. The cumulative installed small and medium wind capacity stood at 130 MW in 2014.

Figures on employment and the UK supply chain of wind are difficult to find but the industry considers its small and medium wind sector (<500kW) comprising 15 UK-based manufacturers as world leading[149]. In 2012, 3,304 full-time employees were directly working in the small and medium wind industry, which represents a threefold growth rate since 2010. Annual gross market revenue stands at over £110m. In 2013-14, however, many companies reduced their workforce, in some cases by half, due to market uncertainty resulting from FIT degression (see Performance of the FIT: wind). According to RenewableUK[150] this was the result of the <50kW micro-wind sector market declining by almost 80% in 2013 following FIT adjustments. It is also concerned that developers and installers of medium wind turbines (with a 50-500kW capacity) will face a similar decline in trade in light of rapid FIT degression.

CKD Galbraith[151], an independent property consultancy in Scotland, has reached a similar conclusion regarding the prospects of the small and medium scale (<500kW) wind sector. They consider that degression, which lowered the FIT tariffs by 20% in April 2015 as a result of deployment levels in Year 5 of the FIT exceeding the maximum level for wind power, is threatening the industry. In general, tariff levels have decreased by 43% in the 1.5-15kW bracket, 37% in the 15-100kW bracket and 32% in the 100-500kW bracket for wind generation despite industry CAPEX cost reduction of only 10.6% since 2011[152].

---

[145] Personal communication with a representative from the Solar Trade Association.

[146] KTN, 2013, UK Solar Photovoltaic Roadmap – A Strategy for 2020, Knowledge Transfer Network, London.

[147] Personal communication with a representative from the Solar Trade Association.

[148] RenewableUK, 2014, Local Supply Chain Opportunities in Onshore Wind, RenewableUK, London. P. 5

[149] RenewableUK, 2014, Small and Medium Wind Strategy, RenewableUK, London.

[150] RenewableUK, 2014, Small and Medium Wind Strategy, RenewableUK, London.

[151] CKD Galbraith, 2015, CKD Galbraith identifies subsidy threat to smaller wind projects, < http://www.ckdgalbraith.co.uk/news/ckd-galbraith-identifies-subsidy-threat-smaller-wind-projects >.

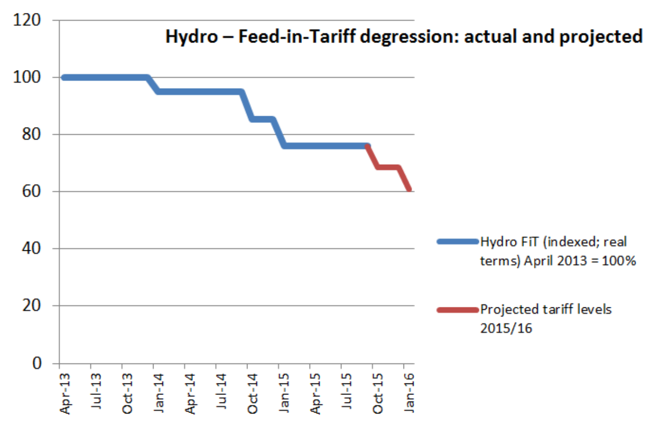
[152] RenewableUK, 2014, Small and Medium Wind Strategy – The current and future potential of the sub-500kW wind industry in the UK, London, UK.

The shrinking home market has been partially compensated by strong exports with one turbine exported for every turbine installed in the UK. Nearly 25,000 turbines are exported every year, creating an annual UK manufacturing export revenue of £5.36m. Depending on which RenewableUK growth scenario you look at, small and medium wind could employ anywhere between 1,987 and 10,156 jobs in 2023. This discrepancy is the result of industry forecasts based on weak or strong domestic demand, which is linked to the presence and levels of FITs.

7.1.3 Hydro

According to the British Hydropower Association (BHA)[153] only 2-3 MW/annum of small-scale hydro were installed prior to the introduction of the FIT. Since the introduction of the FIT, an average of 10-15 MW/annum has been installed with a total capacity of nearly 72MW at the end of March 2015[154]. The BHA has doubts whether the >100MW of hydro currently in the FIT pre-accreditation pipeline with a connection deadline of 2016 will be installed. Rapid degression is also making many hydro projects unviable and has caused a dramatic decline in new projects.

Figure 25 shows actual and projected degression as well as the number of planning submissions and extraction licence applications received in Scotland, where the majority of FIT installations are located. These figures from BHA show that both the number of new hydro planning submissions and applications for water extraction licences, required for hydro schemes, has declined significantly 2014-2015 as a result of FIT degression over the same period.



New hydro planning submissions (Scotland)	Jan/Feb 2014	Jan/Feb 2015
Full planning applications	16	1
Scoping requests	40	-
Combined capacity	25.5MW	2.0MW

Water extraction licence applications received (Scotland)						
	2010	2011	2012	2013	2014	2015
	26	35	47	83	48	2

Figure 25: Impacts of FIT degression on hydro, new hydro planning submissions and water extraction licence applications received in Scotland[155]

The BHA identified a combination of rapid FIT degression and short pre-accreditation windows as a cause for a declining number of installations. The BHA argue that as an established technology, hydro has less opportunity to reduce costs through innovation, which poses questions regarding its potential to reach grid parity in the short term. At the same time, hydro offers long term generation beyond the subsidy period with installations continuing to generate power with minor refurbishments for 50-80 years. Hydro also has the benefit of strong local

[153] British Hydropower Association, 2015, Small-scale hydro – An integral part of the UK renewable energy mix, Presentation to Amber Rudd, 11 March, 2015.

[154] DECC, March 2015 Monthly Central Feed-in Tariff Register Statistics, Department of Energy and Climate Change, London

[155] British Hydropower Association, 2015, Small-scale hydro – An integral part of the UK renewable energy mix, Presentation to Amber Rudd, 11 March, 2015.

supply chains as, on average, 70% of the cost of new hydro is in civil construction, which is usually procured locally[156].

On the other hand, a BIS report[157] points towards a decline in the gross value added, including supply chain of the entire hydroelectric energy industry. This trend appears to be supported by investment data, where at £30m hydroelectricity represents the smallest capital commitment alongside the marine electricity industry. The BIS report specifically mentions the lack of new large hydroelectric facilities, as all the major natural facilities have been exploited and that new business investment is in small scale schemes, which often fall under the FIT. According to the report, industry commentators noted that new businesses investing in small scale schemes often use electricity on-site and only sell excess capacity to the grid.

7.1.4 Anaerobic Digestion (AD)

Figures on employment and growth specifically for FIT-supported AD are difficult to source. According to the Renewable Energy View 2014[158], the UK Anaerobic Digestion (AD) sector employed 2,640 people across the UK supply chain in 2012-13, although it appears as though the downstream employment and growth effects (i.e. on farms) are considered more important than upstream employment and growth effects (i.e.along the supply chain). According to the Annual AD report 2014[159], the number of FIT and non-FIT supported operation sites increased by 34%, input by 55% and employment by 36% between 2012 and 2013. On-farm plants represent the largest share of AD plants (45 out of 120 AD plants in 2013 and 62 of 153 AD plants in 2015), although their share of input tonnage has decreased from 37.3% in 2012 to 32.2% in 2013 (see Figure 26).

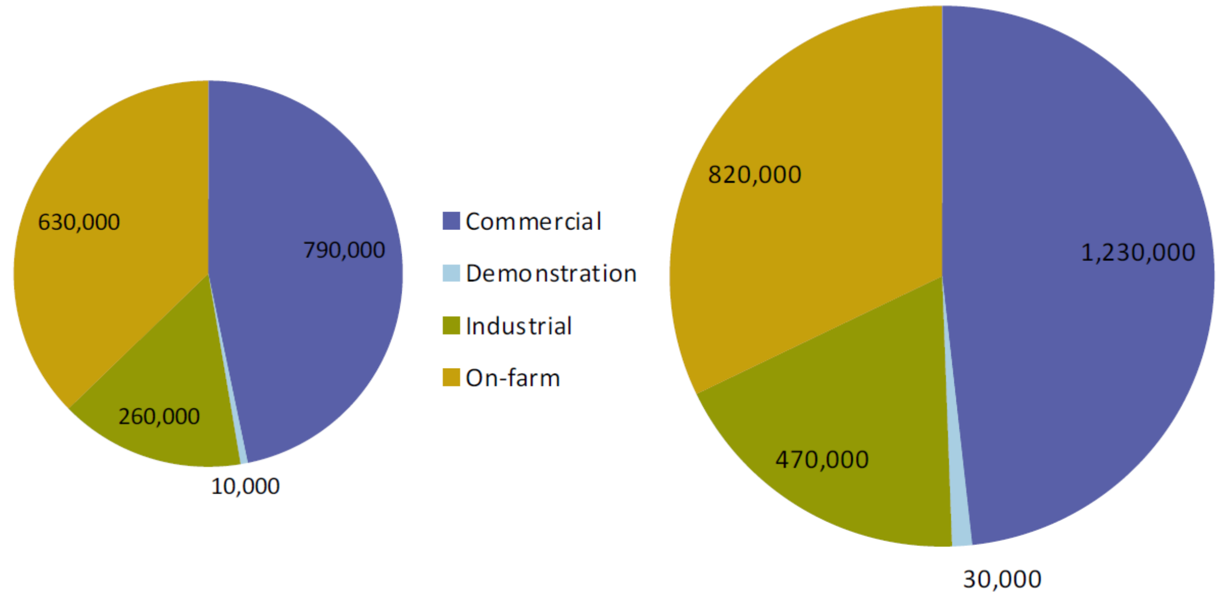


Figure 26: Grossed estimates of UK AD sector input tonnages in 2012 and 2013 by type[160]

[156] British Hydropower Association, 2015, Small-scale hydro – An integral part of the UK renewable energy mix, Presentation to Amber Rudd, 11 March, 2015.

[157] BIS, 2015 The Size and Performance of the UK Low Carbon Economy, Department for Business, Innovation and Skills, London.

[158] REA, Innovas and PwC, 2014, Renewable Energy View 2014, Renewable Energy Association, London.

[159] Defra, 2015, Anaerobic Digestion Strategy and Action Plan – Annual Report 2014, Department for Environment, Food and Rural Affairs, London.

[160] Defra, 2015, Anaerobic Digestion Strategy and Action Plan – Annual Report 2014, Department for Environment, Food and Rural Affairs, London.

This reflects the increasing uptake of AD by food producers and processors as gross estimates of input tonnage for commercial AD increased from 46.7% to 48.2% over the same period.

According to a 2012 report by the Renewable Energy Association (REA)[161], there are around 20 companies currently designing and building AD plants in the UK, with around 80% of components sourced from the UK. In this area, the UK is leading in technology development although these figures might reflect AD market development in the first two years of the FIT, when large food waste plants dominated installation figures. The tendency is now towards smaller installations for farm waste management and it is not clear what role the UK plays in technology development, although the global dominance of food AD plants suggests that the UK's waste AD focus leads itself to technology leadership in this area. According to the Renewable Energy View 2014[162], there was a total of 140 UK companies across the UK AD supply chain in 2012-13.

