THE DECENTRALISED ENERGY TRANSITION

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A report by:

LIGHTSOURCE

Good Energy

Foresight group

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In addition, references to financial information relate to indicative information that has been prepared solely for illustrative purposes. Our work was completed on 20 October 2015 and we have not undertaken to update the document for events or circumstances arising after that date.

Analysis co-ordinated by:

KPMG

cutting through complexity

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ABSTRACT

The way we produce and consume energy could change dramatically over the next decade. Just as the mobile phone changed the nature of telecommunications, so breakthroughs in the costs of solar and battery technologies could offer new ways to power and heat our homes and our businesses.

When combined with the roll out of smart meters to every home and business in Britain and the development of demand side response, these decentralised sources of energy can empower consumers to take control of their energy usage and lower their energy bills. By optimising the way we produce and consumer energy, the costs of the overall system can be reduced.

This decentralised vision can be delivered without long-term subsidies within 5 years. However, a number of facilitating steps are required to achieve this, including:

- Front-loading the remaining spend under Feed-in Tariffs to the next few years and focussing that spend on the technologies that have the greatest potential to support this 'smarter' energy system;
- Kick-starting the deployment of storage technologies in residential properties;
- Recognising the value that storage brings to the electricity system as a whole and removing the market and regulatory barriers that prevent this; and
- Incentivising grid companies to support the deployment of decentralised energy.

The purpose of this report is to add value to the debate on the future direction of energy policy, recognising that decisions taken over the next few months will set the course for Britain's energy sector for the next decade and beyond.

EXECUTIVE SUMMARY

INTRODUCTION

Energy is essential for everyday life. It powers the economy. It lights and heats our homes and businesses. It also represents a significant part of household bills and business costs. Yet most of us are passive consumers of energy, relying on distant power stations and gas terminals, pipes and wires to supply the energy we need.

But technological breakthroughs around the world are changing all that. The rapid falls in the costs of solar panels and battery storage, combined with the roll out of smart meters and the continued development of demand side response (DSR) measures, provide the basis of a very different way of producing and consuming energy in the future.

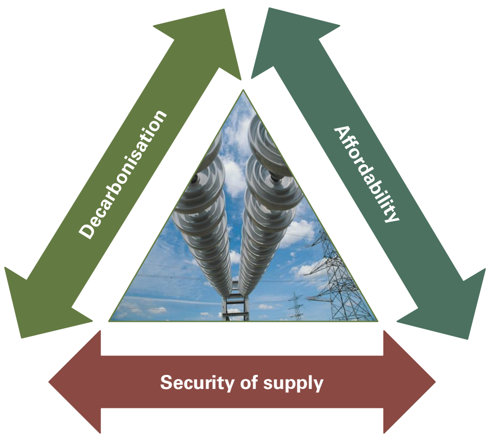
These changes can empower consumers to take control of their energy usage and lower their energy bills. These *'prosumers'* can harness new technology to manage their own energy usage and production at a local level, exporting power back into the grid when it is economically advantageous to do so. Crucially, optimising energy usage and production in this way offers the prospect of *lower* energy bills for households and business.

In *'The Decentralised Energy Transition'*, we explore the potential role of decentralised energy in meeting Britain's energy needs and carbon reduction targets *at lower cost to consumers.* The purpose is to add value to the debate on the future direction for Britain's energy system, as the still new Conservative Government considers its options on energy policy, recognising that decisions taken over the next few months will set the course for Britain's energy sector for the next decade and beyond.

This report is produced by Lightsource Renewable Energy, Good Energy and Foresight Group. UK Power Networks (UKPN) has provided data input on the regulatory changes required to support decentralised energy, with Tesla providing data input on storage. The analysis was co-ordinated by KPMG.

CONTEXT

Around the world, governments are grappling with the three key objectives of energy policy (illustrated below): keeping energy bills as low as possible, whilst keeping the lights on and meeting carbon reduction goals in order to help tackle climate change.



In the UK, the new Conservative Government faces some difficult choices as it seeks to meet these objectives:

- With production from oil and gas in the North Sea declining year on year, Britain's dependence on imported energy is now back to a level last seen in 1973.
- Capacity margins for the Great Britain power system are at their lowest levels for around a decade as old coal and nuclear stations close.
- The UK has legally-binding renewable energy and carbon reduction targets to meet and further targets may be agreed at the Paris Climate Change Conference this December; and
- There is significant uncertainty about the path of global commodity prices (oil, gas and coal) in the future.

In making these policy choices about the future direction for the UK energy sector, the Government has made clear that consumers must be at the heart of policy making. As Amber Rudd stated in a speech in May 2015, "DECC's priorities are clear: keeping the lights on and powering the economy; keeping bills low for families and businesses and getting a climate deal in Paris this year" [2].

EXISTING DECC PROJECTIONS

Previous DECC forecasts have relied on a very rapid build out of *large-scale* plant to meet these policy objectives.

DECC's September 2014 Energy and Emissions Projections[3] estimate nearly 100GW of new large-scale capacity coming on line by 2035 consisted of:

- 47GW of additional renewables;
- 18GW of new nuclear;
- 12GW of Carbon Capture and Storage – coal and gas (CCS); and
- 17GW of new CCGTs.

Whilst pursuing a diverse mix of energy sources makes sense in an uncertain world, all of these technologies would need long-term support of one form or another:

- The low carbon technologies (renewables, nuclear and CCS) would be dependent on support in the form of the Renewables Obligation (RO) or Contracts for Difference (CfDs); and
- The new CCGTs would be reliant on capacity payments generated by the Capacity Auction.

All of this support would add to energy bills and imply significant increases through the 2020s. Recent Government projections show the Levy Control Framework (LCF), which caps the amount to be spent on 'green' energy, is £1.5 billion over-budget by 2020/21[4] at a time of unprecedented fiscal restraint. As a result, DECC has announced significant reductions in the subsidies available for a number of low carbon technologies.

On top of the LCF spend, for large scale plant, additional costs are borne in reinforcing the grid infrastructure to transmit electricity from increasingly dispersed locations around the country to homes and businesses, where the load is. Moreover, even with these very rapid build out rates of low carbon plant, DECC estimates that further policy action would be needed to meet the fourth Carbon Budget (2023-27), with the fifth Carbon Budget (2028-32) expected to be tighter still and require further steps to decarbonise the power sector.

THE POTENTIAL ROLE OF DECENTRALISED ENERGY

There is a different way to meet Britain's energy needs that does not involve such rapid build rates of large scale plant and the associated additional support costs that will add substantially to energy bills. This alternative pathway involves unlocking the potential of *decentralised energy*.

Decentralised energy is a broad term used to describe localised energy systems where electricity and heat are generated close to the load they serve. A decentralised electricity system moves away from the traditional utility model whereby large generation plants produce electricity that flows in one direction through the main national transmission grid and local networks to the consumer. For heat, it can involve harnessing renewable sources of heating, Combined Heat and Power (CHP) and district heating. Due to technological breakthroughs, decentralised energy systems have the potential to both deliver lower bills for households and businesses over the medium term, as well as reduce the costs of grid reinforcement.

Demand side management (DSM) and demand side response programmes are a key enabler of decentralised energy systems. They allow consumers to shift load and redistribute a part

[2] Amber Rudd, Energy, Climate Change and the Queen's Speech, https://decc.blog.gov.uk/2015/05/27/energy-climate-change-and-the-queens-speech/

[3] DECC, Updated Energy and Emissions Projections, September 2014, https://www.gov.uk/government/collections/energy-and-emissions-projections

[4] http://www.parliament.uk/business/publications/written-questions-answers-statements/written-statement/Lords/2015-07-22/HLWS164/

of their demand to coincide with onsite generation and also avoid periods of peak demand and prices. Technologies may include:

- Smart thermostats and heating control systems in commercial buildings;
- Interruptible supply contracts that attract lower tariffs for Commercial and Industrial (C&I) players[5]; and
- The use of remotely-controlled electrical heating systems as well as smart appliances (washing machines, tumble dryers, dishwashers) that are able to switch off or down at times of high demand or prices for domestic consumers.

The Government has been encouraging the deployment of these technologies and some financial incentives now exist through the Capacity Market and Supplementary Balancing Reserve measures. The Government has also indicated that it will support the recommendation of the Competition and Markets Authority to introduce half-hourly metering and settlement, and Time-of-Use tariffs (ToUT) to help demand be more responsive to price signals. There are also currently a number of schemes and incentives for DSR participation, such as National Grid's development-stage 'Demand Turn Up' project[6].

When combined with the falling costs of solar and battery storage, and the roll out of smart meters to every home and business in Britain, these facilitating steps enable the development of 'smart grids', the deployment of 'whole house' solutions for consumers, and new business models for C&I players.

THE 'WHOLE HOUSE' SOLUTION – EMPOWERING THE CONSUMER

Indicative results from Lightsource's household PV-only projects suggests that solar photovoltaic (Solar PV) can typically supply approximately 20 to 35 per cent of a household's power needs (if not linked to other technologies). Excess power production, for example on a summer's day, will be exported back to the grid when it is produced, often at times when it is of limited value to the system as a whole.

By contrast, a 'whole house solution' or a 'smart home', which links the output from solar PV to a hot water system, smart meter and other types of energy storage (either fixed battery unit or electric vehicle), can deliver self-consumption rates from 60 per cent up to 90 per cent depending on the solar and storage systems' size[7]. The 'whole house solution' also enables the consumer to export electricity when it is economically advantageous to do so, i.e. when the system needs the exported electricity and prices are high.

New apps are being developed to optimise home energy management. These can be set to reflect individual preferences and take account of the latest weather forecast feeds, so the individual consumer does not have to actively manage the system on a day-to-day basis. Such apps can also control in-home heating systems, allowing customers to vary their in-home settings remotely and minimise wastage.

THE BUSINESS CASE FOR DECENTRALISED ENERGY

For many C&I players, decentralised energy is already a reality. Rooftop solar has grown rapidly in the C&I sector in recent years, with the typical load for a C&I business often matches more closely with the output from solar PV. Half-hourly metering is also already commonplace in the C&I sector, enabling businesses to take advantage of load shifting. For larger players, interruptible supply contracts also offer the prospect of lower bills to compensate for the possibility of an interruption in supply.

SOLAR PV – ON THE WAY TO 'GRID PARITY' IN THE UK

Decentralised solutions are being made possible by the rapidly falling costs of solar and battery storage. From virtually no solar PV in 2010, solar PV deployment in the UK has increased dramatically to around 8GW of total installed capacity in Q2 2015 according to DECC[8]. The UK also led Europe with the

[5] C&I in this report refers to small and medium sized commercial and industrial users.

[6] National Grid, Power Responsive, http://www.powerresponsive.com/

[7] Lightsource analysis based on initial pilot projects

[8] DECC, Solar photovoltaics deployment, August 2015, https://www.gov.uk/government/statistics/solar-photovoltaics-deployment

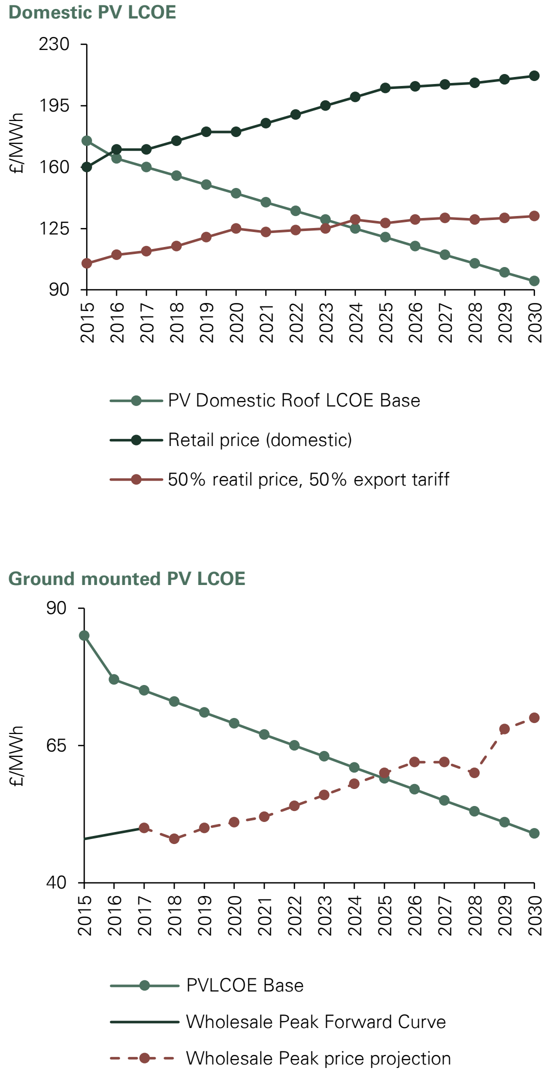
highest increase of solar PV deployed in 2014 with almost 2.5GW installed.

Underpinning high deployment rates, costs have fallen significantly across all solar PV technologies. For <4 kW installations, installation costs in 2010 were approximately £5,000 per kW and are currently at a median figure of around £1,800 per kW[9]. Similarly, Parsons Brinckerhoff's cost assumption for new builds[10] is even lower at £1,688 per kW for <4kW installations and £1,021 per kW for installations over 250kW.

In line with global trends, it is expected that solar PV will be the first low carbon technology to reach 'grid parity'[11] in the UK. However, the rate at which it would reach grid parity is more uncertain as this is largely dependent on the cost of fossil fuels. With the fall in oil prices and the possible slowdown in emerging market growth, fossil fuel prices will remain relatively low and, if these low prices persist, this could delay the rate at which renewable generation reaches grid parity.

In July 2015, a joint Renewable Energy Association (REA)[12] and KPMG report titled *'UK solar beyond subsidy, the transition'*, estimated that 'grid parity' will be reached over the next few years in the UK depending on "specific circumstances for an individual investor" including "site-specific costs, investor desired returns, levels of on-site consumption of the electricity produced and effective electricity tariff", as well as the evolution of fossil fuel prices. In this context, grid parity is expected to happen first for residential customers (assuming the comparator is retail prices) over the next few years, followed by C&I developments by 2020 and then for Ground-Mounted solar (assuming a wholesale price comparator) in the early 2020s.

FIGURE 1: SOLAR PV LCOE VERSUS ELECTRICITY TARIFF COMPARATORS



Source: Renewable Energy Association, KPMG analysis, 'UK solar beyond subsidy: the transition', July 2015

In addition to being the low carbon technology closest to grid parity, solar is also the most popular renewable technology according to

[9] DECC, Solar PV Cost Data, May 2015, https://www.gov.uk/government/statistics/solar-pv-cost-data

[10] Parsons Brinckerhoff, Small-Scale Generation Cost Update, August 2015, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/456187/DECC_Small-Scale_Generation_Costs_Update_FINAL.PDF

[11] Grid parity is defined as the point at which the levelised cost of solar PV falls below the alternative cost of supplying that power; hence removing the need of government support to generate cost-effectively. For residential customers, typically the retail price is used as the comparator.

[12] REA and KPMG UK, UK solar beyond subsidy: the transition, July 2015, http://www.r-e-a.net/news/new-rea-kpmg-report-solar-aims-to-be-first-renewable-to-be-free-of-subsidy. Grid parity will depend on "specific circumstances for an individual investor" including "site-specific costs, investor desired returns, levels of on-site consumption of the electricity produced and effective electricity tariff".