Plants up to 250kW are likely to be for farm waste management or bespoke add-ons to processing industries. 250–500kW plants are more likely to take a combination of farm waste and crop (larger installations within this band more likely to be used exclusively for crops). >1 MW plants, which experienced significant uptake in Year 1 and 2 of the FIT, are more likely to be for food waste. The relative increase in numbers of <500kW plants installed (see section on Uptake of Anaerobic Digestion) cannot be attributed to a single factor. Among the reasons for increasing AD deployment on farms was the opening of the AD loan scheme to farmers. Installations on farms are more likely to encourage job retention while larger AD plants may have a FTE job associated with management, operation and maintenance. Build, Own, Operate plants are more likely to be remotely managed, which reduces the need for on-site employment.

AD of slurry and food wastes is an effective option to reduce greenhouse gas emissions and improve fuel efficiency. High quality AD design and management, especially gas-tight digestate storage, also allows associated acidification and eutrophication to be minimised. Growing crops for AD is generally seen as environmentally detrimental, except where co-digestion of crops is required to improve the benefits of waste AD by making it economically viable and where limited areas of maize feedstock cultivation can act as a break crop to help optimise short arable crop rotations[163].

The National Non Food Crop Centre (NNFCC) estimates that around 9% of AD capacity is crop only and around 17% of the total maize area in England is purpose-grown to feed AD[164]. Although this equates only to 0.5% of England's total arable area[165], a proliferation of AD plants with crop feedstocks could impact on land rental and/or maize prices. Defra has commissioned research in this area which is due to be published in the latter half of 2015.

On balance, the security of income streams from AD can reduce the volatility of farm income, although AD plant operation may place additional time demand on farmers as the economics of small-scale on-farm AD do not allow for employment of a skilled, full-time operator. The focus on waste also improves farms' waste management. Methane from manures and slurries is captured which would otherwise be leaked into the atmosphere. If the waste is also converted

---

[161] REA, 2012, Renewable energy: Made in Britain, Renewable Energy Association, London.

[162] REA, Innovas and PwC, 2014, Renewable Energy View 2014, Renewable Energy Association, London.

[163] Defra, 2013, Comparative Life Cycle Assessment of Anaerobic Digestion and other bioenergy options. Department for Environment, Food and Rural Affairs, London.

[164] Defra, 2015, Anaerobic Digestion Strategy and Action Plan – Annual Report 2014, Department for Environment, Food and Rural Affairs, London.

[165] Defra, 2014, Area of Crops Grown For Bioenergy in England and the UK: 2008-2013, Department for Environment, Food and Rural Affairs, London.

into a fertiliser and used to displace mineral fertilisers, waste processing can provide high sustainability outcomes, even if the yield of biogas remains low.

Summary

Figures on direct growth effects of the FIT to the economy are not available.

Reports suggest that renewable energy is more labour-intensive than either coal- or gas-fired power plants. In the short term, building new renewable generation capacity is more likely to create more jobs than investing in an equivalent level of fossil-fuel-fired generation. The magnitude of difference is of the order of 1 job per annual GWh produced. A UKERC report suggests that more jobs/annual GWh have been created as a result of the FIT compared to equivalent investments in fossil fuel-fired generation in the absence of the FIT. As the UK has been in recession, and is still continuing to recover from it, the FIT as a form of fiscal and monetary stimulus has been and is contributing to job creation.

A report by the Renewable Energy Association, Innovas and PricewaterhouseCoopers suggests that the solar PV industry supported 15,620 UK jobs in 2,200 enterprises across the UK supply chain during 2012/13. Inverters and solar PV modules are sourced from outside the UK, as well as around 80% of mounting systems. However, labour and other costs are fully UK based. The total UK content is probably around 56% (capital, labour and operational expenditures).

A study by the Building Research Establishment's National Solar Centre (NSC) established that domestic solar PV installations support around 20 FTEs (full time equivalent jobs) /MW installed capacity compared to 7 FTEs/MW for ground-mounted projects. The Centre for Economics and Business Research (Cebr), who were commissioned to undertake market research by the Solar Trade Association (STA), assumes that the number of jobs supported by rooftop installations will decrease to 16 FTEs/MW and the number for ground-mounted to 5.6 FTEs/MW by 2030 as a result of Cebr's forecast for rising output per worker across the economy.

In 2012, 3,304 full-time employees were directly working in the small and medium (<500kW) wind industry, which represents a threefold growth rate since 2010. Annual gross market revenue stands at over £110m. Nearly 25,000 turbines are exported every year, creating an annual UK manufacturing export revenue of £5.36m.

As an established technology, hydro has less opportunity to reduce costs through innovation, which poses questions regarding its potential to reach grid parity in the short term. At the same time, hydro offers long-term generation beyond the subsidy period with installations continuing to generate power with minor refurbishments for 50-80 years. Hydro also has the benefit of strong local supply chains as on average 70% of the cost of new hydro is in civil construction is usually procured locally.

The UK AD sector employed 2,640 people across the UK supply chain in 2012-13 although the downstream employment and growth effects (i.e. job retention on farms) are considered more important for AD than upstream employment and growth effects (i.e.along the supply chain). The security of income streams from AD can reduce the volatility of farm income. A focus on waste also improves farm waste management.

8. Wider benefits of the FIT

8.1 Diversifying energy supply and energy security

8.1.1 Electricity Suppliers

The diversity and number of electricity suppliers in the UK has increased significantly over the last 5 years. In 2010 around 99.7% of electricity supplied to UK households came from the Big Six[166]. This figure fell to 97.7% in 2013. Recent research by Cornwall Energy suggests that independent suppliers, including FIT installations (made up of individuals, communities, housing associations, local authorities, cooperative organisations and companies) as well as emerging utilities such as First Utility, Good Energy and OVO, have increased their average market share from 5.3% at 31 January 2014 to 9.6% at 31 January 2015[167]. Cornwall Energy (numbers also used by Energy UK[168]) estimates that just under 30% of FIT generation is sold to non-Big Six suppliers[169] – an indication of how the FIT is contributing to supplier market diversification.

8.1.2 Energy Security and Reliability of supply

Reliability, as with all renewable energy technologies, is difficult to measure and subject to connectivity and storage options. Given the dominance of domestic solar PV installations among FIT eligible technologies installed to date, it is likely that more electricity gets used on site compared to other renewable and non-renewable technologies. This is suggested by the lowest ever National Grid peak weather corrected demand forecast for the high summer period 2015 of 37.5 GW[170] (Table 12).

	SOR – 2014	SOR – 2015
Peak Demand Forecast	38.4	37.5
PV (Solar) Capacity	2.4	4.4

Table 12: Peak summer demand and installed embedded solar PV capacity[171]

The continuing trend of falling peak electricity demand and lower minimum demand levels results in system operability issues. This is linked to the relatively low predictability of electricity supply specifically from FIT eligible renewable energy technologies. The National Grid published a Solar PV Briefing Note[172] in 2012 which suggests that up to a penetration of around 10% of households (2.2m households) or 10GW of generation, solar PV can be accommodated

[166] Mitchell, C., 2012, Presentation given at the New Energy Securities Challenges Workshop, 10 May 2012, Royal Geographical Society, London.
[167] Cornwall Energy, 2015, Big Six continue to fight back in domestic supply market, < http://www.cornwallenergy.com/Opinion/Big-Six-continue-to-fight-back-in-domestic-supply-market >.
[168] https://www.energy-uk.org.uk/publication/124-research-and-reports.html
[169] Personal communication with a representative from Cornwall Energy.

[170] National Grid, 2015, Summer Outlook 2015, National Grid Plc, Warwick.
[171] National Grid, 2015, Summer Outlook 2015, National Grid Plc, Warwick.
[172] National Grid, 2012, Solar PV Briefing Note, < https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/66609/7335-national-grid-solar-pv-briefing-note-for-decc.pdf >.

without making the operation of the transmission system significantly more difficult. Beyond this domestic penetration level of 10%, however, solar PV requires changes to the operation of the transmission system, which, while costly, could contribute to the development of a more decentralised grid infrastructure.

Centralised grid infrastructures are vulnerable to terrorism, severe weather events and other threats due to the relatively small number of major points of potential failure such as large power plants, major substations and high-voltage transmission lines. The more decentralised the energy system is, the less prone it is to large-scale failure and decentralised renewables do not necessarily compromise grid performance. Denmark, with around a third of electricity consumption covered by wind, features one of the highest rates of grid reliability in Europe. Germany's System Average Interruption Duration Index (SAIDI) suggests that Germany set a record for reliability in 2011 with a downtime of only 15.31 minutes despite all of its 17 nuclear power stations being offline following the Fukushima disaster[173].

The increasing share of embedded generation, described by the National Grid as 'small generation units connected to the distribution network, such as solar PV and wind [which] the System Operator does not receive live metering for', may therefore contribute to system reliability if it is embraced as part of a system. Embedded solar PV capacity increased from 2.4 GW in Feb 2014 to 4.4 GW in Feb 2015 with estimates of 5.5 GW in Feb 2016.

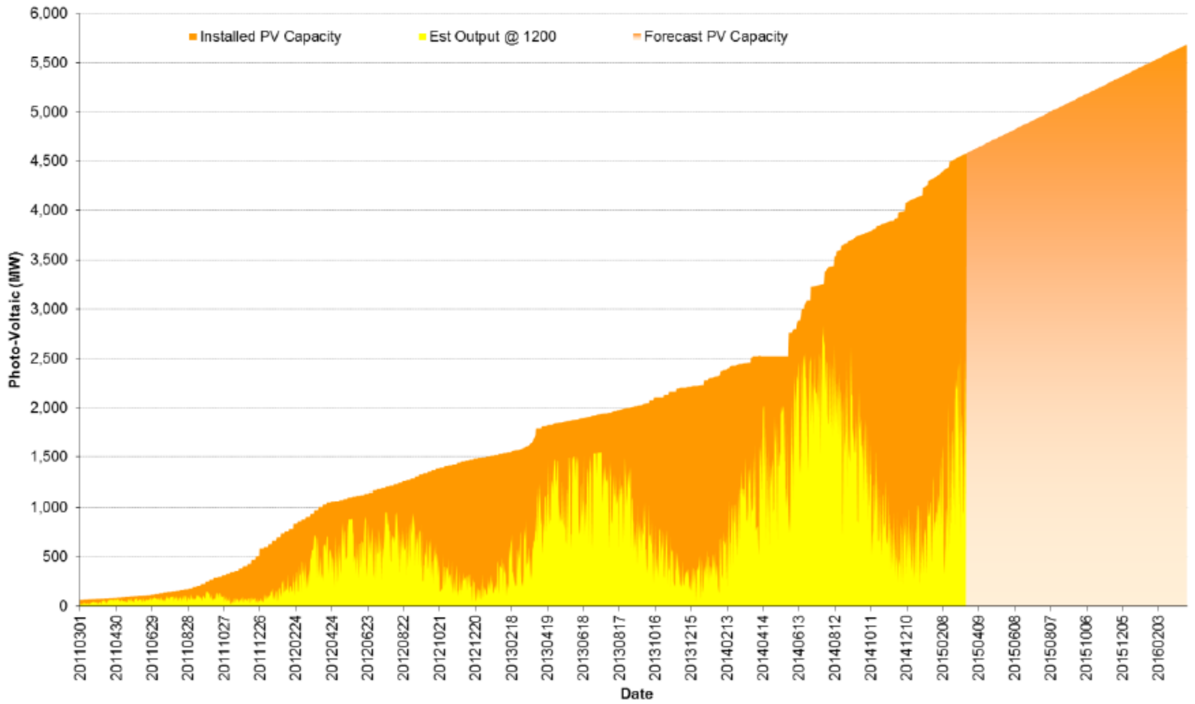


Figure 27: Total solar PV capacity and estimated generation[174]

Table 12 above shows how peak weather corrected demand forecast for summer 2015 has dropped by 900MW since 2014, primarily due to a 2GW increase in embedded solar PV generation. As peak demand occurs from mid-day to afternoon during high summer period (see

[173] Guevara-Stone, L., 2014, Can decentralised energy make America's power grid blackout-proof?, Rocky Mountain Institute, RenewEconomy, < http://reneweconomy.com.au/2014/can-make-americas-power-grid-blackout-proof-14292 >.

[174] National Grid, 2015, Summer Outlook 2015, National Grid Plc, Warwick.

Table 12, Figure 27 and Figure 28), the National Grid explicitly states that increasing embedded generation such as domestic solar PV is a major contributor to the trend of decreasing grid demand[175].

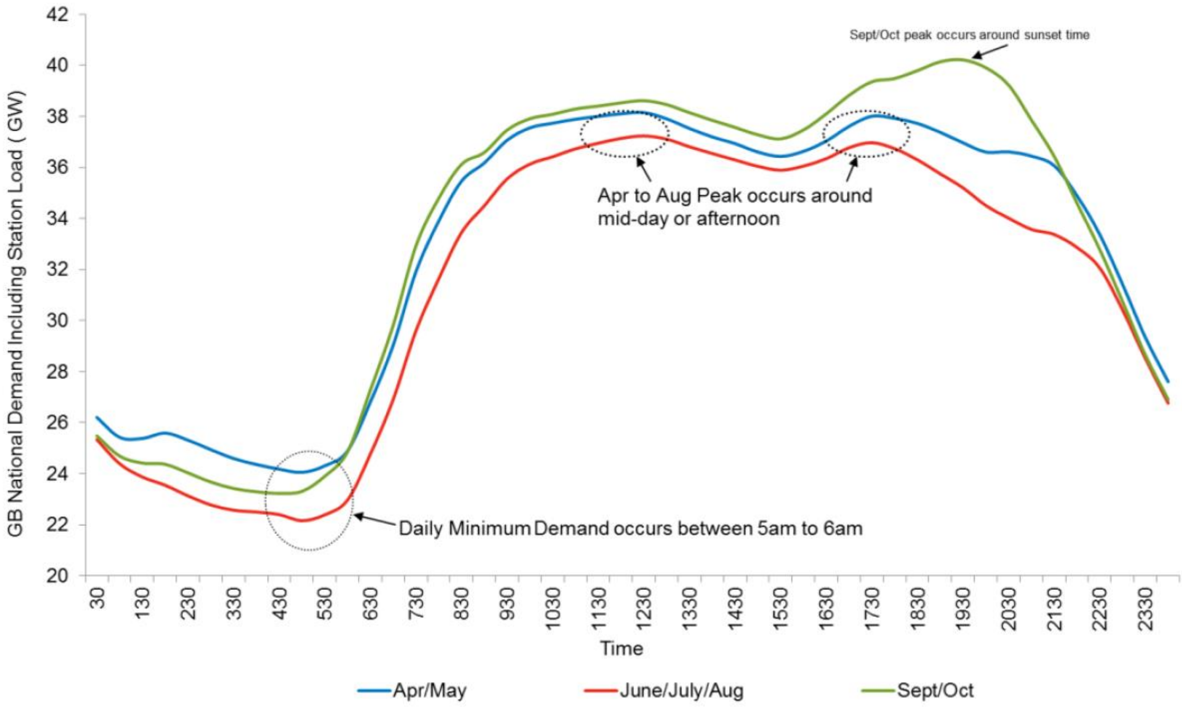


Figure 28: Half hourly demand profiles during 2014 British summer time period[176]

Table 13 shows the differences in seasonal wind load factors from 2011-13 and 2014. The mean annual load factor of wind for 2014 was 29%.

Year/Mean Load Factor	Winter	Spring	Summer	Autumn
2011-2013	**30%**	**23%**	**16%**	**28%**
2014	**45%**	**26%**	**18%**	**28%**

Table 13: Comparison of seasonal wind load factors from 2011-13 and 2014[177]

The increase in mean annual load factor is partly the result of 2014 being a particularly windy winter and partly the result of the greater geographic dispersion of wind farms. There is a 20% chance of wind load factors dropping below 6% and a 10% chance that the load factor will be below 4% during the summer daytime.

Fundamentally, a high penetration of renewables such as solar PV in sunny locations and wind turbines in windy conditions can lead to an oversupply of electricity. This oversupply of electricity implies that either fossil fuel and/or nuclear generators have to reduce their output, which makes them less efficient to operate, or wind and solar PV generators may need to be curtailed and prevented from generating. Both cases incur losses for plant operators. For <5MW

[175] National Grid, 2015, Summer Outlook 2015, National Grid Plc, Warwick.
[176] National Grid, 2015, Summer Outlook 2015, National Grid Plc, Warwick.
[177] National Grid, 2015, Summer Outlook 2015, National Grid Plc, Warwick.

wind and solar installations receiving FITs, the low wholesale electricity prices resulting from high renewables penetration 'actually raise the apparent subsidy paid to operators from electricity consumers, since the subsidy is measured as the difference between the set tariff paid to wind and solar, and the wholesale power price'[178].

The Royal Academy of Engineering[179] suggests that improvements in our ability to manage demand to reflect the increasing output from wind (and other intermittent sources such as solar PV) are necessary to integrate larger amounts of non-dispatchable generation capacity. Increasing interconnection with the continent also increases system flexibility although wind output can still be low across large regions. Storage options need to be developed to help cope with periods of calm which, except on rare occasions, persist for no more than a few days. Advancements in storage technology are apparent in the automobile industry and an increasing penetration of electric vehicles represents an increasing share of electric storage capacity which could add to system balancing options.

A report by the Parliamentary Office of Science and Technology on intermittent electricity generation[180] uses figures from Germany to highlight issues for renewable electricity generation in general. Output of solar PV in Germany, for example, deviates from output forecasts by 5% on average. This is much lower than for wind (maximum deviations of 35%) and implies that the reserve electricity generating capacities currently required to balance out fluctuating generation from FIT installations is currently not significant. On the other hand, zero percent of solar PV may be categorised as reliable capacity as a percentage of maximum capacity, compared to 7-25% for wind and 77-95% for fossil fuel or nuclear power. This can cause major problems for grid infrastructure designed around a small percentage of fluctuating generation capacity. However, given the trend towards diversity in terms of technologies (also for storage, including electric cars), scales of plant capacities and demand-side management practices[181], changes to the grid infrastructure are likely to be able to meet the challenge of increasingly intermittent generation.

FIT-supported intermittent technologies like wind and solar may be combined with local heating schemes to help balance out peaks and troughs in electricity generation. According to Co-operatives UK, 'in Denmark, district heating plants are now installing electric boilers, which can be used at times when there are high wind speeds and surplus electricity on the grid. This effectively means that surplus electricity is stored as hot water. Local networks can therefore provide grid balancing services, which, in the UK, is currently done through national-level grid intervention'[182].

Emerging trends such as 'grid defection'[183], which primarily involve the combination of solar PV with emerging storage technologies derived from advances in mass producing batteries for electric vehicles may significantly enhance the resilience and capacity of demand side response

[178] FS-UNEP Collaborating Centre/BNEF, 2015, Global Trends in Renewable Energy Investment 2015, Frankfurt School, FS-UNEP Collaborating Centre for Climate and Sustainable Energy Finance and Bloomberg New Energy Finance, Frankfurt am Main.

[179] RAENG, 2014, Wind Energy – implications of large-scale deployment on the GB electricity system, Royal Academy of Engineering, London.

[180] Houses of Parliament, 2014, Intermittent Electricity Generation, Parliamentary Office of Science & Technology, London.

[181] Mitchell, C., Froggatt, A., Hoggett, R., 2014, Governance and disruptive energy system change, Conference Paper, International Workshop on Incumbent – Challenger Interactions in Energy Transitions, 22-23 September 2014, Stuttgart, Germany.

[182] Parliament UK, 2013, Energy and Climate Change – Sixth Report – Local Energy, Proceedings of the Committee and Energy and Climate Change, Parliament of the United Kingdom, London.

[183] Rocky Mountain Institute, 2014, The Economics of Grid Defection – When and where distributed solar generation plus storage competes with traditional utility service, Rocky Mountain Institute, Boulder, Colorado.

of combinations of technologies partly supported by the FIT. Especially once **solar PV-plus-battery systems** reach grid parity, which according to the Rocky Mountain Institute appears likely within the 30 year planned economic life of centralised power plants and transmission infrastructures, demand side response and resilience may become a key feature of microgeneration technologies currently supported by the FIT.

HSBC[184] suggests that FITs for certain technologies in Germany will no longer be necessary around 2020 because installation costs will be falling rapidly as solar PV and wind markets in particular grow in global scale. Given that around 30% (and potentially rising to 50% by 2025) of German generation capacity is less than 10MW, as domestic solar PV has been diffused at an unprecedented scale, the process of re-localising power production (re-municipalisation/communalisation) appears unstoppable. A report by Germany Trade and Invest (Photovoltaic Industry Overview, 2014-15) foresees the German solar PV plus battery market to reach more than 100,000 systems annually by 2018 compared to 6,000 in 2013 and Germany's Federal Environment Ministry, in cooperation with the state-owned KfW bank, continue to support uptake[185].

Morgan Stanley[186]sees potential for customers moving 'off-grid' through a combination of solar PV plus battery systems in part to avoid utility grid fees. The 'off-grid' scenario is considered the most disruptive use of energy storage but 'there are also less disruptive applications such as strengthening the grid to compensate for the variability of solar output'. Solar demand is likely to be driven by embedded generation if a favourable regulatory environment persists as Morgan Stanley predict significant reductions in installation costs. At the same time they do not forecast significant impacts on fossil-fuel demand.

This fits with arguments that the solar PV plus energy storage, and especially associated 'grid defection', are exaggerated. According to Toby Shea, a Moody's Vice President – Senior Analyst, 'we believe the cost of batteries in a solar-battery system is still an order of magnitude too expensive to substitute grid power. The capital cost of batteries today is around $500-600/kWh but costs for widespread solar-battery application would need to drop to $10-30/kWh'. The size of batteries for 'grid defection' is also currently in excess of what people are likely to accept and Moody's puts forward the argument that people are too accustomed to the convenience and reliability of the grid.