DECC's Public Attitudes Tracking survey[13], with an 81% public approval rating.

As solar costs head toward grid parity over the next few years, and if solar remains popular with businesses and the general public, this offers the prospect of deployment without a Feed-in Tariff or other direct support over the medium term.

IMPACT OF SOLAR DEPLOYMENT ON ELECTRICITY GRID AND MARKET

If deployment can be made cost effective without direct financial support over the medium term, this could result in continued very rapid take up, with major implications for power demand on the electricity transmission grid. National Grid's Future Energy Scenarios (FES), published in July 2015, estimated that transmission demand could fall to historic lows of 15GW or less by 2030 on some summer afternoons if solar deployment was around 30GW, as in the 'Consumer Power' scenario.

There will be other effects too. The widespread deployment of renewables, like solar, that have zero marginal costs, will also have the effect of lowering prices in the wholesale market. This is the so called 'merit order' effect. Good Energy calculates that the impact of wind and solar generation in 2014 wholesale prices in the UK resulted in an overall savings of £1,550 million arising from the merit order effect (including solar 'savings' of £150 million)[14], which could lower consumer bills.

While solar panels can function even when the sun is not shining, the sun shines for an average of just 34 per cent of daylight hours in the UK and, in the winter, average sunlight per day can drop to less than 20 per cent. Additionally, although solar can be more predictable than other renewables, like wind, it does experience strong fluctuations over the course of a day and its maximum output (close to midday) does not coincide with the times of greatest demand on the system (the morning or evening peaks). Some have argued for solar paying higher grid and system balancing costs to reflect higher variability and the fact that most users need to draw on electricity from the grid when irradiation levels are low. DECC has commissioned a study from Frontier Economics to look further at this issue. However, the impact of solar on the grid changes if you can find a way to store the electricity.

ENERGY STORAGE – THE 'GAME-CHANGER'

Commercial deployment of energy storage is widely regarded to be a *'game changer'* for the electricity system over the coming decade. For example, a recent Policy Exchange report, titled "Eight Great Technologies"[15], highlighted the role storage can play, adding that "Britain is or can be global leaders… in a new, high technology industrial revolution."

Energy storage can take a number of different forms, including:

- Power-to-heat systems, such as hot water boilers or heat pumps;
- Stationary battery storage; and
- Controlled charging of Electric Vehicles and plug-in hybrids.

Energy storage enables the 'de-coupling' of onsite generation from consumption, allowing consumers to store excess onsite generation at times of low demand and use or export that energy when it is most economically advantageous to do so. Storage can also help reduce peaks on the electricity grid and local voltage fluctuations. Similarly, as electric vehicles (EVs) are effectively a form of storage, a high penetration of EVs into the market could affect the daily power curve.

In 2010, commercial deployment of storage technologies seemed some way off. However, falling costs and improvements in scalability mean that high-volume storage is expected to become commercial without support in the next few years. Citigroup estimates that there will be up to 240GW of energy storage in the global market by 2030[16], as costs are expected

[13] DECC, Public Attitudes Tracking survey: Wave 14, August 2015, https://www.gov.uk/government/statistics/public-attitudes-tracking-survey-wave-14

[14] Good Energy, Externalised Benefits of Solar and Wind: An Investigation into the Merit Order Effect, August 2015

[15] Policy Exchange, Eight Great Technologies, January 2013, http://www.policyexchange.org.uk/images/publications/eight%20great%20technologies.pdf

[16] Citigroup, Dealing with Divergence, January 2015, https://ir.citi.com/20AykGw9ptuHn0MbsxZVgmFyyppuQU

to decline steadily in line with increased deployment and continued technological development, possibly even emulating the cost reduction profile for solar PV.

Consistent with this, recent months have seen significant developments regarding the deployment of battery technologies in the UK market:

- In April 2015, Tesla announced that it will be the first company to sell an energy storage unit known as the Powerwall at a price competitive rate for delivery in late 2015[17] (US$3,000 for a 7kWh model). This has both residential and commercial application, as up to nine Tesla Powerwall devices can be linked together.
- Powervault, a London start-up, is looking to enter the domestic market[18] with its 2kWh and 4kWh systems at £2,000 and £2,800 respectively.
- Good Energy hopes to have a storage proposition available in 2016[19] and are currently piloting small-scale storage with Moixa's Maslow battery. The Maslow battery has an added feature in that it can be aggregated independently of location and hence can be 'shared' by the distribution networks. This creates a second income stream for consumers.
- Western Power Distribution is currently running a trial project called SoLa, funded through the Low Carbon Networks Fund[20], which aims to address the technical constraints for Low Voltage networks arising from the deployment of solar PV. The trial is using battery storage in domestic and community properties to increase self-consumption and reduce potential requirements for network reinforcement.

In addition to the above, several 'household' names such as SMA, LG and Samsung to name a few have started offering domestic-scale storage solutions.

INTERNATIONAL DEVELOPMENTS

Recent international developments suggest that decentralised energy, utilising solar and storage, can become a significant part of the UK energy mix as large scale adoption of these technologies is likely to lead to further price reductions:

- Solar PV is now at 'grid parity' in approximately 30 countries and 14 US States, according to a recent Deutsche Bank study[21];
- In the US, President Obama has unveiled the Clean Power Plan[22] setting a 32% decarbonisation target by 2030 from 2005 levels. A key part of his plan is the rapid build out of decentralised energy, including solar and storage. The roll out of storage technologies is now mandated as part of regulatory settlements in a number of US States.
- The German Government is targeting 40 per cent of power generation to be from renewables by 2020, with continued significant growth in decentralised energy. In 2013, more than half of investments in renewables were made by small investors[23]. The German Government has also introduced a grant for the deployment of domestic storage when linked to solar.

Ut3HVhTrcjz4ibR%2Bx79LajBxlyoHIoSDJ3S%2BWRSMg8WOc%3D

[17] Tesla Energy, Press release on Tesla Powerwall, http://www.teslamotors.com/en_EU/presskit. Prices quoted are only for battery costs and do not include inverter and installation costs.

[18] Powervault, press release, June 2016, http://www.powervault.co.uk/wp-content/uploads/2014/09/PowerVault-release-FINAL-23-6-15.pdf

[19] Utility Week, Good Energy to launch storage offer by April 2016, August 2015, http://utilityweek.co.uk/news/good-energy-to-launch-storage-offer-by-april-2016/1157402#.Vd3L9vlViUI

[20] http://www.westernpowerinnovation.co.uk/Document-library/2015/SOLA-BRISTOL-Progress-Report-May-2015.aspx

[21] Deutsche Bank, Crossing the Chasm, February 2015, https://www.db.com/cr/en/docs/solar_report_full_length.pdf. Out of a sample of 60 countries analysed. 14 additional states in the US are poised to reach grid parity.

[22] Official White House website, August 2015, https://www.whitehouse.gov/climate-change#section-clean-power-plan

[23] Heinrich Böll Foundation, The German Energiewende, July 2015

BARRIERS TO DECENTRALISED ENERGY

There are several barriers that could slow the transition to a decentralised energy model in the UK. These can be grouped as follows.

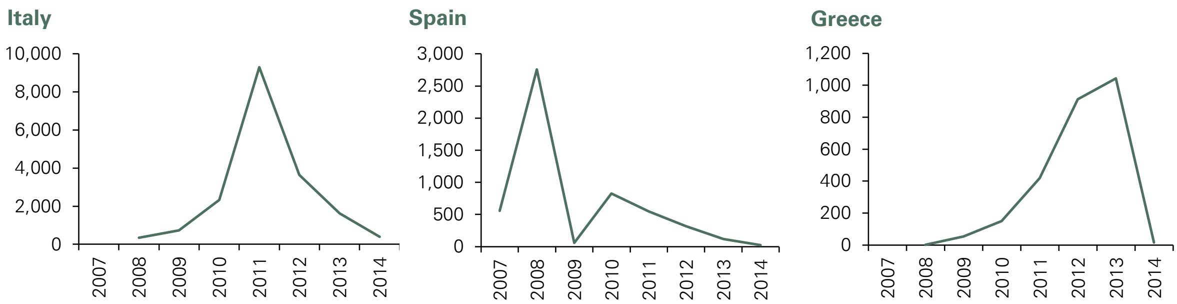
REGULATORY AND POLICY BARRIERS – IMPACT OF SIGNIFICANT TARIFFS CUTS

The UK Government has proposed very sharp cuts in the tariffs for solar PV in its FITs consultation published on 27 August 2015. This reflects a desire to bring spending on renewable support back down towards the Government's LCF limit of £7.6 billion p.a. in 2020/21 (in 2011/12 prices) and thereby limit the impact on consumer bills. The consultation proposes reducing direct support to zero for residential deployment by 2019, effectively closing the FIT scheme introduced in 2010.

International evidence makes clear what happens to a market when such severe subsidy cuts are made in such a short time scale.

The recently released Bloomberg report 'Investment opportunities post retroactive subsidy cuts' highlights a number of barriers to the transition to decentralised energy generation, in particular the impact of substantial cuts to government support for renewables in Italy, Spain, Greece, Romania and the Czech Republic. In Spain where cuts of this nature were made in 2008, solar PV deployment year on year decreased from 2,758MW in 2008 to 60MW in 2009.

FIGURE 2: PV INDUSTRY 'CLIFF-EDGE' IN ITALY, SPAIN AND GREECE (YOY PV MW DEPLOYED)



Source: SolarPower Europe (formerly European Photovoltaic Industry Association)

The Partners associated with this report recognise the need to reduce costs to consumers as far as possible. Whilst not agreeing with cuts of this severity or speed, we have sought to take as given the envelope of overall spend projected on solar FITs to 2020/21 as a starting point for considering what other policy changes could facilitate the transition to widespread deployment of decentralised energy described above in a world *without* long-term support.

REGULATORY AND POLICY BARRIERS – STORAGE

There are currently limited incentives for Distribution Network Operators (DNOs) and Transmission Owners (TOs) to actively expand storage capacity in the UK under Ofgem's RIIO framework.

Indeed, the current basis for setting transmission network charges imposes costs when energy is imported from *and* exported to the grid. Storage units are, in effect, 'double charged' for use of the transmission network, which penalises developers of storage facilities at the transmission level. This system fails to recognise the full value that storage can provide to networks, such as load shifting and reducing demand at peak hours. The value of storing excess generation from variable renewables will only increase as the UK seeks to decarbonise its economy further.

There is a lack of clarity in the definition of storage from a regulatory perspective, which is usually treated as a generation asset, potentially leading to confusion around regulatory treatment and remuneration and the existence of any ownership or operational restrictions. Storage is in a number of ways unlike a generation asset, as it merely time-shifts original generation and can export for a limited period only. In this context, DNOs should be allowed to secure additional non-regulated income from the provisions of storage related services provided.

Finally, there are no formal targets in place set by the Government or regulator on the volume of storage required in the UK. By contrast, California has set a target of 1,325MW, resulting in several ambitious storage projects which are currently underway.

NETWORK CONSTRAINTS

Grid connection constraints are amongst the most significant non-economic barriers to the widespread deployment of solar PV.

There has been a significant increase in the number of connections to the network since 2010, as the costs of decentralised energy have fallen and Government support through feed-in tariffs has encouraged the development of local generation. However, even as connections have increased to 687,000[24] in 2014/15, the DNOs themselves have little or no control over the supply to their network or the balancing of this supply with demand either within their network or onto the transmission network.

The increase in the number of connection requests has placed considerable strain on the distribution network, and consequently DNOs are increasingly struggling to incorporate demand for distributed generation into the grid. Limited capacity is an increasingly key constraint for DNOs and the emergence of such delays suggests that strategic network investment should be encouraged where this would provide a more co-ordinated, economic and efficient means of accommodating future distributed generation or demand connections.

DEMAND SIDE CONSTRAINTS

The success of initiatives such as demand side response, smart meters and local generation is dependent at least in part on the level of consumer engagement with load-shifting initiatives. Engagement has been low to date but, with new technology, decentralised energy provides an opportunity for consumers to empower themselves and take control of their own energy security and lower their bills.

24 http://www.energynetworks.org/modx/assets/files/events/dgfora/2015/DGF2015_London_Presentation_reduced.pdf

POLICY RECOMMENDATIONS FOR SUPPORTING DECENTRALISED ENERGY

Steps need to be taken to overcome these barriers and facilitate the transition to this lower cost, more decentralised vision of the energy system of the future. The package of measures described below draws on the experience of other countries where decentralised energy is growing, and takes as given the envelope for spending on FITs the Government has proposed under the Levy Control Framework. Without these (or similar) facilitating measures, the progress towards a decentralised energy system is likely to be stalled.

KEY RECOMMENDATIONS

1. **Re-profile FITs spend within the overall Levy Control Framework envelope**
   a. *Without* increasing the total spend on solar FITs proposed under the LCF to 2020, set higher tariffs in the short term to allow the industry to make a quicker transition to a no-support world.

FIT TARIFFS (P/KWH)

	CUSTOMER TYPE	2016/17	2017/18	2018/19	2019/20
<4kW	Residential	7.0	6.0	5.0	0.0
4-50kW	C&I	6.5	5.25	4.25	0.0
50-250kW	C&I	5.5	4.25	3.25	0.0
250-1000kW	C&I	3.0	1.75	0.75	0.0

   b. For residential customers (with <4kW systems), the tariff would need to be 7 p/kWh in 2016/17, 6 p/kWh in 2017/18 and 5 p/kWh in 2018/19, before falling to zero from April 2019. The proposed tariffs for C&I customers are also shown in the table below.
   c. Offsetting savings could be made by closing the scheme *earlier* than proposed in the DECC consultation document (2020), as well as reducing FITs support for ground-mounted solar and large-scale roof-mounted solar (>500kW), and other technologies, like micro wind turbines, which have less potential for further cost reduction and being part of a 'whole house solution'.
   d. The proposed residential tariffs set out above would need to be higher than recommended if they were implemented in isolation, without the other supporting measures listed below.

2. **Introduce a time-limited deployment grant to kick-start the battery storage market**
   a. Implement a time-limited scheme for the deployment of battery technologies linked to solar PV installation, along the lines of the scheme used in Germany, where batteries linked to solar get a 30 per cent rebate[25]. In principle, this would also be similar to the scheme currently running in the UK for stimulating the take-up of electric vehicles.
   b. Provide grants of approximately £300 per kWh of discharge capacity available to residential customers to install battery storage technologies as part of a 'smart whole house' solution, with a cap on total spend to 2020 of approximately £300 million. So, for example, a 3kWh battery system would be eligible for a deployment grant of £900. The deployment grant per customer could be capped at £1,500.

[25] http://www.bmwi.de/EN/Topics/Energy/Storage/funding-for-decentralized-energy-storage.html

c. This would be paid for by re-directing existing innovation funding from UK and EU innovation funding sources.

3. **Recognise the value created for the electricity grid of widespread deployment of battery technologies**
   a. With widespread deployment of storage, peaks on the electricity grid can be avoided and hence grid reinforcement costs can be reduced. With storage, the value of exported electricity from decentralised generation can reflect demand on the system (rather than being supplied at times of limited use e.g. middle of a summer's day).
   b. This value that storage brings to the system needs to be properly recognised through targeted products offered in the balancing mechanism and/or capacity market that incentivise the aggregation of demand side response from the residential and C&I sectors that utilise storage technologies. Such products would increase competition between products in the balancing market/capacity market and help stimulate behavioural change to realise the full potential of storage technologies.
   c. These steps would need to be facilitated by the introduction of Time-of-Use tariffs and half-hour metering for domestic customers, by 2018/19, as recommended by the Competition and Markets Authority (CMA).