HSBC[187], on the other hand, argues that the cost of batteries, despite being currently prohibitively high, need to be seen in the context of smoother supply-demand variations and potentially lower investment requirements for grid infrastructures, lower peak demand and reduced need for back-up capacity. The Rocky Mountain Institute[188] points towards the traditional utility-customer relationship which is coming under pressure from these technological developments and diffusion, even if they do not get widely adopted. What is considered more important is that an increasing share of consumer load will be powered by on-site renewables. Maintaining grid connections also implies that grid parity of optimally sized, grid connected solar PV plus battery systems may be reached sooner compared to off-grid solutions. As they

---

[184] HSBC, 2014, Energy Storage – Power to the People, HSBC Global Research, HSBC Bank plc, London.

[185] Germany Trade & Invest, 2014, Industry Overview – The Photovoltaic Market in Germany, < http://www.gtai.de/GTAI/Content/EN/Invest/_SharedDocs/Downloads/GTAI/Industry-overviews/the-photovoltaic-market-in-germany-en.pdf >.

[186] Morgan Stanley Research, 2014, Solar Power & Energy Storage – Policy Factors vs. Improving Economics, Morgan Stanley Blue Paper, Morgan Stanley Research, New York.

[187] HSBC, 2014, Energy Storage – Power to the People, HSBC Global Research, HSBC Bank plc, London.

[188] RMI, 2015, The Economics of Load Defection – How grid-connected solar-plus-battery systems will compete with traditional electric service, why it matter, and possible paths forward, Rocky Mountain Institute, Boulder, Colorado.

maintain grid connection, they may offer value to the grid if utilities change their business model appropriately. This may involve utilities shifting towards service provision, potentially through smart grids[189] by investing in storage[190] or by moving towards an integrator model offering finance, design and installation of solar PV plus battery solutions[191] (see also section on Non-traditional business models).

Diversifying energy supply within the UK is seen to improve energy security. However, this diversification is dependent on the availability of raw materials overseas. Rare earth metals from China play an important role for renewable energy technologies. One example of this is tellurium, which is required to make thin, cheap solar PV panels but only makes up 0.0000001% of the earth's crust, three times rarer than gold[192]. A difficulty therefore lies in securing the materials required for low-carbon energy generation. Encouraging the increased uptake of solar panels has wider geopolitical effects as a result of resource mining and trade of materials required for low-carbon energy generation. A shift from a highly centralised power generation system to a more dispersed system assuming a continuously increasing share of renewables will have a different impact on the geopolitics of resource mining and trade than more centralisation, assuming larger shares of nuclear and CCS[193].

8.2 Transmission losses

During the transmission of electricity, some energy is always 'lost' from the transmission system, usually in the form of heat[194]. Transmission losses currently account for about 2% of the electricity transmitted[195]. A 2007 Ofgem report[196] suggested that because of the characteristics of distributed generation, which includes all FIT eligible technologies, transmission losses may be reduced to a certain extent as an increasing share of electricity gets used on-site or locally. Lower demand for transmission also reduces the overall costs of transmission. According to E.On, 'local generation reduces transmission losses and reduces carbon emissions'[197]. There are no specific figures on the FIT's impact on transmission losses. Improved (remote) meter readings would allow for alternative FIT mechanisms in the future based on on-site consumption and reduced transmission capacity as opposed to a FIT just for electricity generation.

189 HSBC, 2014, Energy Storage – Power to the People, HSBC Global Research, HSBC Bank plc, London.

190 Parkinson, G., 2015, Citi: Battery storage to hasten demise of fossil fuels, RenewEconomy, < http://reneweconomy.com.au/2015/citi-battery-storage-to-hasten-demise-of-fossil-fuels >.

191 Morgan Stanley Research, 2014, Solar Power & Energy Storage – Policy Factors vs. Improving Economics, Morgan Stanley Blue Paper, Morgan Stanley Research, New York.

192 Jones, N., 2013, A Scarcity of Rare Metals Is Hindering Green Technologies, Yale 360, Yale School of Forestry & Environmental Studies, Yale University, New Haven, CT.

193 Barrett, M., Bradshaw, M., Froggatt, A., Mitchell, C., Parag, Y., Stirling, A., Watson, J., Winzer, C., 2011, Energy Security in a Multi-polar World, Discussion Draft, < http://www.exeter.ac.uk/energysecurity/documents/Energy_Security_in_a_Multipolar_World_Working_Paper_DRAFT.pdf >.

194 National Grid, 2015, Transmission Losses, < http://www2.nationalgrid.com/UK/Industry-information/Electricity-system-operator-incentives/transmission-losses/ >.

195 Elexon, 2013, Transmission Losses – Guidance, Elexon, London.

196 DTI/Ofgem, 2007, Review of Distributed Generation, Department of Trade and Industry, London.

197 E.On, 2015, What is decentralised energy?, < https://www.eonenergy.com/for-your-business/large-energy-users/manage-energy/energy-efficiency/decentralised-energy-experts/What-is-decentralised-energy >.

8.3 Fuel poverty

In March 2015 DECC published the Fuel poverty strategy for England[198]. The focus of measures in the Strategy to reduce fuel poverty lies in energy efficiency in homes, with a particular focus on homes in private tenure. Fuel poverty is a complex issue influenced by household income, energy prices and the thermal efficiency of dwellings (in turn reflecting a whole range of dwelling characteristics). Limited evidence has been found indicating direct causal influence of the FIT either mitigating the effects of fuel poverty, or exacerbating fuel poverty. As the FIT is based on levies on energy bills, the costs of the scheme are borne by the poorer sections of the population as much as the better-off[199]. The FIT may therefore be considered a regressive tax as it is paid for by everyone and because poor people spend a larger share of their income on energy than rich people do. This generally applies to policies designed to encourage the diffusion of immature technologies and target emissions through increases in the cost of energy as these policies disproportionately affect lower income households[200]

The Centre for Sustainable Energy (CSE) has recently undertaken detailed analysis[201] on behalf of the Committee on Climate Change to explore the key defining characteristics of households estimated to be fuel poor in England in 2013. Whilst not the focus of their research, the modelling undertaken by the CSE explored the implications of different approaches to funding low carbon measures.

The CSE modelling showed that reduced energy demand to offset increased fuel prices may go some way to addressing the problem although these may be only part of a successful policy mix, rather than a standalone instrument. These recommendations would seem to contrast with the benefits of the FIT scheme, which do not automatically allow such focused targeting. Single policy instruments such as the FIT, if not targeted correctly, have the potential to create negative policy externalities, particularly when the focus of the instrument is on the supply rather than demand side. Therefore careful monitoring of policy cost distribution is a must.

Practical ways of addressing fuel poverty using FIT include the redistribution of the benefits of the FIT by providing free electricity, for instance as part of a rent-a-roof scheme for solar PV. An example of this is Chase Community Solar, a Community Benefit Society that installs solar PV on the roofs of homes occupied by low-income, mainly elderly tenants in the Cannock Chase district in Staffordshire. The tenants are supplied with free electricity and as most of them are retired and/or limited by long-term illness, they can make use of free electricity during the daytime. 75% of finance is being raised by means of a share issue open to all over 16s and projected to pay 7% per annum over 20 years. The remaining 25% was provided via a social loan from Big Society Capital through distributor Pure Leapfrog[202].

---

[198] This in turn was built on Fuel Poverty: A Framework for Future Action 2013 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/211180/FuelPovFramework.pdf

[199] Kinghan, M., 2015, An answer to the potentially regressive impact of solar subsidies?, Blog post, 3 February 2015, < https://www.2degreesnetwork.com/groups/2degrees-community/resources/answer-potentially-regressive-impact-solar-subsidies_3/ >.

[200] Roberts, S., 2008, Energy, equity and the future of the fuel poor, Energy Policy, 36: 4471-4474.

[201] Centre for Sustainable Energy, 2014, Research on fuel poverty – The implications of meeting the fourth carbon budget, Report to the Committee on Climate Change, Centre for Sustainable Energy, Bristol.

[202] Kinghan, M., 2015, An answer to the potentially regressive impact of solar subsidies?, Blog post, 3 February 2015, < https://www.2degreesnetwork.com/groups/2degrees-community/resources/answer-potentially-regressive-impact-solar-subsidies_3/ >

8.3.1 Local authorities and fuel poverty

Another route to using the FIT to address fuel poverty is through local authorities. Similar to the Community Benefit Society example of Chase Community Solar, fuel poor households can receive free electricity from solar PV installed on their roofs by the local authority. A longitudinal case study in the South of England[203] has highlighted how families who are vulnerable to fuel poverty have taken advantage of free electricity from solar PV panels installed by the local authority and supported by the FIT. A number of the social housing tenants succeeded in responding to free electricity by shifting their load and changing their behaviour (see section on Behavioural/consumption change and public perception)

Recent research commissioned by Citizen's Advice[204], shows that fuel poverty alleviation through the FIT, and specifically solar PV, requires timely, precise and 'digestible' information. Of the 647 survey respondents in the survey, 54 had a solar PV system installed by a social landlord. 58% of the social housing tenants did not access information or advice on solar PV when it was installed and they would have benefited most from information on likely savings to electricity bills, how to use the system effectively and technical information of the system. Overall satisfaction with the quality of information and advice available is lower with this group than for users in general (58% of social housing tenants were consulted during the installation process but only 29% consider themselves informed), which limits opportunities for fuel poverty alleviation and load shifting (26% (14 out of 54) social housing tenants found information on how to use the system most effectively (e.g. using electricity during daytime) unsatisfactory). The result is that social housing tenants are less likely to have changed their energy saving behaviour post-installation[205].

The in-depth case study by Fox[206] suggests that information using lay language ('use it or lose it') and peer-to-peer knowledge sharing can potentially enhance the use of solar PV for households vulnerable to fuel poverty. A 2005 study for the Sustainable Consumption Roundtable[207] also indicates that having technology installed through council or housing association does not automatically create awareness. Positive impacts on energy efficiency are more likely where the residents had been provided with well-presented information on the purpose of installed technology as well as simple and clear instructions about what they could do to maximise efficiency.

There is a lot more scope to diffuse fuel poverty alleviating business models supported by the FIT and greater incentives need to be provided for schemes that engage with fuel poor households through free electricity.

---

[203] Fox, N., Doctoral research 2015, SPRU, University of Sussex.

[204] Flanagan, B., Wilkinson, T., 2015, Solar PV User Experience – Research conducted for Citizens Advice, Summary of key findings prepared for workshop on 20 March 2015, Citizens Advice, London.

[205] Flanagan, B., Wilkinson, T., 2015, Solar PV User Experience – Research conducted for Citizens Advice, Summary of key findings prepared for workshop on 20 March 2015, Citizens Advice, London.

[206] Fox, N., Doctoral research 2015, SPRU, University of Sussex.

[207] Dobbyn, J., Thomas, G., 2005, Seeing the light: the impact of micro-generation on the way we use energy – Qualitative research findings, Sustainable Consumption Roundtable, London.