4. **Incentivise DNOs and the TSO to support deployment of decentralised energy**
   a. Provide a regulatory mechanism that permits DNOs and TSOs to own and operate electrical energy storage as a regulated network asset, whilst also providing non-regulated services to other market players. Introduce regulatory settlements for DNOs and National Grid that incentivise the growth in decentralised energy and recognise the network cost savings that can result as a result of lower peak demand on the system.
   b. Introduce grid access rules for customer sites that enable two-way flows to help manage the system in 'smart' way to avoid bottlenecks.
   c. Implement a storage-specific and flexible grid connection application process, instead of a conventional generation application as used for wind and solar.

IMPACT ON BILLS

We believe these changes can be made within the existing LCF limits proposed by Government to 2020/21 and within existing Government spending envelopes, by refocussing existing funds towards the key technologies.

We also estimate that these policy changes can help deliver savings over the medium term:

- With regards the LCF limits to 2020, DECC has stated in its consultation on FITs that a maximum of £100 million of additional expenditure is available for new deployment up to 2018/19. Assuming increased self-consumption rates as a result of storage, it is estimated that about £60 million would be required to support the deployment of 100,000 3.5kW solar PV units per annum totalling 1.1GW over this period at these tariffs, well within the overall LCF cap.
- Over the longer term, it should result in a significantly lower LCF in the 2020s than the previous DECC forecasts, which imply LCF spending rising to about £15 billion per annum (in real 2011/12 prices) by 2025.

1 INTRODUCTION

The electricity system in Great Britain relies on a centralised grid network, with power supplied by distant power stations down transmission and distribution lines to homes and businesses. This conventional approach, based on unidirectional flows from producers to consumers, has been the basis for our energy system over many decades.

In recent years, we have seen the rapid deployment of solar PV, driven by long-term subsidies and falling costs of solar panels. When combined with other developments, like the falling costs of battery storage and the roll out of smart meters, this offers a different way to meet Britain's energy needs going forwards. It harnesses the power of new technology. It can empower consumers to take greater control of their own energy production and reduce their energy bills. If the right transitional measures are put in place, it is a system that does not require long-term subsidies.

In *'The Decentralised Energy Transition'*, we explore the potential role of decentralised energy in meeting Britain's energy needs and carbon reduction targets at lower cost to consumers. The purpose is to add value to the debate on the future direction for Britain's energy system, as the still new Conservative Government considers its options on energy policy, recognising that decisions taken over next few months will set the course for Britain's energy sector for next decade and beyond.

This report is produced by Lightsource Renewable Energy, Good Energy and Foresight Group. UK Power Networks has provided data input on the regulatory changes required to support decentralised energy, with Tesla providing data input on storage. The analysis was co-ordinated by KPMG.

1.1 CONTEXT FOR THIS REPORT

The new Conservative Government faces a number of challenges as it seeks to define its future energy policy:

- With production from oil and gas in the North Sea declining year on year, Britain's dependence on imported energy is now back to a level last seen in 1973.
- Capacity margins for the Great Britain power system are at their lowest levels for a decade or more as old coal and nuclear stations close;
- The UK has legally-binding targets to meet on renewable energy and carbon reduction and further targets may be agreed at the Paris Climate Change Conference this December;
- There is significant uncertainty about the path of global commodity prices (oil, gas and coal) in the future.

In the July Budget, the Government published a forecast showing a potential overspend on subsidies for low carbon technologies against its Levy Control Framework limit of £4.3 billion in 2015/16 and increasing to £7.6 billion per annum by 2020/21 (in 2011/12 prices). As a result, the Government has announced cuts to a number of low carbon subsidies, in order to bring spending back down towards the spending cap and limit the impact on consumer bills.

Given the importance attached to energy bills, this report looks at the potential impact on bills and the LCF of different solutions to Britain's energy needs. In the next section, we consider the existing DECC projections and their implications for spending under the LCF. We then go on to consider an alternative scenario, based on greater reliance on decentralised energy and a more interactive management of demand and supply across the energy system.

2 EXISTING PROJECTIONS FOR UK ELECTRICITY SECTOR

This section considers different projections on how the power sector might develop. The aim is to:

- Set a baseline counterfactual when considering alternative scenarios;
- Illustrate how uncertain such forecasts can be in a rapidly changing market; and
- Identify the relative merits of decentralised energy against the baseline projections.

The most recent published projections from the Department of Energy and Climate Change (DECC) from October 2014 are used as a starting point. The report also considers other public projections such as National Grid's Future Energy Scenarios, and the Committee of Climate Change projections in the 2015 Progress Report to Parliament[26].

2.1 DECC PROJECTIONS

2.1.1 BACKGROUND

DECC provides an annual update on energy and emissions projections. This gives an overview of the trends in energy demand, supply and greenhouse gas (GHG) emissions based on the policy environment at the time of publication.

The latest DECC energy and emissions projection were released in October 2014[27], with projections up to 2035. These incorporates progress against the 2nd, 3rd and 4th Carbon Budgets to 2027. Against the reference scenario[28], DECC has also provided sensitivities to capture macroeconomic uncertainties including fossil fuel prices and economic growth.

2.1.2 BUILD-OUT RATES

DECC's projection on cumulative new build capacity can be seen in Figure 3 DECC estimates that around 100GW of new capacity will come on stream cumulatively by 2035, comprising:

- 47GW of renewables;
- 18GW of new nuclear;
- 12GW of Carbon Capture and Storage (coal and gas); and
- 17GW of new CCGTs.

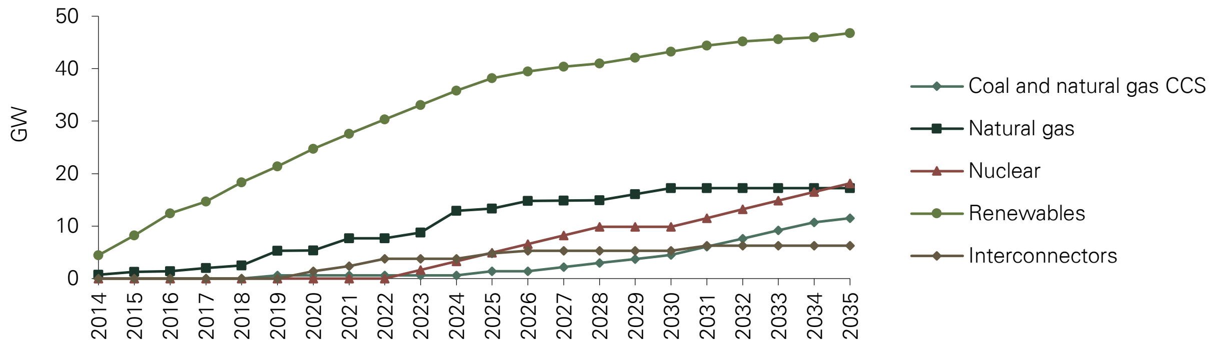
DECC's reference scenario assumes no new unabated coal, oil and storage capacity (including pumped storage hydroelectricity).

[26] More information in Appendix 1

[27] https://www.gov.uk/government/collections/energy-and-emissions-projections

[28] DECC's reference scenario is based on central estimates of growth and fossil fuel prices. It incorporates "all agreed policies where decisions on policy designs are sufficiently advanced to allow robust estimates of impact".

FIGURE 3: DECC NEW BUILD CAPACITY PROJECTION



Source: DECC Energy and Emissions Projections, Oct 2014

Whilst pursuing a diverse mix of energy sources makes sense in an uncertain world, all of these technologies would need subsidy. The low carbon technologies (renewables, nuclear and CCS) would be dependent on subsidy in the form of CfDs. The new CCGTs would be reliant on capacity payments generated by the Capacity Market. All of the subsidies would add to bills and imply significant increases in the 2020s in the total spending under the Government's Levy Control Framework. That is before taking account of the costs of additional grid infrastructure to transmit the electricity from increasingly dispersed locations to homes and businesses, where the load is. Moreover, even with these very rapid build out rates, DECC estimates that further policy action would be needed to meet the 4th Carbon Budget (2023-27), and the 5th Carbon Budget (2028-32) expected to be tighter still.

2.1.3 CARBON EMISSIONS

With a strong renewable build rate this decade, DECC estimates that the UK will be able to meet the 2nd and 3rd Carbon Budget targets based on current policies but will require further policy interventions to meet the 4th Carbon Budget. Existing policies that contribute to lower emissions include the Renewable Obligation, Contracts for Difference, Renewable Transport Fuel Obligation (RTFO), Energy Company Obligation (ECO), and Renewable Heat Incentive (RHI) among other schemes.

FIGURE 4: PERFORMANCE AGAINST CARBON BUDGET

NET UK CARBON ACCOUNT

CARBON BUDGET	1 (2008-12)	2 (2013-17)	3 (2018-22)	4 (2023-27)
$MtCO_2e$				
Traded sector	1,185	1,185	1,185	1,185
Traded sector cap	1,227	1,078	985	690
EUA's purchased	(41)	-20	(258)	(143)
EUA's cancelled by UK Government	4	-	-	-
Non-traded sector	1,760	1,628	1,479	1,393
of which non-CO_2	524	476	429	397
Territorial emissions[29]	2,945	2,686	2,206	1,940
Carbon budget	3,018	2,782	2,544	1,950
Net carbon amount	2,982	2,706	2,464	2,083
Budget shortfall	**(36)**	**(76)**	**(80)**	**133**

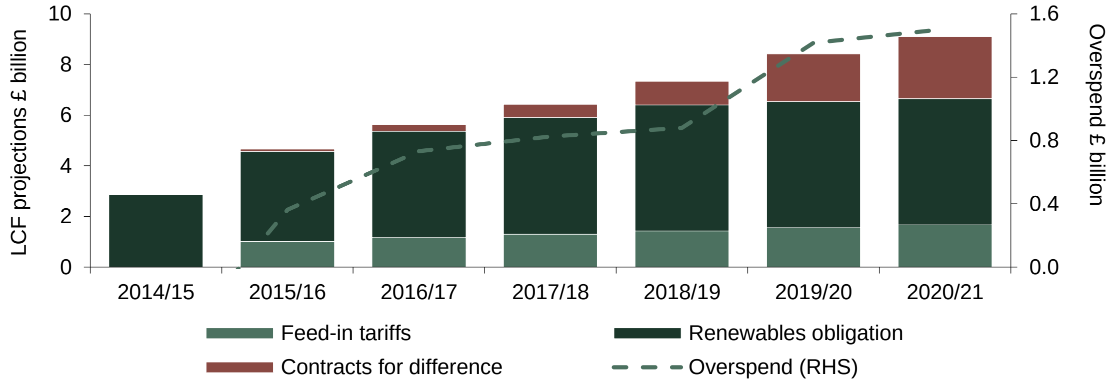
Note: A positive shortfall indicates that emissions are over-budget whereas a negative shortfall indicates that emissions are within budget

Source: DECC Energy and Emissions Projections, October 2014

2.1.4 COST IMPLICATIONS OF DECC PROJECTIONS

In July 2015, the government published its latest forecasts for spending under the levy control framework. Figure 5 illustrates the projected overspend on the LCF[30] of approximately £1.5 billion in 2020/21, is about 20 per cent higher than the proposed budget of £7.6 billion pa (in 2011-12 prices). The Government has proposed a number of cuts to renewable subsidy budgets in order to bring spending back down, particularly on solar PV, onshore wind, and biomass technologies.

FIGURE 5: LEVY CONTROL FRAMEWORK PROJECTIONS AND OVERSPEND



Note: All figures in 2011/12 prices

Source: OBR, Economic and Fiscal Outlook, July 2015; DECC EMR Deliver Plan, Dec 2013

[29] Territorial emissions comprise both emissions covered by the EU Emissions Trading Scheme (EU ETS) (referred to as "traded" emissions) and emissions outside the EU ETS (referred to as "non-traded" emissions).

[30] OBR, Economic and fiscal outlook, July 2015, http://budgetresponsibility.org.uk/economic-fiscal-outlook-july-2015/

Looking further ahead, the proposed build out rates shown in Figure 3 imply very rapid growth in subsidy budgets. Using a realistic set of assumptions about the costs of different technologies into the 2020s, we estimate that the LCF would need to rise to about £15 billion by 2025 to deliver these build out rates. This would be before any additional measures required to hit the 4th and 5th Carbon Budgets, and would not take account of additional capacity payments required to deliver significant new CCGT build.

The Climate Change Committee (CCC)[31] has noted that the LCF is likely to "overstate the additional cost of low-carbon generation to consumers" as CfDs are settled relative to the wholesale price instead of gas generation. The CCC recommends an alternative calculation using the levelised cost of new CCGTs with the appropriate carbon price as the appropriate counterfactual to low carbon generation. There is considerable merit in the CCC's argument. However, for the purposes of this report, we have continued to calculate support levels using the Government's current definition.

[31] CCC, Meeting Carbon Budgets – Progress in reducing the UK's emissions, June 2015

3 POTENTIAL ROLE FOR DECENTRALISED ENERGY

The projected build of c.100GW of new large-scale capacity is one way to address Britain's energy needs. A diverse mix of technologies makes sense in an uncertain world and there will still be a need for new large-scale capacity as older plant, particularly coal, comes off the system. However, all that additional capacity will require subsidy of one form or another. By optimising the way we produce and consume energy, the combination of decentralised energy and smarter grids has the potential to reduce the build out of new large-scale plant below the c.100GW previously put forward by DECC.

This section discusses what is meant in this report by 'decentralised energy' (DE), and the potential system-wide benefits of pursuing this model. A vision for how decentralised energy could develop for households throughout the UK is then set out – the 'whole house' solution. In addition, recent international developments are highlighted to suggest the movement away from traditional, centralised generation around the world is gaining momentum.

3.1 WHAT IS DECENTRALISED ENERGY?

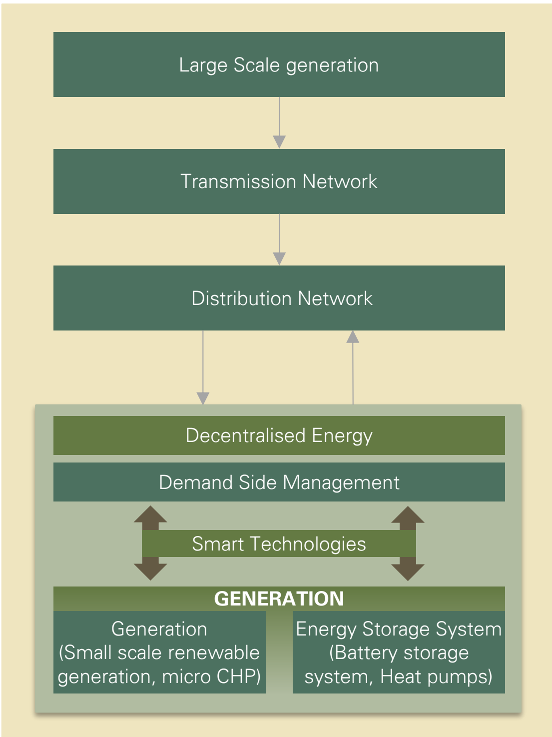
This section defines what is meant by decentralised energy in this report and outlines how this proposition could work in practice.