8.4 Non-traditional business models

FIT eligible technologies pose a challenge to incumbent business models and encourage investment by many non-traditional investors, such as individuals and communities, within the energy system. One of the key features of the UK's electricity generation landscape since 2010 is the increasing diversity of business models engaging in distributed generation, demand management and demand-side response. Non-traditional business models that can be directly attributed to the FIT are primarily social enterprises.

Of the hundreds of community groups involved in renewable electricity generation only a small fraction would exist without the FIT. Community Interest Companies and Industrial and Provident Societies (which cover two main business formats; Bona Fide Co-operatives (commonly called Co-ops) and Societies for the Benefit of the Community (commonly called BenComs)) engaging in community energy are the most prominent examples of the use of non-traditional business models for electricity generation that make use of the FIT. Evidence from qualitative studies[208] indicates that most cooperative and community projects would not have been established or even conceived in the first place without the FIT.

It has been estimated that community energy could deliver 3 GW of solar PV, onshore wind and hydro generation by 2020, representing 14% of the total capacity of these technologies and 1.4% of total electricity consumption[209]. Optimistic projections suggest that community energy may eventually help meet as much as 18% of UK energy demand[210]. As mentioned in the section on Communities and schools, the figures on community groups' engagement with the FIT are incomplete as there is no requirement for community energy projects to state their community 'status' when applying for the FIT unless they apply for a special benefit. **Ofgem**'s CFR register therefore poorly represents the true numbers of community groups.

Crowd funding, such as share offers from cooperatives, enable investments for as low as £1, although there usually is a minimum level of investment required to avoid burdensome paperwork. With share offers, shareholders generally only benefit from the FIT payments but not from the use of the electricity generated.

Crowd sourcing is considered one of the financial innovations that is changing the energy generation landscape[211]. Abundance Generation in the UK raised $13m since beginning operations in 2012. Its biggest project in 2014 was a 500kW wind turbine in Cornwall. It took only five months to raise £1.6m and one of their four different types of return attached to their energy projects is dependent on the FIT[212].

Commercial non-traditional business models are unlikely to have emerged exclusively as a result of the implementation of the FIT but growing business relating to the FIT will have played

[208] Nolden, C., 2013, Regulating the diffusion of renewable energy technologies: Interactions between community energy and the feed-in tariff in the UK, PhD Thesis submitted to the University of Exeter, Exeter.
[209] Capener, P., 2014, Community Renewable Electricity Generation: Potential Growth to 2020, report to Department of Energy and Climate Change, < https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/274746/20140108_Community_Energy_Modelling_FinalReportJan.pdf >.
[210] Element Energy, 2008, Power in Numbers: The benefits and potential of distributed energy generation at the small community scale. A report for the Energy Saving Trust, Energy Saving Trust, London.
[211] FS-UNEP Collaborating Centre/BNEF, 2015, Global Trends in Renewable Energy Investment 2015, Frankfurt School, FS-UNEP Collaborating Centre for Climate and Sustainable Energy Finance and Bloomberg New Energy Finance, Frankfurt am Main.
[212] Abundance Energy, 2015, FAQs, < https://www.abundancegeneration.com/why-invest/faq/ >.

an important role. One example of this is ANESCO[213], one of the fastest growing companies in the UK. They specialise in energy efficiency advice, although one of their core business areas is solar PV installation and metering, some of which is installed to benefit from the FIT. Another is Moleenergy[214], a company specialising in renewable energy diffusion in the farming sector which emerged out of growing interest in solar PV as a result of FIT remuneration and has now diversified into biomass installations, solar thermal and heat pumps.

Another example of a non-traditional business model is Good Energy Ltd, one of the emerging utilities challenging the dominance of the Big Six. Good Energy made £88,172,013.19 in total FIT payments (total generation payments plus total export payments) out of a total of £708,791,067.06 in Year 4 of the FIT[215]. This is on par with British Gas Trading Ltd and only exceeded by SSE Energy Supply Ltd with around £96m and E.On Energy Solutions Ltd with around £132m in total FIT payments for the same period, despite their much larger market share for electricity generation. These figures indicate that Good Energy Ltd.'s business model is much more dependent on distributed, FIT eligible generation than the business model of traditional energy utilities. This raises questions regarding the sustainability of their business model in the absence of a FIT to support distributed generation.

8.5 Behavioural/consumption change and public perception

There is little research specifically relating to FIT technologies but given the scale of proliferation of renewable generation installations under the FIT, it is conceivable that this rapid deployment has influenced public perception of renewables. In this section we review recent findings on overall public perception and make specific observations on the FIT.

8.5.1 Public attitudes

According to DECC's Public Attitudes Tracker[216], renewable energy sources continue to receive high levels of support. Over three-quarters of UK adults (78%) support the use of renewables to generate electricity, fuel and heat in the UK, a similar proportion to June 2014 (79%) and March 2014 (80%). The level of support for individual renewable energy sources are similar to that reported in the previous wave; off-shore wind (74%), biomass (61%), onshore wind (67%), wave and tidal (73%) and solar (80%).

These numbers are relevant to the FIT, which accounts for the vast majority of installed solar PV, and a share of onshore wind and biomass (AD) technology. Despite this relatively high general public support, the roll-out of renewable technologies and onshore wind in particular, has led to strong public debate.

Earlier sections show that there is now a multitude of installation sizes, technology types, ownership models and a diffusion of benefits accruing from the FIT, which contrasts with the sharp pro versus anti wind storylines favoured by media. It may be useful to more clearly differentiate these various technologies and scales in future policy and public facing communications.

[213] http://www.anesco.co.uk/

[214] http://www.moleenergy.com/home

[215] Ofgem, 2014, Feed-in Tariff – Annual Report 2013-14, Office of Gas and Electricity Markets, London.

[216] DECC, 2014, Public Attitudes Tracker – Wave 11 Summary of key findings, Department of Energy and Climate Change, London.

A DECC report (forthcoming)[217] supported by several academic publications[218,219,220] indicates that 100% commercially-owned infrastructure projects are less popular with the public than projects that enable participation. As entirely commercial projects also move more slowly through planning processes, the report suggests that there is potential for shared ownership and community leadership to become conventional for all infrastructure types. There is also anecdotal evidence of community involvement and specifically school solar schemes and community energy schemes improving views on renewable technologies and encouraging behaviour and attitude change[221].

The DECC report, which makes extensive use of academic studies, stresses that the great varieties in ownership models of community energy projects, the way control is allocated and how benefits are distributed does not guarantee unanimously positive reception. There is still a case that community benefits can make planning processes seem fairer to participants in terms of both process and outcome as compensation for accepting local impacts of nationally significant infrastructure[222].

8.5.2 Effects on participant energy use and behavioural change

Research commissioned by Citizen's Advice[223] indicates that 47% of survey respondents (647 in total) that had purchased a solar PV system outright or had it installed as part of a rent-a-roof scheme, 25% of survey respondents who purchased a solar PV system on finance and 20% of those who had it installed by a social landlord, reportedly changed their energy consumption behaviour following installation (this needs to be seen in the context of self-reporting bias and that early behaviour change may get lost over time). The figures for changing timers on immersion heaters to match electricity generation are 21%, 17%, 23% and 11% respectively. This area clearly requires more research to identify how much load is shifted and how consumption practices change over time.

A longitudinal case study from the South of England (see section on Local authorities and fuel poverty) has highlighted how families have taken advantage of free electricity from solar PV systems by changing certain domestic routines. For example by laundering at times of day when the sun is shining the social housing tenants have succeeded in saving between £20 and £50 per month over the summer. A number of the families also made some financial savings at different times of the year thanks to their development of new skills and knowledge relating to energy generation and use. While savings were generally not as high as in the summer, it would appear that domestic FIT installations, supported by knowledge sharing and the provision of appropriate information, can sustain behavioural change which can lead to an overall reduction in energy costs and offer a financial buffer against fuel poverty[224].

---

[217] DECC, Forthcmoning, What works to help site infra-structure in local areas? Department of Energy and Climate Change, London.

[218] Devine-Wright, P., 2005, Local aspects of UK renewable energy development: exploring public beliefs and policy implications, Local Environment, 10(1): 57–69.

[219] Rogers, J. C., Simmons, E. A., Convery, I., Weatherall, A., 2008, Public perceptions of opportunities for community-based renewable energy projects, Energy Policy, 36(11): 4217–4226.

[220] Warren, C. R., McFadyen, M., 2010, Does community ownership affect public attitudes to wind energy? A case study from south-west Scotland, Land Use Policy, 27: 204-213.

[221] Clarke, R., 2014, Solar Schools Qualitative Research, < http://magic.solarschools.org.uk/ >.

[222] DECC, Forthcoming, What works to help site infra-structure in local areas? Department of Energy and Climate Change, London.

[223] Flanagan, B., Wilkinson, T., 2015, Solar PV User Experience – Research conducted for Citizens Advice, Summary of key findings prepared for workshop on 20 March 2015, Citizens Advice, London.

[224] Fox, N., Doctoral research 2015, SPRU, University of Sussex.

This supports findings from a report in 2005 which suggests that ‘it is not sufficient to install the technologies and leave householders to make of them what they will. The greatest effects have been felt in households that were introduced to their micro-generators from the start and given clear explanations of how they can be used to advantage’[225].

In-depth research particularly on participant community energy use has recently been undertaken as part of the EVALOC project[226]. It specifically addresses the lack of evidence-based measurement and evaluation about the outcomes, impacts and added benefits of low-carbon community action.

EVALOC was a 4-year research project funded under the ESRC-EPSRC Energy and Communities programme which ran from 2011-2015. It specifically evaluated how 6 selected low-carbon communities funded under DECC’s Low Carbon Communities Challenge changed individual and community energy behaviours, achieved verifiable savings in energy use and CO_2 emissions and brought about sustained and systemic change. Community-based learning through collaborative action research as well as monitoring and evaluation were a central feature of the project. Longitudinal LSOA (Lower Super Output Area) energy data was gathered 2008-2012 and local carbon mapping was undertaken involving around 300 households. 5 of the 6 projects involved community renewables. Table 14 provides some interesting insights into the knock-on effects of community renewable electricity engagement.

Interestingly, the low carbon community projects with electricity savings exceeding the national average, Eco Easterside, Kirklees-Hillhouse and Low Carbon West Oxford (marked in red in Table 14), were focused on renewable electricity supply from FIT eligible technologies (e.g. using solar PV), despite all three household samples starting from an electricity consumption baseline below national average in 2008 (see top row). These figures point towards the possibility of community energy projects significantly changing electricity behaviour if they are accompanied by energy feedback and action as well as group learning.

The EVALOC report also undertook some longitudinal evaluations of household electricity use following physical and behavioural change (n=37), just physical change (n=29) or no intervention (n=11). Median changes in electricity consumption 2008-2013 were -12%, -3% and +5% respectively.

[225] Dobbyn, J., Thomas, G., 2005, Seeing the light: the impact of micro-generation on the way we use energy – Qualitative research findings, Sustainable Consumption Roundtable, London.

[226] Gupta, R., 2015, Insights from EVALOC project – Evaluating low carbon communities, Oxford Institute for Sustainable Development, Oxford Brookes University, Oxford.

Community	LCCC interventions (household level)	Household sample no (approx.)	2008 average household electricity use (baseline in kWh)	Percentage change in electricity use (2008-2012)
National figures	-		**4,198**	**-4%**
Awel Aman Tawe	Behaviour change (group-based learning)	1,175	**4,987**	**+1%**
Sustainable Blacon	Physical & technical; behaviour change (energy feedback & group-based learning)	5,590	**3,765**	**-4%**
Eco Easterside	Physical & technical incl. LZTs[227]; behaviour change (energy feedback & group-based learning)	1,160	**3,368**	**-6%**
Hook Norton Low Carbon	Physical & technical incl. LZTs; behaviour change (group-based learning)	1,070	**6,949**	**-3%**
Kirklees-Hillhouse	LZTs; behaviour change (energy feedback)	2,235	**3,660**	**-12%**
Low Carbon West Oxford	LZTs; behaviour change (energy feedback & group-based learning)	1,540	**3,658**	**-5%**

Table 14: EVALOC – Changes in domestic electricity use[228]

[227] LZT - Low or zero carbon technology

[228] Gupta, R., 2015, Insights from EVALOC project – Evaluating low carbon communities, Oxford Institute for Sustainable Development, Oxford Brookes University, Oxford.

Analysis of household participant energy use has been undertaken by DECC[229]. The report shows that 70% of all households in GB with solar PV installations (369,700) could be assigned a unique property reference number, which allowed them to be matched with property attribute data from the Valuation Office Agency. Properties with domestic solar PV installations are typically detached houses (34%) or bungalows (20%), despite their share of the total housing stock being much lower at 15% and 10% respectively. Flats, on the other hand, are underrepresented, with only 1.5% purpose-built or converted flats registered as FIT properties compared a share of up to 14% of the housing stock (see Figure 29). Simply put, properties with solar PV are typically large, detached and between 30 and 70 years old[230].

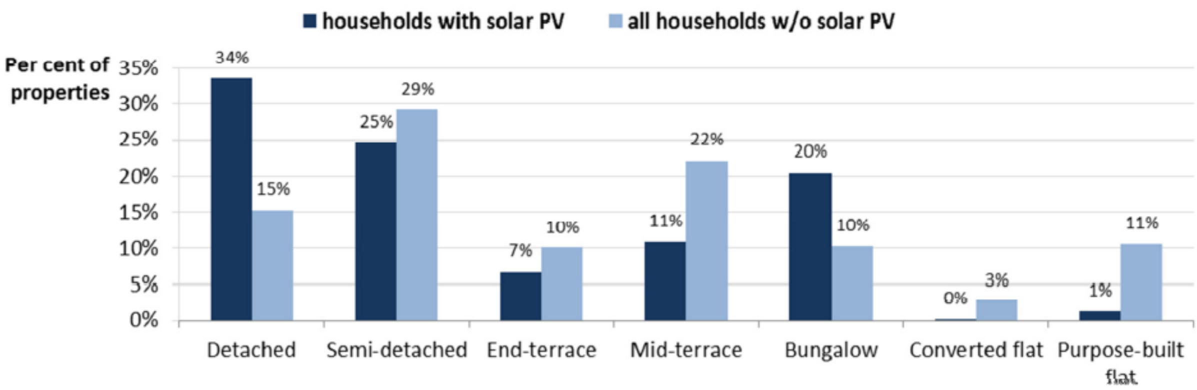


Figure 29: Relative frequency of building types in the whole housing stock and in the subset of solar PV installations[231]

FIT households used substantially more electricity than those without FIT installations. In 2010, for example, national average energy consumption per household was 4,200kWh compared to a mean electricity consumption of FIT properties of 5,400kWh (27% higher). One explanation is that households with solar PV installations tend to be larger, which typically results in higher electricity use. Behavioural differences of occupants resulting from socio-demographic characteristics and different attitudes towards energy use may also be significant factors.

By 2012, this gap in electricity consumption had narrowed to 16% (4,200kWh vs 4,900kWh). The results suggest that the installation of solar PV panels contributes to a substantial reduction in electricity use from the grid (see also section on Energy security and Reliability of supply). These findings have been verified in a more recent DECC publication[232], which suggests that since 2012 households with solar PV reduced their use of grid electricity by 16% compared to a fall of 5% in similar properties that do not have solar PV installations. The reasons behind this trend are probably the use of electricity generated by the solar PV installations on site, which reduces demand of grid electricity, as well as increased energy awareness and a change in consumption behaviours[233].

229 DECC, 2014, Energy usage in households with Solar PV installations, Department of Energy and Climate Change, London.

230 DECC, 2015, National Energy Efficiency Data-Framework, Department of Energy and Climate Change, London.

231 DECC, 2014, Energy usage in households with Solar PV installations, Department of Energy and Climate Change, London.

232 DECC, 2014, Energy usage in households with Solar PV installations, Department of Energy and Climate Change, London.

233 DECC, 2015, Annex B: Electricity use in households with solar PV, Department of Energy and Climate Change, London.

8.5.3 Effects on the uptake of energy efficiency measures and engagement with related policies

An analysis[234] of the uptake of energy efficiency measures in properties with solar PV installations between 2010 and 2013 revealed that the share of properties with at least one energy efficient measure installed increased from 56% to 61%, suggesting an increased level of energy awareness[235], perhaps due to energy efficiency criteria being introduced to the FIT in 2012. Newer figures suggest that 86% of households with solar PV installations had at least one energy efficiency measure installed, most frequently cavity wall and loft insulation[236].

There is some evidence that uptake of solar thermal systems more than doubled between 2008 (37,419 units sold) and 2010 (88,379 units sold) before numbers fell to below 2008 figures in 2014 (30,460 units sold)[237]. These figures suggest that uptake of solar PV and other FIT eligible technologies has substantially reduced interest in solar thermal technology. One of the reasons may be that FIT generators with solar PV are diverting excess electricity to heat their water tanks rather than exporting it.

Public engagement with other policies alongside the FIT is more difficult to quantify, although a high proportion of Green Deal Plans have been taken out by households that already have solar PV installations. There is also some evidence that the vast majority of renewable energy installations under the Green Deal so far are solar PV. Savings from the solar PV installations are subsequently used to pay back the Green Deal Loan. Uptake of measures under policies such as the RHI are thought to be lower than anticipated among social landlords as a result of FIT changes in 2011, impacting trust in government schemes and stifling investment. For households and new builds, renewable heat has been replaced by solar PV as an investment as the FIT continues to skew the expectations on returns, but exact figures are missing for these trends.

---

[234] DECC, 2014, Energy usage in households with Solar PV installations, Department of Energy and Climate Change, London.

[235] DECC, 2015, Annex B: Electricity use in households with solar PV, Department of Energy and Climate Change, London.

[236] DECC, 2015, Annex B: Electricity use in households with solar PV, Department of Energy and Climate Change, London.

[237] STA, 2015, UK Solar Thermal Statistics – May 2015, Solar Trade Association, London.

Summary

As the FIT is based on levies on energy bills, it may be considered a regressive tax. However, wider benefits of the FIT include decreasing grid demand, the development of targeted fuel-poverty alleviation measures, business-model innovation and the diversification of supply, which, combined with storage, could be a driver for a fundamental challenge to our energy system

Just under 30% of FIT generation is sold to non-Big Six suppliers, which is an indication of how the FIT is contributing to market diversification. Given the dominance of domestic solar PV installations among FIT eligible technologies installed to date, more electricity gets used on site compared to other renewable and non-renewable technologies. The installation of solar PV panels also contributes to a substantial reduction in electricity use from the grid. This is suggested by the lowest ever National Grid peak weather corrected demand forecast for the high summer period 2015 of 37.5 GW.

Improvements in our ability to manage demand to reflect the increasing output from wind (and other intermittent sources such as solar PV) are necessary to integrate larger amounts of non-dispatchable generation capacity. Storage options need to be developed to help cope with periods of calm which, except on rare occasions, persist for no more than a few days. Several academics and financial service companies consider solar-PV-plus-battery systems a potential driver for a fundamental change of our energy system.

Fuel poverty projections indicate that where the costs of measures such as the FIT are recovered through domestic energy bills, fuel poverty appears worse. The overall cost distribution therefore needs to be closely monitored. The FIT can be used to target fuel poverty and there is some evidence of community energy, local authority and social housing schemes supplying free solar electricity to fuel-poor households as part of rent-a-roof schemes. Simple and clear instructions are necessary to maximise the benefits of such programmes.

The FIT has been accompanied by business model innovation and diversification, ranging from social enterprises specialising on community energy such as Community Interest Companies and Industrial and Provident Societies, and commercial energy service companies providing installation, metering and maintenance services to emerging utilities challenging the dominance of the Big Six and in some cases developing their business model around distributed FIT and non-FIT generation.

Community involvement in infrastructure development, such as FIT supported renewable electricity generation projects, enables projects to move through planning processes more swiftly although it does not guarantee unanimously positive reception. There are calls for shared ownership and community leadership to become conventional for all infrastructure types.

There is evidence of behaviour change as part of community energy projects. One 5-year case study with sample sizes exceeding n=1,000, points towards household electricity savings exceeding the national average if FIT-supported community renewable electricity projects are accompanied by energy feedback and action as well as group learning. Similar findings regarding feedback and information provision have also been reported as part of a longitudinal case study of social housing tenants receiving free electricity from solar PV systems. Evidence of individual households with solar PV that have not received targeted advice is less robust. One study indicates that self-reported behaviour change is more likely when installations were purchased outright, although these households are more likely to have a higher than average energy consumption to start with.

There is also some evidence of the FIT displacing demand for measures supported by other policies, especially solar thermal technology.

9. Conclusion

The data analysed for this evidence review suggest that the FIT has succeeded in meeting the top three of its original objectives. The number of FIT installations, 682,511 at the end of Year 5, provides evidence for the successful diffusion of small-scale renewable energy technologies and the FIT as a support measure given DECC's original projections of 780,000 installations by 2020. Particularly strong growth in the number of FIT installations in Year 2 as a result of unanticipated drops in the cost of solar PV systems actually required government to introduce more frequent tariff reductions ("baseline" degression) together with degression dependent on rates of deployment to better control the costs of the FIT scheme and take into account change in technology costs.

Since then, growth in the number of FIT installations, specifically solar PV, has been contained more in line with original projections. The most noticeable change is the cumulative installed FIT capacity share of registered domestic installations declining from 76% in Year 1 to 55% in Year 4. However, the unforeseen dominance of domestic solar PV installations in terms of total installations (640,344 domestic <=4kW solar PV installations at the end of Year 5 represented 93.8% of the cumulative number of FIT installations and 95% of solar PV installations) continues to have an effect on the FIT's achievements.

For example, the impact on annual household bills in 2014, £9, was well in excess of the projections of £6.50 for 2015, while generation per installation stood at 5.4 MWh/a in Year 4 compared to original DECC projections of 7.7 MWh/a in 2020. This is the result of small renewable electricity systems requiring higher remuneration to make them economically viable while individual domestic sites are unlikely to have the right exposure to maximise output from the systems installed.