Decentralised energy is a broad term that is used widely in differing contexts. In this report, decentralised energy refers to energy systems where electricity and heat are generated close to the load they serve coupled with demand side management. DE encompasses small-scale renewable technologies including rooftop solar, small-scale wind, biogas, geothermal and storage. Typically, it also involves technologies that unlocks demand side response potential. By combining local generation and the ability to manage demand, DE systems can dramatically reduce reliance on the central grid network.

The scope of decentralised energy is not limited to one type of customer, but can encompass domestic consumers and SMEs, as well as a larger scale commercial and industrial consumers. DE can also apply to community initiatives, such as the deployment of solar PV on social buildings such as schools, council houses, community centres and churches.

Although a broad range of customers inevitably have different supply and demand profiles, some potentially more suited to a DE model than others, each offers a viable renewables – based alternative to reliance on predominantly large-scale, centralised generation.

FIGURE 6: ILLUSTRATIVE MODEL OF DECENTRALISED ENERGY

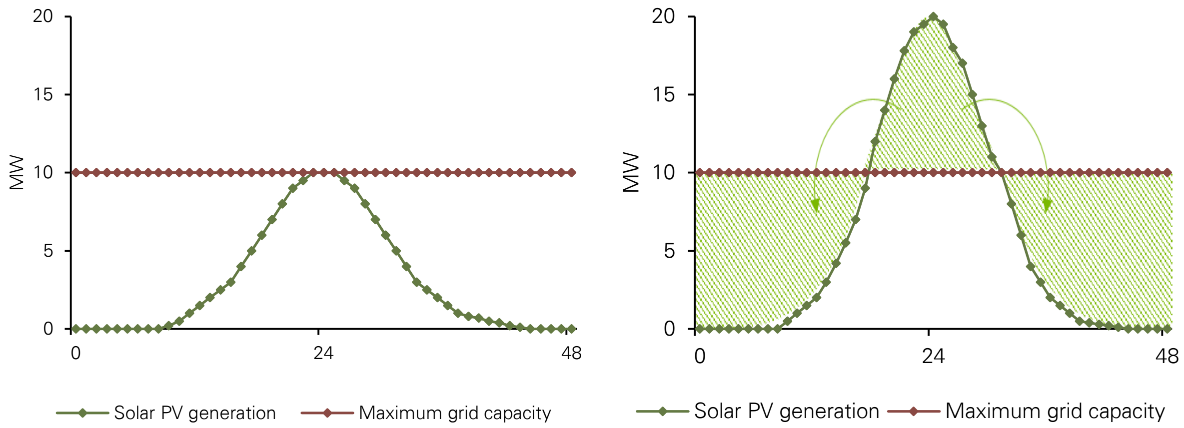


SUPPLY SIDE

Developments in renewable technologies such as solar PV allow domestic customers to facilitate as much as 20 to 35 per cent[32] of their own total electricity consumption on average, with the remainder exported to the grid.

The development of compact home-storage units, allows customers to store excess energy accumulated when generation exceeds consumption and use it when the reverse is true, increasing domestic self-consumption of PV generation to between 60 to 90 per cent[33]. For example, Figure 7 shows the maximum amount of solar PV installations possible in a solar farm due to the maximum grid capacity. Excess generation above grid constraints can simply be used to charge battery cells for discharge at a later time.

FIGURE 7: ILLUSTRATION OF IMPACT OF STORAGE ON SOLAR PV GENERATION



Note: Chart (a) shows the peak solar PV generation constrained by grid capacity. Chart (b) shows the advantage of using storage to increase solar PV installations for the same grid capacity

Source: KPMG illustration

Solar coupled with storage means a consumer's self-utilization can now constitute a high proportion of consumption and lead to lower peak demand. The viability of such a model has led to the coining of the term 'prosumer', for consumers who produce much of the energy that they consume. In addition, where generation exceeds consumption and storage capacity, excess electricity can be exported to the distribution network.

Ultimately, once the prosumer model is fully adopted, utilising the full suite of technologies, along with optimised demand side response, the self-consumption percentage is likely to increase even further. Steve Holliday, CEO of National Grid, expects decentralised energy to become the norm. He was recently quoted as saying: 'the idea of baseload power is already outdated. I think you should look at this the other way around. From a consumer's point of view, baseload is what I am producing myself. The solar on my rooftop, my heat pump – that's the baseload'[34]. In its recent consultation on the flexibility of the electricity system[35], Ofgem states that the UK is 'now moving to a system where generation is distributed and more variable, where consumers can better monitor and manage their energy use, and where new technologies and business models are emerging'.

As well as electricity, there is also considerable scope for the development of decentralised heating capabilities. **Combined Heat and Power** is the simultaneous generation of heat and electricity close to the point of use, also referred to (for example by the IEA[36]) as cogeneration, and can significantly reduce inefficiencies in electricity generation and

[32] Roughly 25% of generation is used by consumers while 75% is exported to the grid.

[33] Lightsource

[34] http://worldenergyfocus.org/wp-content/uploads/2015/09/EP_WEF_2015_15_MR01.pdf

[35] https://www.ofgem.gov.uk/sites/default/files/docs/2015/09/flexibility_position_paper_final_0.pdf

[36] IEA, 2008, Combined Heat and Power – evaluating the benefits of greater global investment

energy usage. CHP can generate energy in large scale plants or at a micro level, capturing much of the energy wasted as heat during the electricity generation process, with thermal efficiency levels of micro CHP from renewable generation now over 90 per cent[37]. The Carbon Trust has assessed a number of trial micro CHP projects, such as CHP boilers, in the UK and identified average reductions in energy costs of 20 per cent where CHP is deployed.[38]

District heating is a means for distributing heat generated at a community level to households and non-households, via a network of insulated pipes, and is prevalent in a number of European countries such as Denmark, Germany and France. Heat sources for district heating can be diverse and from more than one point of supply, including both renewables and fossil fuels. This flexibility suggests that a combination of large-scale CHP and district heating could form a decentralised model for heating that would allow the balancing of supply and demand whilst leveraging efficiencies in generation.

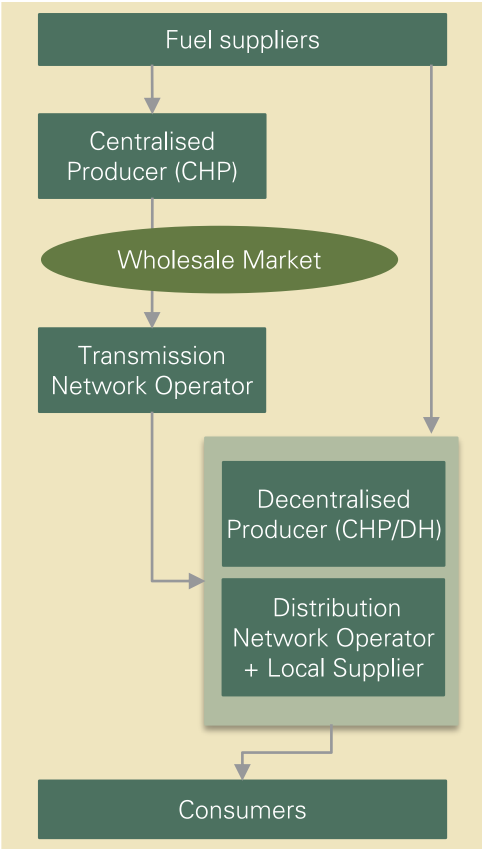
A recent example is SELCHP, a CHP facility based in South East London that generates electricity and heat using household waste. The heat generated through CHP is used as part of a local 5km district heating scheme supplying 2,500 properties[39] in close proximity to the plant, with the pipe network completed in 2014. The electricity generated supplies 48,000 homes in the local area. Such low carbon micro CHP is currently encouraged through Ofgem's Domestic Renewable Heat Incentive[40]

DEMAND SIDE

Demand Side Response involves shifting consumption load from periods of low generation/high demand to periods of high generation/low demand. This greatly reduces the overall energy system cost and the cost of grid re-enforcements.

Although a decentralised model substantially reduces a prosumer's reliance on the grid, current technology prosumers will still need access to the grid where a combination of self-generation and storage falls short of their demand. Demand side management and demand side response technologies allow consumers to maximise the efficiency of energy consumption and limit the cost and quantum of these imports from the grid. In a decentralised model, it allows consumers to shift and distribute their demand to coincide with onsite generation and avoid periods of peak grid demand (and prices). Technologies may include:

FIGURE 8: ILLUSTRATIVE MODEL OF DECENTRALISED HEATING



- Smart thermostats and heating control systems in commercial buildings;
- Interruptible supply contracts that attract lower tariffs for C&I players; and
- The use of remotely-controlled electrical heating systems as well as smart

[37] http://www.iea-ebc.org/fileadmin/user_upload/docs/Annex/EBC_Annex_54_Micro-Generation_Support_Mechanisms.pdf

[38] http://www.carbontrust.com/media/19529/ctv044_introducing_combined_heat_and_power.pdf

[39] http://www.selchp.co.uk/energy-recovery/combined-heat-and-power/

[40] https://www.ofgem.gov.uk/environmental-programmes/domestic-renewable-heat-incentive-domestic-rhi/about-domestic-rhi

appliances (washing machines, tumble dryers, dishwashers) that are able to switch off or down at times of high demand or prices for domestic consumers.

Empowering consumers to increase the efficiency of energy consumption can be facilitated through the development of smart technologies at a domestic and SME level, some of which are already in progress. For example, current ambition is that smart meters will be rolled out across the UK by 2020[41]. Smart meters provide data around energy use on a real-time basis to both consumers and energy companies, increasing customer awareness of levels of energy use. Smart meters would allow distribution network companies to set a cost reflective set of DUoS charges (for example Seasonal Time of Day rates with higher charges for peak time usage) that incentivise efficient energy use. With the ability to achieve accurate half-hourly metering, suppliers can offer customers innovative tariff structures such as Time-of-Use tariffs.

A ToUT-based approach incentivises both the consumer and industry to carry out effective demand-side management. Taking a whole system approach, ToUT will also enable the industry to value generation and thus the flexibility of energy storage systems more precisely. Smart meters also have the capability to measure exports as well as imports of electricity, which will facilitate the introduction of export tariffs based on half-hourly measurements. If suppliers were obliged to offer cost-reflective tariffs based on actual rather than estimated data, consumers could avoid peak charges by charging the battery when tariff prices are low and discharging when tariff prices are high. This would help the distribution networks to avoid reverse flows and reduce voltage rise issues.

Critical to the integration of decentralised energy into UK energy networks is the development of smart grids – electricity networks that intelligently integrate generation, transmission and distribution assets and facilitate efficient interaction between the grid and customers. Smart grids allow active management of supply and demand on a real-time basis and thus the integration of increased local generation to distribution networks.

Increased decentralised generation will require changes to traditional generation, transmission and distribution roles and responsibilities. For instance, distribution network operators in the UK, such as UKPN, have traditionally distributed energy relatively passively from the transmission network in a world where the vast majority of customers were consumers. Under a decentralised model, distribution network operators will need to become more involved in system operations, including system balancing and design, and transition towards a Distribution System Operator (DSO) model where distribution networks are semi-autonomous and more resilient.

Decentralised energy therefore has the potential to enhance energy efficiency in the UK, on the supply side through reducing reliance on transmission and distribution networks, as well as through demand side initiatives.

3.2 BENEFITS OF DECENTRALISED ENERGY SYSTEMS

Decentralised energy has the potential to deliver lower bills for households and businesses over the medium term as a result of improvements in efficiency and network operations with a lower carbon foot-print than the traditional transmission connected system. However, quantifying the benefits of decentralised energy on UK energy systems is not straightforward to capture, not least because, although a number of decentralised energy technologies are in operation around the world, they have rarely been tested in combination. The main expected benefits of a decentralised energy system are as follows:

SUBSIDIES ONLY REQUIRED IN THE SHORT TERM

DECC is projecting approximately 100GW of large-scale generation by 2035 to meet the UK's energy needs. As solar PV is expected to reach grid parity in the next few years, building new decentralised capacity in the medium term is expected to require less long-term subsidy than other technologies, and reduce the build rates required for large-scale plant, thereby

[41] http://www.smartenergygb.org/national-rollout/how-its-happening

reducing the impact of Government's policies on household bills.

REDUCE INVESTMENT REQUIRED IN PEAKING PLANT TO MEET HIGH DEMAND

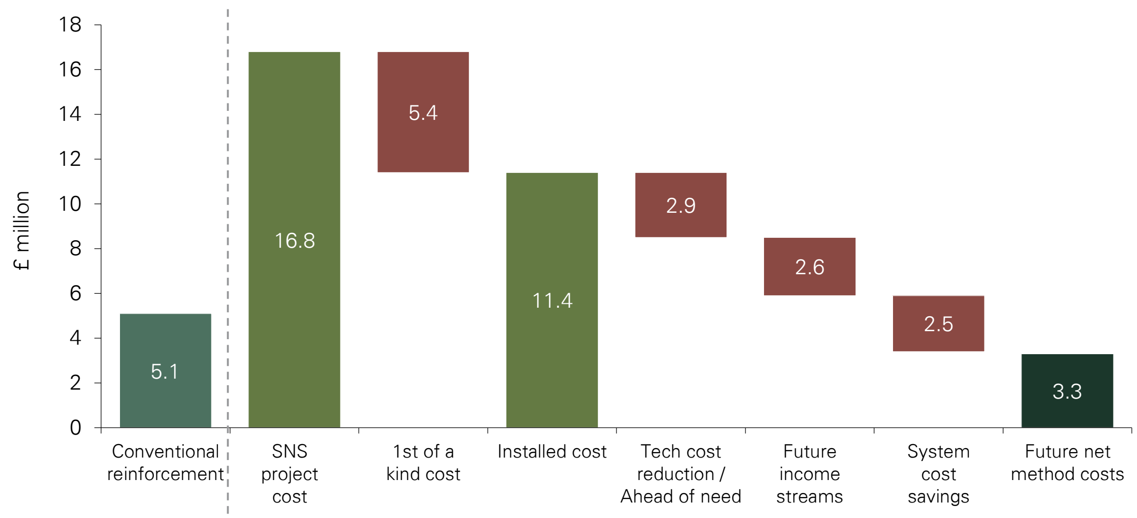
At present, in order to meet the UK's Loss of Load Expectation (LoLE) at times of peak demand, peaking plants are required. These plants are, for the most part, unable to participate in the current market without the additional payments provided by the Capacity Mechanism[42]. Total (gross) capacity payments from the first auction held in early 2015 are expected to be £956 million[43]. A combination of storage and demand side response, coupled with enhanced efficiencies such as smart appliances, will reduce peaks in demand and hence reduce the scale of peaking plant required.

REDUCE BALANCING MARKET COSTS

National Grid is forecasting system balancing costs for 2015/16 to be £882 million [44]. Of the £882 million, £178 million is for response, including the spinning reserve, and £126 million for the fast reserve. The expansion of storage and demand side response would be expected to significantly reduce the costs of balancing the electricity system, as the system operator could match demand to supply or use stored capacity promptly to maintain voltage levels, regulate frequency and act as spinning reserve capacity.

Trials are underway at various locations aimed at refining these cost savings. Take, for example, the 6MW trial storage facility at Leighton Buzzard. The project cost is £11.4 million, however this is expected to decrease to £8.5 million for future installations. The net cost is considerably lower at £3.3 million, following the deduction of the NPV of future income streams from the provision of services to the grid (£2.6 million) and system cost savings (£2.5 million) arising from system balancing services such as the displacement of peaking plant. The net future cost is £2.2 million lower than the costs of conventional reinforcement in this location.

FIGURE 9: CURRENT ESTIMATE ON CONVENTIONAL REINFORCEMENT COSTS VERSUS SMARTER NETWORK STORAGE (IF TECHNOLOGY IS PROVEN SUCCESSFUL)



Note: All values are based on Net Present values with a 10 year period and a 7.2% discount rate. Installed cost includes project Capex and Opex

Source: UKPN, Smarter Network Storage Low Carbon Network Fund Progress Report, December 2014

42 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/389832/Provisional_Results_Report-Ammendment.pdf

43 https://www.frontier-economics.com/documents/2015/01/lcp-frontier-economics-review-first-gb-capacity-auction.pdf

44 http://www2.nationalgrid.com/UK/Industry-information/Electricity-transmission-operational-data/Report-explorer/Services-Reports/

REDUCE NETWORK REINFORCEMENT COSTS

It is anticipated that the introduction of decentralised energy will fundamentally change the way the grid operates in the future. Closely matching storage to decentralised generation and demand in terms both of location and capacity could reduce peak power flows on networks creating additional capacity headroom.

The level of savings depends in part on the levels of consumer engagement achieved, which could be higher where customers are involved in supply and well as demand. UKPN, a DNO operating in the south and east of England, has identified £141 million [45] of savings from smart grid solutions over the course of the RIIO-ED1 in its business plan, including savings in network reinforcement totalling £35.1 million and £43.4 million through demand side response initiatives. However it is also noted that at very high levels of decentralisation, reinforcement costs may increase due to the variability of renewable energy.

REDUCE TRANSMISSION AND DISTRIBUTION NETWORK LOSSES

It is estimated by DECC that in 2014, transmission losses amounted to c.8 per cent of total electricity demand, with 23 per cent of this occurring in transmission networks and 7 per cent in distribution[46] networks.

The level of recorded losses in heat and energy in the UK has been largely unchanged for the last thirty years. There is considerable scope for transmission loss reductions by, simply, reducing the quantum of energy transferred through the transmission and distribution networks – this can be achieved by generating heat and electricity close to where it is used.

According to the IPCC, approximately two thirds of primary energy used to generate electricity around the world is lost as heat. The Association for Decentralised Energy (ADE) estimates that in the UK, as much as 54 per cent of the energy used to produce electricity is lost by the time it reaches consumers. CHP generation can significantly reduce waste of heat at the point of generation, as well as transmission. Modern CHP plants can achieve efficiency ratings of over 90 per cent, compared to c.48 per cent for a gas fired power plant. There is thus the potential to reduce consumer bills significantly through the incorporation of CHP generation into local networks, in particular when combined with district heating solutions. The ADE estimates that potential savings from the cost-effective introduction of CHP could save up to £2 billion per annum.

IMPACT ON WHOLESALE MARKET

The widespread deployment of zero-marginal cost renewables will also have the effect of lowering prices in the wholesale market – the so called 'merit order effect'. A high deployment of solar will provide substantial low marginal cost generation, which will produce lower clearing prices in the wholesale market[47]. As a result, wholesale prices will be shifted lower to the benefit of consumers.

Good Energy calculates that the impact of wind and solar generation on 2014 wholesale prices in the UK resulted in an overall savings of £1,550 million arising from the merit order effect (including solar 'savings' of £150 million)[48].

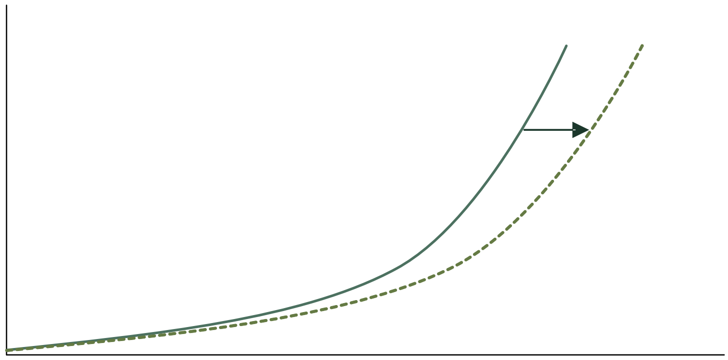
[45] UK Power Networks Business Plan (2015-2023) Annex 9 – Smart Grid Strategy (March 2014)

[46] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/447632/DUKES_2015_Chapter_5.pdf

[47] The merit order is the supply curve for the wholesale electricity market with the different generation units arranged in order of increasing marginal cost.

[48] Good Energy, Externalised Benefits of Solar and Wind: An Investigation into the Merit Order Effect, August 2015

FIGURE 10: ILLUSTRATION OF MERIT ORDER EFFECT



REDUCE SUPPLIER COSTS

Smart meters provide data to energy companies, which will reduce operating costs such as site visits for meter readings and the development of dynamic pricing structures that incentivise efficient demand side behaviours.

DECC in its 2011 study[49] has quantified potential cost savings arising from smart meters based on case studies and analysis of comparable international smart meter installations. DECC has estimated total benefits arising from smart meters in present value terms, assessed at a consumer, business and UK-wide level. Total benefits are expected to be circa £15.8 billion, total costs £10.8 billion, and net benefits of approximately £4 billion. Of the total benefits, £8.6 billion is expected to arise from reduced supplier costs through avoided site visits and reduced customer enquiries, switching and debt handling.

3.3 THE 'WHOLE HOUSE' SOLUTION – EMPOWERING THE CONSUMER

Deployed on its own, solar PV can usually only provide a minority of a household's power needs. Excess power production, for example on a summer's day, will be exported to the grid when it is produced, often at times when it is of limited value to the system as a whole.

By contrast, a 'whole house solution' or 'smart home', which links the output from solar PV to a hot water system, smart meter and other types of energy storage (either fixed battery unit or electric vehicle), can deliver self-consumption rates from 60 per cent up to 90 per cent. This 'whole house solution' also enables the consumer to export electricity when it is economically advantageous to do so, i.e. export when the system needs the exported electricity and prices are high or import electricity from the grid when the system has excess supply.

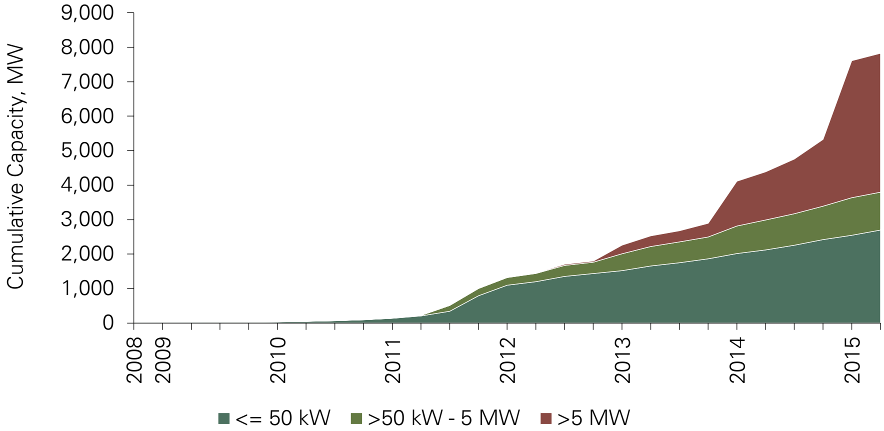
New apps are being developed to optimise energy management in this way automatically, without the individual consumer having to actively manage the system on a day-to-day basis. Moreover, apps can also control in-home heating allowing customers to vary their in-home settings remotely and minimise

3.4 THE BUSINESS CASE FOR DECENTRALISED ENERGY

For many C&I users in Great Britain, decentralised energy is already a reality. The deployment of rooftop solar has grown rapidly in the UK in recent years within the C&I sector (where typically small commercial sites generate >50 kW), as shown in the chart below.

[49] Smart meter rollout for the domestic sector (GB), DECC, 2011

FIGURE 11: UK CUMULATIVE INSTALLED SOLAR PV CAPACITY



Source: DECC, Solar photovoltaics deployment, September 2015

However, unlike residential consumers, the load for a C&I business often matches well the output from solar PV, as the majority of business activities typically take place during daylight hours. As a result, a C&I business has the potential to achieve a self-sufficiency percentage that is higher than a residential consumer, allowing de facto independence from the grid and fluctuations in price.

In addition to a close correlation between generation and consumption profiles, half-hourly metering is also already commonplace in the C&I sector, enabling businesses to take advantage of demand side response initiatives such load shifting, for example adjusting consumption to off-peak hours when prices are lower. Half-hourly tariff data allows dynamic pricing structures that reflect short term changes in market conditions and incentivised these adjustments. For larger players, interruptible supply contracts also offer the prospect of lower bills, where commercial terms are negotiated with the system operator to increase the flexibility of the system and the ease of balancing.

3.5 INTERNATIONAL DEVELOPMENTS

Recent international developments suggest that decentralised energy can be a reality in the UK as costs continue to fall around the world and deployment of increasingly advanced decentralised technologies continues. The following examples highlight the potential scale and affordability of decentralised energy:

- Solar PV is now at grid parity in approximately 30 countries and 14 US States, according to a recent Deutsche Bank study[50];
- In the US, President Obama has unveiled the Clean Power Plan[51] setting a 32 per cent decarbonisation target by 2030 from 2005 levels. A key part of his plan is the rapid build out of decentralised energy. Hillary Clinton has gone even further, committing (if elected) "more than half a billion solar panels installed across the country by the end of [her] first term"[52] and "expand the amount of installed solar capacity [in the US] to 140 gigawatts by the end of 2020, a 700% increase from current levels". This is expected to be achieved on the basis of lower costs, strong regulation and easier access to solar instead of direct support.
- In India, the Government of Narendra Modi has announced plans to increase the deployment of solar from a capacity of c.4GW to 100GW by 2022. This includes a

[50] Deutsche Bank, Crossing the Chasm, February 2015, https://www.db.com/cr/en/docs/solar_report_full_length.pdf. Out of a sample of 60 countries analysed. 14 additional states in the US are poised to reach grid parity.

[51] Official White House website, August 2015, https://www.whitehouse.gov/climate-change#section-clean-power-plan

[52] Hillary Clinton, Stand for Reality speech, 26 July 2015

major expansion of rooftop solar in cities, public buildings, airports, and railway stations.

- In Europe, Germany currently leads the world in cumulative solar PV installations with approximately 21 per cent of capacity or 38GW[53]. Cost have decreased from approximately €5,000 per kW in 2006 to €1,300 per kW in 2014. The German Government is targeting 40 per cent of power generation to be from renewables by 2020, with continued significant growth in decentralised energy. In 2013, more than half of the investments in renewables were made by small investors[54].
- Australia is also increasing its investment in renewable energy and solar power. Currently, c.13 per cent of Australia's generation is from renewables, with a target of 23.5 per cent (33TWh) by 2020[55]. With strong solar resources, cumulative installed capacity for solar PV has increased from 137MW to 4.5GW. Similarly average system costs for solar PV have declined from an approximate of AUD 8,000 per kW in 2010 to AUD 2,200 per kW in 2014[56].

[53] Fraunhofer ISE, Photovoltaics Report, August 2015, https://www.ise.fraunhofer.de/en/downloads-englisch/pdf-files-englisch/photovoltaics-report-slides.pdf

[54] Heinrich Böll Foundation, The German Energiewende, July 2015

[55] http://www.environment.gov.au/climate-change/renewable-energy-target-scheme

[56] Australian PV Institute, http://pv-map.apvi.org.au/analyses

4 TECHNOLOGY BREAKTHROUGHS AND COST REDUCTION

As new technologies have emerged and the cost of existing technologies has fallen, the economics of decentralised energy have improved and the model has become more attractive.

There have been significant developments in solar PV, electricity storage, demand-side response and smart technology over the last few years. Solar PV has experienced unprecedented capital cost reductions, new battery products are opening up the electricity storage market and the roll-out of smart meters and other enabling technologies are changing the way the market views DSR solutions.

This section outlines the key technological breakthroughs and cost trends observable in the market and comments on how these different technologies are starting to be brought together in a transition to a subsidy-free decentralised power system.

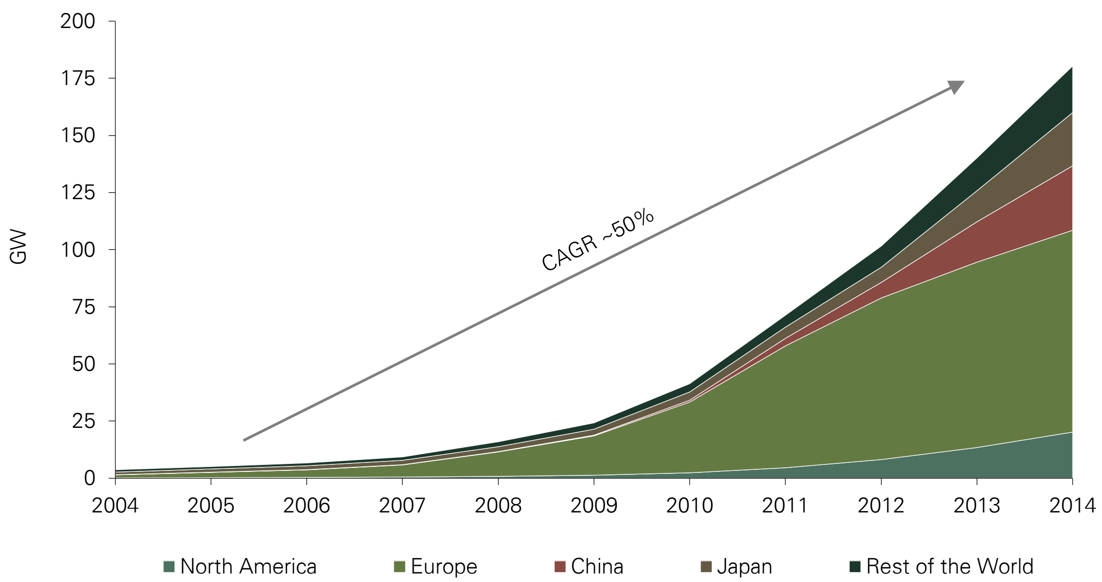
4.1 SOLAR PHOTOVOLTAICS

4.1.1 HISTORICAL DEPLOYMENT AND INSTALLATION COSTS

The deployment of solar photovoltaics generation has increased rapidly since the emergence of the technology. Globally, cumulative installed capacity increased from around 4GW to over 180GW of solar PV installations over the last decade. Germany has had the largest increase, with approximately 21 per cent of total deployment, followed by China and Japan with 16 per cent and 13 per cent respectively.

Figure 12 shows a cumulative annual growth rate (CAGR) of c.50 per cent in global solar PV capacity over the past 10 years.