On the other hand, cumulative capacity of FIT installations stood at 3.57GW at the end of Year 5, which represented around 13.5% of the total installed renewable capacity of 26.4GW in the UK. Over the course of Year 4, FIT installations generated 2,645 GWh of electricity, which represents 0.84% of 317 TWh of UK final electricity consumption. Original DECC projections were approx. 6,000 GWh/annum (or 1.6%) of final UK electricity consumption in 2020. These figures suggest that cumulative FIT capacity is on target to reach original projections.

Similarly, the FIT's cumulative carbon cost effectiveness has improved from £615.17/t CO_2 in Year 2 to £525.79/t CO_2 in Year 4. These figures remains well in excess of original cost effectiveness estimates of £460/t CO_2 but a closer look at year-on-year carbon cost effectiveness reveals that the cost effectiveness has improved from an average of £650.81/t CO_2 for installations in Year 2 to £378.29/t CO_2 for installations in Year 4. Given that total carbon savings in Year 4 were approximately 1.3m tonnes of CO_2 and original projections estimated total savings of 7m tonnes of CO_2 up to 2020, the FIT again appears to be on target.

In terms of individual technologies, the FIT has had mixed effects on their diffusion and technological progression. Total installed capacity of wind under the FIT increased in proportion from around 4% in Year 2 to 10% in Year 5 as the technology is becoming more popular and the average size of individual turbines installed is increasing. In contrast, the average capacity of hydroelectric installations is declining as a result of degression and to a lesser extent limited geographical applicability.

Community and shared ownership of renewable electricity generation technology, at least 60MW in total, is supported almost entirely by the FIT. The relative ease at which these projects progress through the planning system and associated lower costs suggests that the FIT is succeeding not only at empowering people and giving them a direct stake in the transition to a low carbon economy but also at paving the way for the diffusion of low-carbon infrastructures. Advances in storage technology combined with FIT supported generation technologies may pave the way for empowerment beyond public take-up of carbon reduction measures towards active load shifting and load defection.

There is some evidence of change in energy use as the installation of solar PV panels contributes to a substantial reduction in electricity use from the grid. Evidence of behaviour change is less conclusive although one in-depth study suggest that engagement with FIT supported community energy schemes may encourage energy savings in excess of the national average. Another study indicates that certain domestic routines can be adapted to the availability of free solar power, which reduces energy costs and has the potential to offer a financial buffer against fuel poverty.

Job creation and the development of local supply chains are even more difficult to measure. The solar PV industry supported 15,620 UK jobs in 2,200 enterprises during 2012/13, which is around 15% of total jobs in renewable energy industries and a third of all renewables companies in the UK. The share of FIT-supported jobs is unclear, but since the FIT is now the sole support measure for solar PV (since 1 April 2015), most of these jobs are dependent on the FIT. 3,304 full-time employees were estimated to be directly working in the small and medium (<500kW) wind industry, which is also primarily supported by the FIT.

The UK AD sector employed 2,640 people across the UK supply chain in 2012-13 although downstream employment and growth effects (i.e. job retention on farms) are considered more important for AD than upstream employment and growth effects (i.e.along the supply chain). Security of income streams from AD can reduce the volatility of farm income although the sustainability of AD can be called into question where crops are purpose-grown for AD

For certain scales of wind, hydro and anaerobic digestion deployment there appears to be strong UK supply chain development with a UK supply chain content of around 80% in the case of hydro. Even for solar PV, where most of the hardware is sourced from outside the UK, the UK share of the supply chain, primarily in labour and civil construction, is over 50%.

Wider benefits of the FIT include the diversification of the UK electricity market, with just under 30% of FIT generation sold to non-Big Six suppliers (there are more than 20 small FIT licensees). The lowest ever National Grid peak weather corrected demand forecast for the high summer period 2015 of 37.5GW suggests that more electricity from FIT supported technologies gets used on-site compared to other renewable and non-renewable technologies. This is linked to the increasing share of embedded generation, particular of solar PV, contributing to the trend of decreasing grid demand.

The trend of more electricity from FIT-supported technologies being used on-site or locally compared to other renewable and non-renewable technologies is likely to continue and several academics and financial service companies consider solar-PV-plus-battery systems a potentially driver for fundamental change of our energy system. Along with technological innovation, the FIT has also been accompanied by business model innovation and diversification. Social enterprises such as Community Interest Companies and Industrial and Provident Societies tend to focus on community energy while commercial energy service companies offer a range of services including installation, metering and maintenance. Emerging utilities are increasingly challenging the dominance of the Big Six and in some cases they have developed their business model around distributed FIT and non-FIT generation.

To conclude, the FIT has succeeded in meeting many of its original objectives. It is more expensive than originally anticipated but this evidence review points towards the importance of subsidies such as the FIT for emerging technologies and business models as well as behavioural change that many consider necessary for transformative change in the energy sector.

10. Annex

List of organisations contacted for this evidence review:

- British Hydropower Association
- Cornwall Energy
- DECC
- Ofgem (Renewable Electricity)
- Renewable UK
- Scottish Government (Local Energy and Consents)
- Solar Trade Association
- Welsh Government (Energy Water and Flood Division, Department of Natural Resources)

11. Bibliography

Abundance Energy, 2015, FAQs, < https://www.abundancegeneration.com/why-invest/faq/ >.

Agora, 2014, Comparing the Cost of Low-Carbon Technologies: What is the Cheapest Option?, Study by Prognos AG for Agora Energiewende, Berlin, Germany.

Ares, E., Hawkins, O., Bolton, P., 2012, Feed-in Tariffs: Solar PV Review, House of Commons Library, London.

Baker, W., White, V., Preston, I., 2008, Quantifying rural fuel poverty, Report prepared by the Centre for Sustainable Energy to eaga Partnership Charitable Trust, CSE, Bristol.

Barrett, M., Bradshaw, M., Froggatt, A., Mitchell, C., Parag, Y., Stirling, A., Watson, J., Winzer, C., 2011, Energy Security in a Multi-polar World, Discussion Draft, < http://www.exeter.ac.uk/energysecurity/documents/Energy_Security_in_a_Multipolar_World_Working_Paper_DRAFT.pdf >.

Borgmann, M., 2015, Dubai Utility DEWA Procures the World's Cheapest Solar Energy Ever, Renewable Energy World, < http://www.renewableenergyworld.com/rea/news/article/2015/01/dubai-utility-dewa-procures-the-worlds-cheapest-solar-energy-ever >.

BBC News, 2014, Solar farms are a blight on the landscape, says minister, British Broadcasting Corporation, < http://www.bbc.co.uk/news/uk-29679312 >.

BIS, 2015 The Size and Performance of the UK Low Carbon Economy, Department for Business, Innovation and Skills, London.

BRE Group, 2014, BRE National Solar Centre measures job growth in the solar sector, < http://www.bre.co.uk/news/BRE-National-Solar-Centre-measures-job-growth-in-the-solar-sector-965.html >.

British Hydropower Association, 2015, Small-scale hydro – An integral part of the UK renewable energy mix, Presentation for a meeting with Amber Rudd, 11 March, 2015.

Capener, P., 2014, Community Renewable Electricity Generation: Potential Growth to 2020, report to Department of Energy and Climate Change, < https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/274746/20140108_Community_Energy_Modelling_FinalReportJan.pdf >.

CBI, 2012, The colour of growth – Maximising the potential of green business, Confederation of British Industry, London.

Cebr, 2014, Solar powered growth in the UK – The macroeconomic benefits for the UK of investment in solar PV, Solar Trade Association, London.

CHPA, 2012, CHPA response to 'Feed-in Tariff Comprehensive Review Phase 2B' Consultation, Combined Heat and Power Association, London.

CKD Galbraith, 2015, CKD Galbraith identifies subsidy threat to smaller wind projects, < http://www.ckdgalbraith.co.uk/news/ckd-galbraith-identifies-subsidy-threat-smaller-wind-projects >.

Clarke, R., 2014, Solar Schools Qualitative Research, < http://magic.solarschools.org.uk/ >.

Cornwall Energy, 2015, Big Six continue to fight back in domestic supply market, < http://www.cornwallenergy.com/Opinion/Big-Six-continue-to-fight-back-in-domestic-supply-market >.

CSE, 2014, Research on fuel poverty – The implications of meeting the fourth carbon budget, Report to the Committee on Climate Change, Centre for Sustainable Energy, Bristol.

DECC, 2009, Summary: Intervention& Options URN: 09D/703 – Impact Assessment of Feed-in Tariffs for Small-Scale, Low Carbon, Electricity Generation, Department of Energy and Climate Change, London.

DECC, 2010, Feed-in Tariffs – Government's Response to the Summer 2009 Consultation, Department of Energy and Climate Change, London.

DECC, 2010, Impact Assessment of Feed-in Tariffs for Small-Scale, Low Carbon, Electricity Generation, Department of Energy and Climate Change, London.

DECC, 2011, Feed-in tariffs scheme: consultation on Comprehensive Review Phase 1 – tariffs for solar PV, Department of Energy and Climate Change, London.

DECC, 2012, 5 Electricity – Table 5.7. Feed in Tariff generation, Department of Energy and Climate Change, London.

DECC, 2012, Feed-in Tariffs Scheme – Consultation on Comprehensive Review Phase 2B: Tariffs for non-PV technologies and scheme administration issues, Department of Energy and Climate Change, London.

DECC, 2012, Feed-in Tariffs Scheme – Government response to Consultation on Comprehensive Review Phase 2A: Solar PV cost control, Department of Energy and Climate Change, London.

DECC, 2012, Identifying trends on the deployment of domestic solar PV under the Feed-in Tariff scheme, Department of Energy and Climate Change, London.

DECC, 2013, Estimating generation from Feed in Tariff installations, Department of Energy and Climate Change, London.

DECC, 2013, UK Solar PV Strategy Part 1: Roadmap to a Brighter Future, Department of Energy and Climate Change, London.

DECC, 2014, Annual Energy Statement 2014, Department of Energy and Climate Change, London.

DECC, 2014, Analysis of Feed-in Tariff generation data, Department of Energy and Climate Change, London.

DECC, 2014, Community Energy Strategy: Full Report, Department of Energy and Climate Change, London.

DECC, 2014, D3: Opportunities for integrating demand side energy policies, Department of Energy and Climate Change, London.

DECC, 2014, Estimated impacts of energy and climate change policies on energy prices and bills, Department of Energy and Climate Change, London.

DECC, 2014, Feed in tariff load factors, Department of Energy and Climate Change, London.

DECC, 2014, Public Attitudes Tracker – Wave 11 Summary of key findings, Department of Energy and Climate Change, London.

DECC, 2015, Annex B: Electricity use in households with solar PV, Department of Energy and Climate Change, London.

DECC, (forthcoming), What works to help site infra-structure in local areas? Department of Energy and Climate Change, London.

DECC, 2015, Energy trends section 5: renewables, Department of Energy and Climate Change, London.

DECC, 2015, FEED-IN TARIFFS: Commissioned Installations by Month (Up to and including April 2015), Department of Energy and Climate Change, London.

DECC, 2015, FEED IN TARIFFS: COMMUNITIES & SCHOOLS INSTALLATIONS, Department of Energy and Climate Change, London.