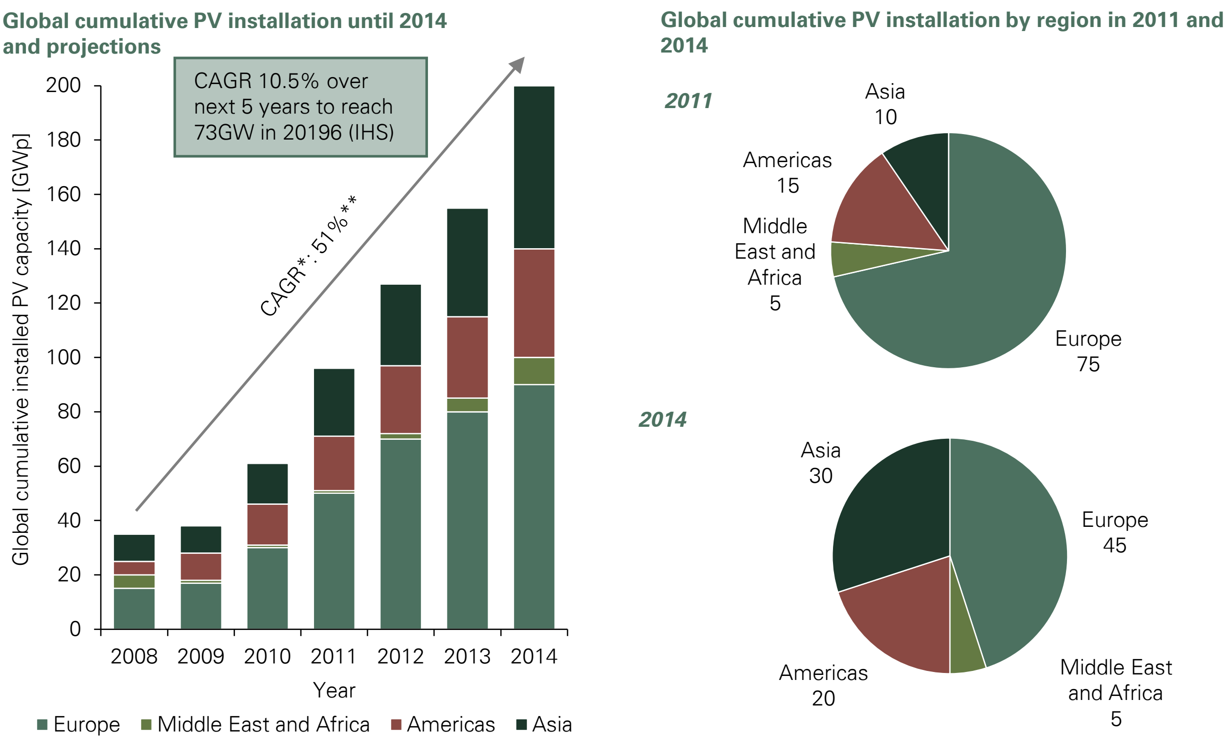
FIGURE 12: GLOBAL CUMULATIVE INSTALLED SOLAR PV CAPACITY



Source: BP Statistical Review of World Energy, June 2015

Figure 13 below shows data from IHS, which shows a very similar CAGR, but also highlights the particularly rapid growth in Asia and the Americas in recent years.

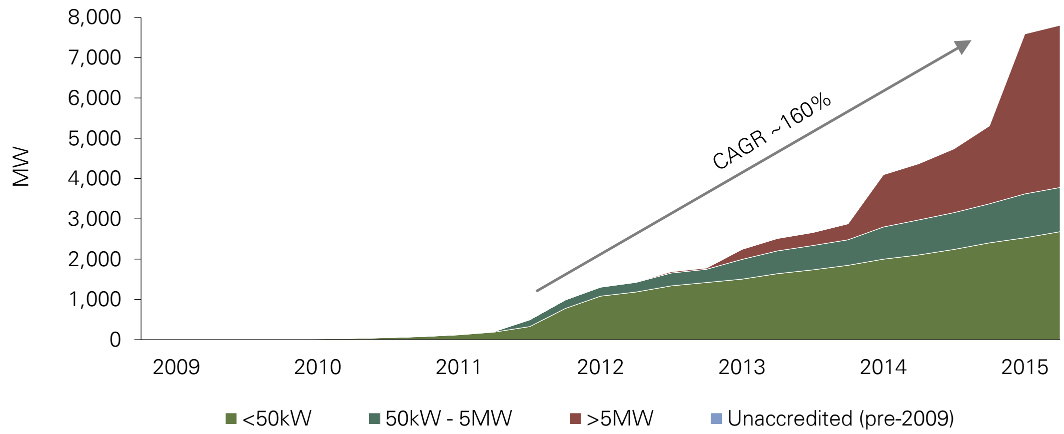
FIGURE 13: IHS SOLAR PV COST ESTIMATES



Source: IHS. Graph: PSE AG 2015. Photovoltaics Report, updated August 2015 (Fraunhofer, ISE). IHS from PV Tech March 2015

The UK has also seen significant deployment over this time period. Installed capacity has increased from virtually 0GW in 2010 to 8GW in Q2 2015 according to DECC[57] as shown in the chart below. The UK also led Europe with the highest increase of solar PV installations in 2014 with almost a 2.5GW increase.

FIGURE 14: UK SOLAR PV DEPLOYMENT



Source: DECC, Solar photovoltaics deployment – quarterly data, August 2015

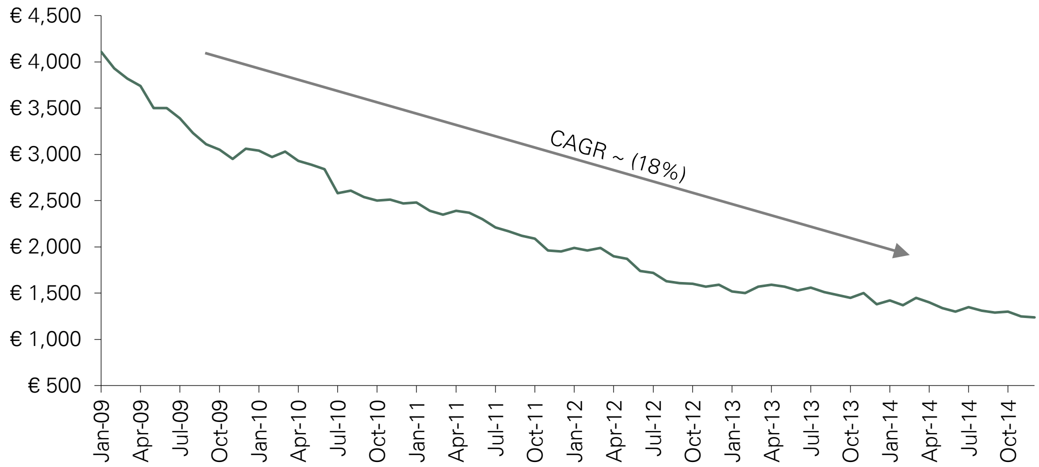
Underpinning high deployment rates is the significant fall in costs across solar PV technologies. For <4 kW installations, installation costs in 2010 were approximately

[57] DECC, Solar photovoltaics deployment, August 2015, https://www.gov.uk/government/statistics/solar-photovoltaics-deployment

£5,000 per kW and are currently at a median figure of £1,834 per kW[58] in the UK. Parsons Brinckerhoff's cost assumptions for new build[59] is even lower at £1,688 per kW for <4 kW installations and £1,021 per kW for installations over 250 kW.

In Germany costs have declined rapidly too. The cost for a 100kW installation has decreased from approximately €4,110 per kW in 2009 to €1,240 per kW in 2014[60]. The Solar Trade Association (STA) expects solar PV costs to be cheaper than wholesale energy as early as 2025.

FIGURE 15: DECLINING COSTS OF A 100KW SOLAR PV INSTALLATION IN GERMANY



Source: Photovoltaik Guide, Photovoltaic Price Index for a 100kW PV installation, http://www.photovoltaik-guide.de/pv-preisindex

4.1.2 COST AND DEPLOYMENT PROJECTIONS

Several analysts predict that solar PV will reach 'grid parity' in Great Britain in the short – to medium-term, i.e. that the cost of solar PV generation will fall below the market cost of energy.

Deutsche Bank estimates that approximately 30 countries and 14 US states are currently at grid parity for domestic consumers[61]. They attribute the progress towards grid parity to 'declining solar panel costs as well as improving financing and customer acquisition costs'.

In July 2015, Renewable Energy Association and KPMG[62] estimated that the levelised cost of electricity for Solar PV had fallen to between £77 and £91 per MWh for ground mounted installations, £117 and £143 per MWh for commercial rooftops and £166 and £190 per MWh for domestic rooftops.

[58] DECC, Solar PV Cost Data, May 2015, https://www.gov.uk/government/statistics/solar-pv-cost-data

[59] Parsons Brinckerhoff, Small-Scale Generation Cost Update, August 2015, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/456187/DECC_Small-Scale_Generation_Costs_Update_FINAL.PDF

[60] Photovoltaik Guide, http://www.photovoltaik-guide.de/pv-preisindex

[61] Deutsche Bank, Crossing the Chasm, February 2015, https://www.db.com/cr/en/docs/solar_report_full_length.pdf

[62] REA and KPMG UK, UK solar beyond subsidy: the transition, July 2015, http://www.r-e-a.net/news/new-rea-kpmg-report-solar-aims-to-be-first-renewable-to-be-free-of-subsidy

FIGURE 16: ESTIMATED PV LCOE IN THE UK BY MARKET SEGMENT

ESTIMATED SOLAR PV LCOE

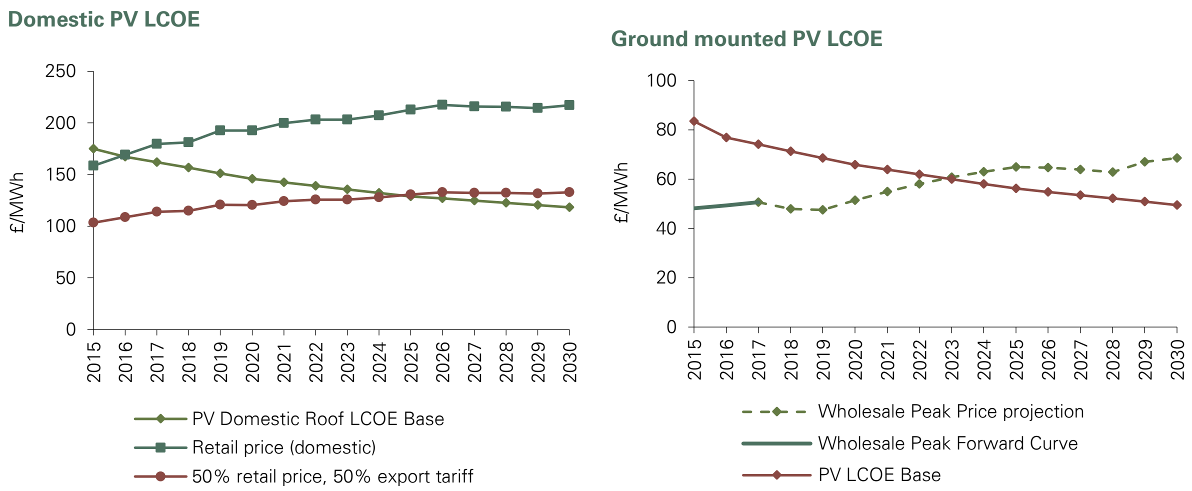
	HIGH	BASE	BEST
£/MWh, 2015 prices			
Ground mounted	91	84	77
Commercial rooftops	143	133	117
Domestic rooftops	190	175	166

Note: All figures do not include grid connection costs where applicable

Source: Renewable Energy Association, KPMG analysis, 'UK solar beyond subsidy: the transition', July 2015

REA and KPMG projections suggest grid parity may be reached in the UK within the next few years, depending on movements in wholesale prices, as well as "specific circumstances for an individual investor", including "site-specific costs, investor desired returns, levels of on-site consumption of the electricity produced and effective electricity tariff". The charts below show the projected solar PV cost reductions for domestic rooftop and ground-mounted installations in comparison to projected retail and wholesale electricity prices.

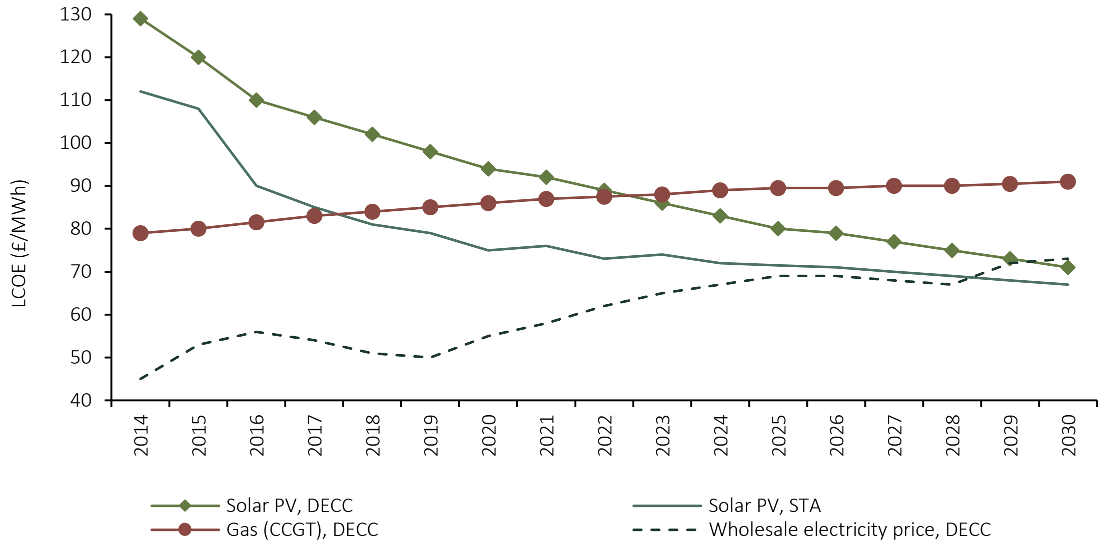
FIGURE17: SOLAR PV LCOE VERSUS ELECTRICITY TARIFF COMPARATORS



Source: Renewable Energy Association, KPMG analysis, 'UK solar beyond subsidy: the transition', July 2015

There is a broad consensus in the market that the levelised cost of solar PV electricity will to continue to fall, although expectation around the rate of the decline in costs vary. The STA has compared the estimated cost of solar PV with that of CCGT, currently the cheapest approach to expanding grid capacity. Figure 18 below shows STA and DECC forecasts of solar PV costs against the wholesale price projections.

FIGURE 18: STA SOLAR PV LCOE PROJECTIONS

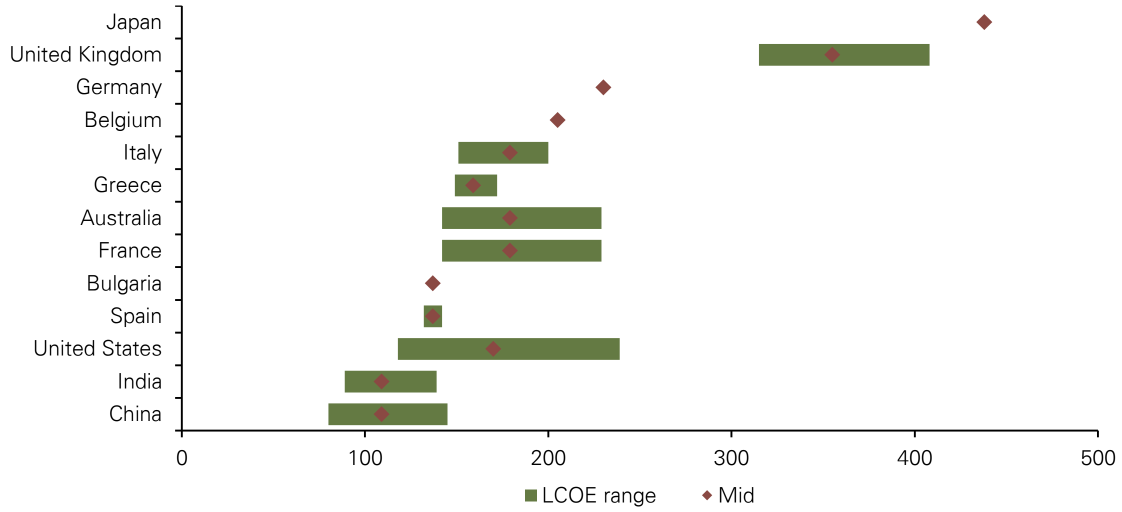


Source: STA and DECC, Projected LCOE for large-scale solar PV and CCGT in 2014 prices

The STA expects the costs of solar PV to be lower than the levelised costs of CCGT five years ahead of DECC projections, decreasing by 33 per cent by 2020, and to be only marginally higher than the wholesale electricity price from 2025 at c.£70 per MWh, c.£20 per MWh lower than the expected (levelised) cost of gas.

Bloomberg New Energy Finance notes that 2015 has 'brought a significant shift in the generating cost comparison between renewable energy and fossil fuels'[63], and the UK's positioning compared to Germany, Belgium and France (shown in Figure 19 below) confirms that there is considerable scope for costs to continue to fall in the UK over the next few years in line with the falling cost of solar modules.

FIGURE 19: LEVELISED COST OF SOLAR ELECTRICITY BY REGION (USD/MWH)



Source: World Energy Council, "World Energy Perspective"

[63] http://about.bnef.com/press-releases/wind-solar-boost-cost-competitiveness-versus-fossil-fuels/

4.1.3 'WHOLE SYSTEM' COST OF DISTRIBUTED GENERATION

It can be argued that distributed generation technologies, such as rooftop solar PV and other small-scale renewables, increase overall network and system balancing costs due to the time and variability of power output.

While solar panels can function even when the sun is not shining, the sun only shines for an average of 34 per cent of daylight hours in the UK and, in the winter, solar intensity can drop to less than 20 per cent. Additionally, although solar can be more predictable than other renewables, such as wind, it experiences strong fluctuations over the course of a day and maximum output (around midday) does not coincide with peak system demand, which as generally in the morning and evening.

Some have argued for solar to pay higher grid and system balancing costs to reflect this variability, and to reflect the fact that most solar PV installation owners rely on electricity from the grid when the sun is not shining. DECC has commissioned a study from Frontier Economics to understand these whole system costs further.

Many market analysts argue that the variability, timing and balancing issues of distributed generation can be mitigated by the introduction of electricity storage. The next section therefore focuses on recent developments in electricity storage technologies such as batteries.

4.2 ENERGY STORAGE

Energy storage is widely regarded as a potentially game-changing technology for meeting electricity sector challenges. Many believe it has the potential to provide the 'missing link' between renewable generation and the need for flexible, balanced electricity supply.

Although some regard storage technologies as more of a long-term solution, not yet commercially viable, falling costs and improvements in scalability have meant that high-volume storage may be commercially viable much sooner than previously anticipated. Deutsche Bank believes "the industry will begin deploying on a large scale within the next c.5 years of less", and that commercial scale battery deployment is "already occurring today in several countries"[64]. Citigroup estimates that there will be up to 240GW of energy storage in the global market by 2030[65].

4.2.1 ELECTRICITY STORAGE TECHNOLOGIES

Various electricity storage technologies exist at different stages of maturity. The table below[66] sets out different technology types by maturity and estimated cost. The most mature large-scale storage technology is arguable pumped hydro, however Deutsche Bank notes the limitations of this technology due to the geographical requirements.

[64] Deutsche Bank, Crossing the Chasm, February 2015, https://www.db.com/cr/en/docs/solar_report_full_length.pdf

[65] Citigroup, Dealing with Divergence, January 2015, https://ir.citi.com/20AykGw9ptuHn0MbsxZVgmFyyppuQUUt3HVhTrcjz4ibR%2Bx79LajBxIyoHIoSDJ3S%2BWRSMg8WOc%3D

[66] Deutsche Bank, Crossing the Chasm, February 2015, https://www.db.com/cr/en/docs/solar_report_full_length.pdf

FIGURE 20: ELECTRICITY STORAGE TECHNOLOGIES

TECHNOLOGY	MATURITY	COST ($KW)	COST ($KWH)	EFFICIENCY	CYCLE LIMITED	RESPONSE TIME
Pumped Hydro	Mature	1,500-2,700	138-338	80-82%	No	Seconds to Minutes
Compressed Air (underground)	Demo to Mature	960-1,250	60-150	60-70%	No	Seconds to Minutes
Compressed Air (aboveground)	Demo to Deploy	1,950-2,150	390-430	60-70%	No	Seconds to Minutes
Lead Acid Batteries	Demo to Mature	950-5,800	350-3,800	75-90%	2,200->100,000	Milliseconds
Lithium-Ion	Demo to Mature	1,085-4,100	900-6,200	87-94%	4,500->100,000	Milliseconds
Flow Batteries (Vanadium Redox)	Develop to Demo	3,000-3,700	620-830	65-75%	>10,000	Milliseconds
Flow Batteries (Zinc Bromide)	Demo to Deploy	1,450-2,420	290-1,350	60-65%	>10,000	Milliseconds
Sodium Sulfur	Demo to Deploy	3,100-4,000	445-555	75%	4,500	Milliseconds
Power to Gas	Demo	1,370-2,740	NA	30-45%	No	10 Minutes
Capacitors	Develop to Demo			90-94%	No	Milliseconds
SMES	Develop to Demo			95%	No	Instantaneous
Flywheels	Demo to Mature	950-5,800	350-3,800	75-90%	2,200->100,000	Milliseconds

Source: Deutsche Bank, https://www.db.com/cr/en/docs/solar_report_full_length.pdf

Currently, there is no one storage technology able to meet all the desired applications as set out above. Energy storage technologies can be roughly categorised into the following:

- **Battery storage:** Battery storage can be divided into two categories; solid-state and flow batteries:
  - Solid-state batteries include a range of electrochemical storage solutions including Lithium-ion and Sodium-Sulphur technologies. Although Sodium-Sulphur technology is currently cheaper and more widely used (especially in Japan) than Lithium-ion, it carries more risk due to higher operating temperatures and its corrosive nature. Furthermore, developments in Lithium-ion based storage have advanced significantly in recent years increasing its competitiveness for widespread scalable usage.
  - Flow batteries store energy directly in an electrolyte solution by ionising its chemical components such as vanadium. Costs have been falling at a similar rate to solid-state batteries. For example, the cost of Imergy Power's vanadium-based flow battery is set to decrease from $500 per kWh to $300 per kWh[67].

[67] Imergy Power Systems, http://www.imergy.com/why-imergy

- **Pumped-storage hydroelectricity:** This works by using large-scale reservoirs to store energy utilising excess electricity to pump water from a lower source into a higher reservoir. This is eventually used to generate electricity when needed. Pumped-storage hydro is currently commercialised, forming over 99 per cent of energy storage capacity globally. There are currently four units in Great Britain with nearly 3GW of capacity.
- **Thermal storage:** Thermal storage technology captures heat to create energy on demand. This is predominantly used for storing heat throughout the year using underground tanks or caverns for district heating. Isentropic is currently developing an electricity storage system using heat to compress argon.
- **Compressed air energy storage (CAES):** CAES systems work by compressing air to create a potent energy reserve. Although still a relatively infant technology, Highview Power is expected to commission a 5MW/15MWh liquid air energy storage plant in 2015 with DECC funding support. Furthermore, Storelectric Ltd is planning to build a 40MW/800MWh power plant in the UK for rollout in 2020.
- **Flywheels:** Flywheels are mechanical devices that harness rotational energy to deliver instantaneous electricity. They work by accelerating a rotor to a very high speed and maintaining the energy in the system as rotational energy. Currently, there is a 20MW/5MWh flywheel storage plant in New York for grid storage owned by Beacon Power. Flywheel storage systems are also being developed to complement wind turbines during periods of high wind speeds.

Of these various technologies, many industry players view new batteries as having significant potential to contribute to the development of electricity storage markets. In its recent report on making the electricity system more flexible, Ofgem wrote that "while storage has been providing flexibility in other countries, and pumped storage has historically played a strong role in Great Britain, the potential of battery and other forms of storage to smooth variable generation or contribute to local balancing has not yet been fully realised in the UK"[68].

This report will focus predominantly on battery storage due to its relative advantages in cost and extensive applications in decentralised energy such as scalability and flexible response over other types of storage.

4.2.2 DEVELOPMENTS IN BATTERY STORAGE COSTS

Similar to solar PV technology, battery storage technology was not developed sufficiently back in 2010 to be a commercially viable option. However with recent global advancements in technology, as evident in the electric vehicle market, prices have decreased significantly in addition to improvements in scalability. A greater volume in market activity has also contributed to the fall in battery prices.

As battery storage progresses towards extensive commercialisation across the global industry, various companies over the past year have been aggressively competing to market their product. The table below consolidate some of these companies with their projected prices on their battery storage products.

[68] https://www.ofgem.gov.uk/sites/default/files/docs/2015/09/flexibility_position_paper_final_0.pdf

FIGURE 21: FALLING BATTERY PRICES IN THE GLOBAL MARKET

ENERGY STORAGE COSTS

	TECHNOLOGY	CURRENT	FORECAST (WITHIN FIVE YEARS)
USD/kWh			
Aquion Energy	Sodium-ion	$500	$250
Eos Energy Storage	Zinc Air		$160
Primus Power	Flow – Zinc Halogen	$500	
EnerVault	Flow – Iron Chromium		$250
Imergy Power	Flow – Vanadium	$500	$300
Redflow (Australia)	Flow – Zinc Bromide	$875	$525
Enstorage (Israel)	Flow	$738	$307

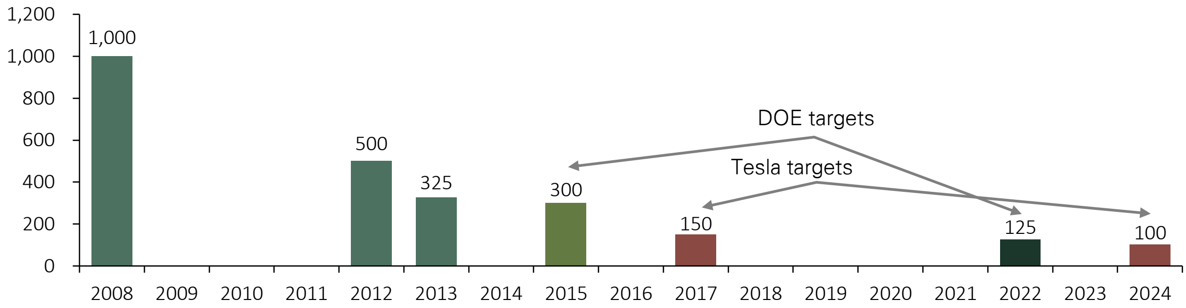
Note: Selected companies shown. Deutsche Bank sources were also obtained from GTM and Energystorage.org
Source: Deutsche Bank, Crossing the Chasm, February 2015

In April 2015, Tesla announced that it will be the first company to sell a domestic energy storage unit known as the Powerwall at a price competitive rate for delivery in late 2015[69]. At US$3,000 for a 7kWh model and an efficiency of greater than 92 per cent, Tesla's entry into the market suggests that energy storage may be able to penetrate the market in the near term. Tesla is also due to release its utility-scale product, the Powerpack at approximately US$250 per kWh[70]. With heavy competition in the horizon following Tesla's entry, it can be expected that costs will continue falling in parallel to technological progression.

Figure 22, below, sets out the expected cost trajectory for batteries arising from increased deployment and technological developments, based on data from Bloomberg New Energy Finance, Navigant and the US Energy Information Administration. On average, battery costs are forecast to fall from c.$700 per kWh in 2013 to c.$200 per kWh in 2033, a reduction of 71 per cent.

The US Department of Energy expects the historic trend of falling battery costs to continue, with a 58 per cent reduction from 2015 prices by 2022. Tesla's estimates for battery costs are expected to fall by at least 30 per cent in 2017 following the opening of their Gigafactory.

FIGURE 22: HISTORIC BATTERY PRICES IN THE US (DOE/TESLA TARGETS)



Source: Deutsche Bank, https://www.db.com/cr/en/docs/solar_report_full_length.pdf
Note: Only includes battery costs. Does not include inverter and installation costs

[69] Tesla Energy, Press release on Tesla Powerwall, http://www.teslamotors.com/en_EU/presskit

[70] Forbes, Why Tesla Batteries are cheap enough to prevent new power plants, http://www.forbes.com/sites/jeffmcmahon/2015/05/05/why-tesla-batteries-are-cheap-enough-to-prevent-new-power-plants/

Installing battery storage also requires an inverter to convert direct current from the solar PV unit and battery to alternating current. While this adds to the Capex cost for installations, prices for inverters have also been falling substantially. At an average price of $0.48 per Watt in 2010, average inverter costs are expected to fall to $0.13 per Watt by 2020 according to GlobalData[71]. IHS is even more optimistic on inverter cost reductions, expecting falls of 9 per cent per annum to $0.11 per Watt in 2018 due to high deployment in Asia[72].

UK DISTRIBUTION GRID DEMONSTRATION PROJECTS

In the UK, there are currently several demonstration electricity storage projects at the distribution grid level supported financially by Ofgem's Low Carbon Network Fund[73]. This includes UKPN's 6MW/10MWh storage project in Leighton Buzzard, NPG's 2.5MW/5MWh storage project in Darlington and SSE's 2MW/0.5MWh storage project in Orkney, among others.

CASE STUDY: SMARTER NETWORK STORAGE (UK POWER NETWORKS):

UK Power Networks and a number of industry partners have invested in a demonstration energy storage facility in Leighton Buzzard, attached to the 11kV distribution network. The storage device has a maximum power capability of 6MW and an energy charge (or discharge) capacity of 10MWh. The aim of the trial project is to improve the understanding of the economics of electricity storage and acquire data on cost effectiveness. The project is also trialling how energy storage could be used as 'an alternative to conventional network reinforcement'.

The benefits of the project described by UKPN and partners include:

- Managing peak demand, reducing losses and improving asset utilisation;
- Cost-effective balancing support to the wider electricity system by (1) supporting residual balancing through fast response and STOR and (2) mitigating suppliers' cash-out risk on imbalances
- Frequency response to accommodate high variability and mitigate reduced system inertia;
- Saving in carbon emissions from displaced generation;
- Validation of business models and economics of storage and full system value;
- Building experience and encouraging adoption on a wider-scale;
- Supporting the development of commercial environment for industry participation in storage; and
- Identification of key market, commercial and regulatory barriers to deployment of storage.