DECC, 2015, Monthly Central Feed-in Tariff Register Statistics (March 2015), Department of Energy and Climate Change, London.

DECC, 2015, National Energy Efficiency Data-Framework, Department of Energy and Climate Change, London.

DECC, 2015, Section 6 – Renewables – June 2015, Department of Energy and Climate Change, London.

DECC, 2015 Annual Report and Accounts, Department of Energy and Climate Change, London. <https://www.gov.uk/government/publications/decc-annual-report-and-accounts-2014-to-2015 >

DECC & Defra, 2011, Anaerobic Digestion Strategy and Action Plan – A commitment to increasing energy from waste through Anaerobic Digestion, Department of Energy and Climate Change and Department for Environment, Food and Rural Affairs, London.

DECC & HMG, 2015, Delivering UK Energy Investment: Low Carbon Energy, Department of Energy and Climate Change & Her Majesty's Government, London

Defra, 2013, Comparative Life Cycle Assessment of Anaerobic Digestion and other bioenergy options, Department for Environment, Food and Rural Affairs, London.

Defra, 2014, Area of Crops Grown For Bioenergy in England and the UK: 2008-2013, Department for Environment, Food and Rural Affairs, London.

Defra, 2015, Anaerobic Digestion Strategy and Action Plan – Annual Report 2014, Department for Environment, Food and Rural Affairs, London.

Devine-Wright, P., 2005, Local aspects of UK renewable energy development: exploring public beliefs and policy implications, Local Environment, 10(1): 57–69.

Dobbyn, J., Thomas, G., 2005, Seeing the light: the impact of micro-generation on the way we use energy – Qualitative research findings, Sustainable Consumption Roundtable, London.

DTI/Ofgem, 2007, Review of Distributed Generation, Department of Trade and Industry, London.

E.On, 2015, What is decentralised energy?, < https://www.eonenergy.com/for-your-business/large-energy-users/manage-energy/energy-efficiency/decentralised-energy-experts/What-is-decentralised-energy >.

EA, 2010, Mapping Hydropower Opportunities and Sensitivities in England and Wales, Environment Agency, London.

Element Energy, 2008, Power in Numbers: The benefits and potential of distributed energy generation at the small community scale. A report for the Energy Saving Trust, Energy Saving Trust, London.

Elexon, 2013, Transmission Losses – Guidance, Elexon, London.

EST, 2015, Community and locally owned renewable energy in Scotland at June 2014 – A report by the Energy Saving Trust for the Scottish Government, March 2015, Energy Saving Trust, Edinburgh.

Flanagan, B., Wilkinson, T., 2015, Solar PV User Experience – Research conducted for Citizens Advice, Summary of key findings prepared for workshop on 20 March 2015, Citizens Advice, London, https://www.citizensadvice.org.uk/about-us/policy/policy-research-topics/energy-policy-research-and-consultation-responses/energy-policy-research/staying-fit/

FS-UNEP Collaborating Centre/BNEF, 2015, Global Trends in Renewable Energy Investment 2015, Frankfurt School, FS-UNEP Collaborating Centre for Climate and Sustainable Energy Finance and Bloomberg New Energy Finance, Frankfurt am Main.

Germany Trade & Invest, 2014, Industry Overview – The Photovoltaic Market in Germany, < http://www.gtai.de/GTAI/Content/EN/Invest/_SharedDocs/Downloads/GTAI/Industry-overviews/the-photovoltaic-market-in-germany-en.pdf >.

Guevara-Stone, L., 2014, Can decentralised energy make America's power grid blackout-proof?, Rocky Mountain Institute, RenewEconomy, < http://reneweconomy.com.au/2014/can-make-americas-power-grid-blackout-proof-14292 >.

Gupta, R., 2015, Insights from EVALOC project – Evaluating low carbon communities, Oxford Institute for Sustainable Development, Oxford Brookes University, Oxford.

Harnmeijer, J., Parsons, M., Julian, C., 2013, The Community Renewables Economy – Starting up, scaling up and spinning out, ResPublica, Newland, Lincoln.

HMG, 2009, The Renewable Energy Strategy, TSO, Norwich.

HM Treasury, 2010, Spending Review 2010, Her Majesty's Treasury, London.

House of Lords, 2008, The EU's Target for Renewable Energy: 20% by 2020 – Volume I: Report, House of Lords, London.

Houses of Parliament, 2014, Intermittent Electricity Generation, Parliamentary Office of Science & Technology, London.

HSBC, 2014, Energy Storage – Power to the People, HSBC Global Research, HSBC Bank plc, London.

IPPR, 2015, Feed-in Frenzy, Institute for Public Policy Research, London.

Jones, N., 2013, A Scarcity of Rare Metals Is Hindering Green Technologies, Yale 360, Yale School of Forestry & Environmental Studies, Yale University, New Haven, CT.

Kinghan, M., 2015, An answer to the potentially regressive impact of solar subsidies?, Blog post, 3 February 2015, < https://www.2degreesnetwork.com/groups/2degrees-community/resources/answer-potentially-regressive-impact-solar-subsidies_3/ >

KTN, 2013, UK Solar Photovoltaic Roadmap – A Strategy for 2020, Knowledge Transfer Network, London.

Mitchell, C., 2012, Presentation given at the New Energy Securities Challenges Workshop, 10 May 2012, Royal Geographical Society, London.

Mitchell, C., Froggatt, A., Hoggett, R., 2014, Governance and disruptive energy system change, Conference Paper, International Workshop on Incumbent – Challenger Interactions in Energy Transitions, 22-23 September 2014, Stuttgart, Germany.

MID Statistics Report, 2014, The Microgeneration Certification Scheme < http://www.microgenerationcertification.org/about-us/statistics >.

Moody's Investor Service, 2015, Despite falling battery costs, consumers unlikely to defect from utilities, < https://www.moodys.com/research/Moodys-Despite-falling-battery-costs-consumers-unlikely-to-defect-from--PR_315969 >.

Morgan Stanley Research, 2014, Solar Power & Energy Storage – Policy Factors vs. Improving Economics, Morgan Stanley Blue Paper, Morgan Stanley Research, New York.

NAO, 2013, The Levy Control Framework, National Audit Office, London.

National Grid, 2015, Summer Outlook 2015, National Grid Plc, Warwick.

National Grid, 2015, Transmission Losses, < http://www2.nationalgrid.com/UK/Industry-information/Electricity-system-operator-incentives/transmission-losses/ >.

NDA, 2015, UK Nuclear decommissioning costs, Nuclear Decommissioning Authority, < http://www.nda.gov.uk/what-we-do/costs/#top >.

NNFCC, 2015, DC15-04 AD Deployment Update for DECC – January 2015, York.

Nolden, C., 2013, Regulating the diffusion of renewable energy technologies: Interactions between community energy and the feed-in tariff in the UK, PhD Thesis submitted to the University of Exeter, Exeter.

Ofgem, 2013, Feed-in Tariff: Guidance for Community Energy and School Installations (Version 1), Ofgem E-Serve, London.

Ofgem, 2014, Feed-in Tariff – Annual Report 2013-14, Office of Gas and Electricity Markets, London.

Ofgem, 2014, Feed-in Tariff Annual Levelisation Process (2013-2014), Office of Gas and Electricity Markets, London.

Ofgem, 2015, Applying for the Feed-in-Tariff (FIT) scheme, < https://www.ofgem.gov.uk/environmental-programmes/feed-tariff-fit-scheme/applying-feed-tariff-fit-scheme >.

Ofgem, 2015, Feed-in Tariff: Guidance for Community Energy and School Installations (Version 2), Office for Gas and Electricity Markets, Ofgem e-serve, London.

Ofgem, 2015, FIT Installation report 31 March 2015 < https://www.ofgem.gov.uk/publications-and-updates/feed-tariff-installation-report-31-march-2015 >.

Ofgem, 2015, Renewables Obligation – Annual Report 2013-14, Ofgem e-serve, London.

Parkinson, G., 2015, Citi: Battery storage to hasten demise of fossil fuels, RenewEconomy, < http://reneweconomy.com.au/2015/citi-battery-storage-to-hasten-demise-of-fossil-fuels >.

Rader, B., 2015, The Finance Industry on DERs: Solar and Batteries are Coming. Rocky Mountain Institute Outlet, < http://blog.rmi.org/blog_2015_04_14_finance_industry_on_ders_solar_and_batteries_are_coming >.

RAENG, 2014, Wind Energy – implications of large-scale deployment on the GB electricity system, Royal Academy of Engineering, London.

REA, Innovas and PwC, 2014, Renewable Energy View 2014, Renewable Energy Association, London.

RenewableUK, 2014, Small and Medium Wind Strategy – The current and future potential of the sub-500kW wind industry in the UK, London, UK.

Roberts, S., 2008, Energy, equity and the future of the fuel poor, Energy Policy, 36: 4471-4474.

Rogers, J. C., Simmons, E. A., Convery, I., Weatherall, A., 2008, Public perceptions of opportunities for community-based renewable energy projects, Energy Policy, 36(11): 4217–4226.

RMI, 2014, The Economics of Grid Defection – When and where distributed solar generation plus storage competes with traditional utility service, Rocky Mountain Institute, Boulder, Colorado.

RMI, 2014, Bridges to New Solar Business Models: Opportunities to Increase and Capture the Value of Distributed Solar Photovoltaics, Rocky Mountain Institute, Boulder, Colorado.

RMI, 2015, The Economics of Load Defection – How grid-connected solar-plus-battery systems will compete with traditional electric service, why it matter, and possible paths forward, Rocky Mountain Institute, Boulder, Colorado.

Stewart, A., and Slater, S., 2011, Implications of the Comprehensive Review of the Feed-in Tariff for the UK PV Industry, Element Energy Limited, Cambridge.

STA, 2015, UK Solar Thermal Statistics – May 2015, Solar Trade Association, London.

Sustainability First, 2013, What Demand Side Services Does Distributed Generation Bring to the Electricity System?, GB Electricity Demand – realising the resources, Sustainability First, London.

The Economist, 2012, The dream that failed, Special Report Nuclear Energy, March 10 2012, London.

Thomas, S., Bradford, P., Froggatt, A., Milborrow, D., 2007, The economics of nuclear power, Report prepared for Greenpeace International, London.

UKERC, 2014, Low carbon jobs: The evidence for net job creation from policy support for energy efficiency and renewable energy, UK Energy Research Centre, London.

UK Parliament, 2013, Energy and Climate Change – Sixth Report – Local Energy, Proceedings of the Committee and Energy and Climate Change, Parliament of the United Kingdom, London.

UK Parliament, 2008, Climate Change Act, Parliament of the United Kingdom, London.

UK Parliament, 2008, Energy Act 2008, Parliament of the United Kingdom, London.

Warren, C. R., McFadyen, M., 2010, Does community ownership affect public attitudes to wind energy? A case study from south-west Scotland, Land Use Policy, 27: 204-213.

Yeo, T., 2015, DCLG's policy towards onshore wind, Energy and Climate Change Committee, London.

Department of Energy & Climate Change
3 Whitehall Place
London SW1A 2AW
www.gov.uk/decc
URN --/----