To date, the Smarter Network Storage project has met with delays predominantly arising from minor design anomalies, and a number of the learnings from the project thus far are highly technical.

Key learnings to date include the identification of potential whole-system services grid-scale storage can provide and establishing the regulatory and market barriers that need to be addressed to enable grid scale storage to deliver its full potential[74].

The period of operation has been too limited to update the long term business case, however no material changes to the benefits set out above are expected.

[71] GlobalData, Solar PV Inverter Market, Update 2015: Segmentation, Market Size, Competitive Landscape, and Analysis to 2020, March 2015

[72] IHS, Presentation at the SNEC 9th (2015) International Photovoltaic Power Generation Conference & Exhibition, April 2015

[73] Ofgem, Low Carbon Network Fund, May 2015, https://www.ofgem.gov.uk/publications-and-updates/first-tier-low-carbon-network-fund-registration-log

[74] http://innovation.ukpowernetworks.co.uk/innovation/en/Projects/tier-2-projects/Smarter-Network-Storage-(SNS)/Project-Documents/Smarter-Network-Storage-LCNF-Interim-Report-Regulatory-Legal-Framework.pdf)

As the largest operational grid storage project in the UK, UKPN has published progress reports on its 6MW storage facility[75]. While grid storage in this project is still unable to pay for itself with a 'future net method cost' at £3.3 million, it is expected to provide positive value by removing the need to spend £5.1 million on conventional reinforcement. Project costs have also fallen since UKPN's first business case in 2012 from £18.7 million to £16.8 million and future net method cost has decreased from £4.0 million to £3.3 million. UKPN notes in the progress reports that there is still further scope for optimisation to maximise the benefits of storage.

UK COMMERCIAL APPLICATIONS

In concurrence with the global market, several companies are mobilising to enter the UK battery storage market over the next year. Examples of new entrants include:

- Tesla's Powerwall and utility-scale Powerpack product for entry in the UK in 2016 as described above.
- Powervault, a London start-up, is looking to enter the domestic market[76] with its 2kWh and 4kWh systems at £2,000 and £2,800 respectively. They expect costs to fall to lower than £1,000 in five years and aim to sell 50,000 units by 2020.
- Good Energy hopes to have a storage proposition available in 2016[77] and is currently piloting small-scale storage with Moixa's Maslow battery. The Maslow battery has an added feature in that it can be aggregated independently on location and hence can be 'shared' by the distribution networks. This creates a second income stream for consumers.

4.2.3 ENERGY STORAGE AND DECENTRALISATION

Towards a decentralised energy scenario, energy storage serves as the 'missing link' that is required to optimise the market against the energy trilemma. Energy storage can be used to separate generation from immediate consumption and hence is able 'generate' electricity at times when demand exceeds supply. Furthermore, energy storage can be coupled with renewable technology to address variability issues. This would enable more renewable technology to be installed and further decarbonisation goals. On the grid level, storage is able to provide effective frequency response to meet the imbalances in supply and demand. Lastly, storage can be used to close price arbitrage and stabilise the wholesale market at a lower cost to consumers.

With global efforts to develop a cost-effective and scalable storage technology, the UK Government should ensure that the policy environment in the UK is conducive for an effective uptake of storage. One option for achieving this is to implement a time-limited scheme for the deployment of battery technologies linked to solar PV installation, along the lines of the scheme recently used in Germany, where batteries linked to solar received a 30 per cent rebate. In principle, this would also be similar to the Government scheme currently running in the UK for the deployment of electric vehicles.

There are other options for financing the deployment of battery storage, such as tax relief and loan arrangements or other financing schemes. However, the simplicity of a grant scheme has been shown to be successful in other countries and with other technologies like electric vehicles and the previous DECC 'boiler replacement' scheme.

Storage technology can also be complemented with demand-side management to form a strong consumer-driven proposition in the future of the energy industry.

[75] UKPN, Smarter Network Storage, http://innovation.ukpowernetworks.co.uk/innovation/en/Projects/tier-2-projects/Smarter-Network-Storage-(SNS)/

[76] Powervault, press release, June 2016, http://www.powervault.co.uk/wp-content/uploads/2014/09/PowerVault-release-FINAL-23-6-15.pdf

[77] Utility Week, Good Energy to launch storage offer by April 2016, August 2015, http://utilityweek.co.uk/news/good-energy-to-launch-storage-offer-by-april-2016/1157402#.Vd3L9vlViUI

4.3 DEMAND-SIDE MANAGEMENT

Demand-side management covers a broad range of mechanisms and capabilities to manage consumer demand for energy, and is a key part of an integrated, whole house solution. Underpinned by increasing consumer awareness and engagement, demand-side response has developed into a powerful proposition to manage demand in energy systems. This has been enabled by concerted efforts from the Government and industry to deploy smart technology.

4.3.1 DEMAND-SIDE RESPONSE

As mentioned above, DSR is one of the key demand side measures to help balance the whole network and increase network efficiency. DSR does not intend to reduce overall demand but to manage peak loads in the system by aggregating and shifting demand.

As variable generation increases together with spot price variability, DSR capabilities will become more attractive[78].

DSR schemes can either be explicit or implicit. Explicit DSR schemes are incentive-based where consumers receive direct payments for automatic changes in consumption volume triggered by certain circumstances. Explicit DSR measures include direct load control (DLC), interruptible load programs, ancillary services, capacity market programmes and emergency DR programmes and often involve an independent commercial aggregator. Implicit DSR schemes are price-based schemes where consumers choose to 'manually' shift their consumption to off-peak periods characterized by lower prices. The change in consumption is triggered by actual price differentials and not automated but decided upon more on a case-by-case basis. The main difference between explicit and implicit DSR schemes is that the former benefits consumers in the form of additional and direct source of revenue requiring a commitment from customers, and the latter benefits consumers through reduced electricity bills without the requirement of any continuous commitment.

There are a number of schemes available which DSR measures can play into, including balancing market services and the Capacity Market (set out in the table below). However, these are not always designed in a way that incentivises the aggregation of DSR from residential and C&I properties with solar and storage.

[78] The Low Carbon London dynamic ToU trial demonstrates the effectiveness of DSR by utilising ToUTs. https://www.ofgem.gov.uk/ofgem-publications/90886/2.lclinfluencingcustomerprofilesandnewinteractions.pdf

FIGURE 23: SCHEMES ALLOWING DSR PARTICIPATION

TYPE	DESCRIPTION
STOR/STOR Runway	NG Balancing Service to increase generation or reduce demand with-in 20 to 240 minutes (depending on the type of contract).
Fast Reserve	NG Balancing Service to procure active power where delivery must start within 2 minutes of the dispatch instruction.
Fast Frequency Response	NG Balancing Service to procure generation increase or demand reduction response with-in 30 seconds. Fast Frequency Response is for arresting a rapid frequency decline (e.g. due to loss of infeed) as opposed to dynamic frequency response which is used to minimise variations in steady state frequency.
Capacity Market	Market wide mechanism for demand reduction within four hours of instruction.
Triad Avoidance	Reduction in demand during TRIAD periods, the three highest system peak demands in any year. Demand reduction at those times is strongly incentivized.
DUoS Charge Avoidance	Reduction in demand at peak time to avoid peak distribution charges for larger 'maximum demand' metered consumers.
DSR by DNOs	This avoids network reinforcement (currently at trial stage).
Demand Turn Up	NG Balancing Services to increase demand during low periods of high generation and low demand (at development stage) – e.g. during periods of summer minimum demand when solar PV output is high.
Imbalance Charge Optimization	Reduction in the exposure to imbalance charges.
Wholesale price optimization	Reduction in the wholesale costs faced by the customers.

4.3.2 SMART GRIDS, SMART METERS AND SMART APPLIANCES

SMART GRIDS

Smart grids are modernised electricity networks that intelligently integrate generation, transmission and distribution assets and facilitate efficient interaction between the grid and customers. Increasingly smart grids will allow a cost effective transition to renewables-dominated generation through active management of supply and demand on a real-time basis.

The development of smart grids will require changes to traditional generation, transmission and distribution roles and responsibilities alongside technological modernisation. Over time, distribution network operators in the UK will need to become more involved in system operations, including system balancing and design.

FIGURE 24: EXECUTIVE SUMMARY OF SMART SAVINGS IN OUR UK POWER NETWORKS' BUSINESS PLAN

SMART GRID SOLUTION (£ millions)	EPN	LPN	SPN	ALL DNOS	RUNNING TOTAL
Benefit from existing Smart Grid network designs and practices	£5	£20	£5	£30	£30
Savings in LV reinforcement compared to forecast volumes	£11.8	£9.9	£13.4	£35.1	£65.1
Saving from Demand Side Response schemes	£11.8	£13.9	£17.7	£43.4	£108.5
Savings in overhead line reinforcements	£8.6	-	-	£8.6	£117.1
Savings from Dynamic Transformer ratings	£7.7	£3.1	£4.2	£15.0	£132.1
Savings from Partial Discharge monitoring of switchgear	£1.9	£2.5	£4.6	£9.0	£141.1
Sum of savings	£46.8	£49.4	£44.9	£141.1	£141.1

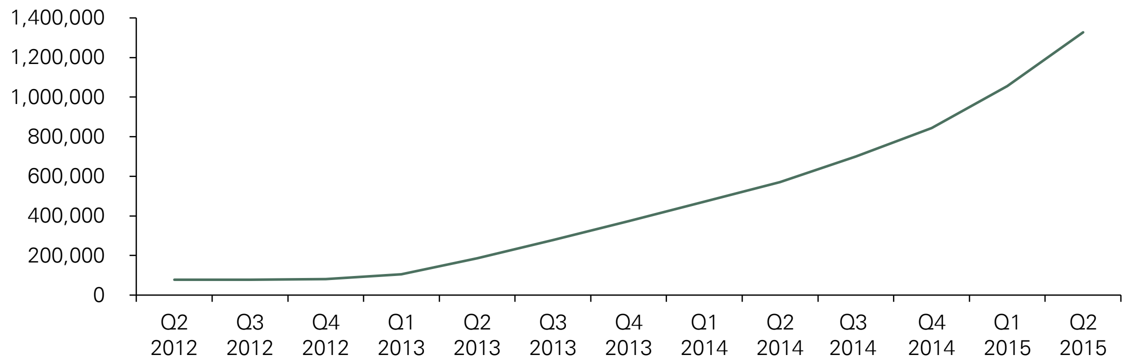
Source: UK Power Networks, Business Plan (2015 to 2023), Annex 9: Smart Grid Strategy

SMART METERS

DECC has mandated the rollout of 53 million (including electricity and gas) smart meters by 2020, which will be implemented by energy suppliers.

So far, approximately two million residential and C&I smart meters have been installed up to 30 June 2015, c.3.2 per cent of the total rollout. A recent survey by independent polling company Populus has found that 84 per cent of consumers whose smart meter has already been installed would recommend them to others. 79 per cent of those questioned have sought to reduce electricity use, for example through turning off lights or reducing heating.

FIGURE 25: NUMBER OF SMART METERS INSTALLED BY LARGER ENERGY SUPPLIERS (GAS AND ELECTRICITY) IN DOMESTIC PROPERTIES



Source: DECC, Smart meter statistics, September 2015.

In theory, the current smart meters in deployment allow ToUT for domestic consumers. However this has only been proven in small scale trials and have yet to be achieved in the large scale. Whilst smart meters are necessary for ToUT, such tariffs will be effective only if settlement for profile class 1-4 consumers (i.e. those who will receive smart meters) is changed from the current 'profiling' mechanism to one based on actual household consumption. The potential benefit is evidenced by larger C&I consumers who already have half-hourly metering and are more familiar with ToUTs and maximum demand based DUoS charging.

SMART APPLIANCES

Smart household appliances do not require high levels of customer engagement to realise value. Smart appliances can be connected to smart meter home area network (HAN) enabled switches or energy management systems to automate the movement of electricity demand to lower price periods (such as off-peak times or when low marginal cost generation is plentiful and demand is light) thereby maximising the efficient use of baseload or zero carbon generation capacity and reducing cost.

For example, a refrigerator could be cheaply fitted with a 'smart' frequency transponder to provide dynamic frequency response. This could help maintain a frequency of 50Hz as well as to reduce any imbalances. The transponder could also allow a fast frequency response in the event of a major loss of infeed.

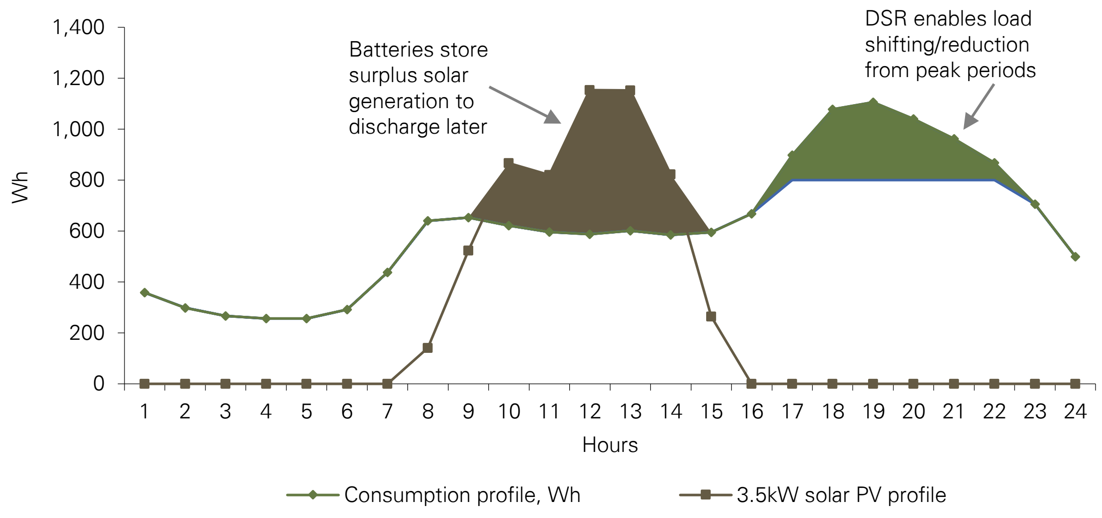
By taking advantage of ToUT, smart appliances could not only reduce consumer bills but also be aggregated to form a stronger DSR proposition. Early trials have pointed to the effectiveness of DSR by utilising ToUTs. For example, the Low Carbon London trials exhibit an average household benefit of £21[79].

At present, progress on smart appliance roll out has been relatively low in the UK. It is hard to estimate the timetable for the rollout of smart appliances across a significant proportion of the UK customer base. 'Smart' features are expected to become mainstream in appliances in the short-medium term, however many traditional appliances will only be replaced with smart appliances when they reach the ends of their useful lives.

4.4 MAKING THE TRANSITION TO SUBSIDY-FREE DECENTRALISED ENERGY

The global advancements in technology as evidenced above allow a more co-ordinated transition towards subsidy-free decentralised energy. As shown in the figure below, a strong solar-storage proposition complemented by DSR can deal with a significant part of *intra-day* demand management. The figure below weighs a typical domestic consumer profile with a typical 3.5kW solar PV fitting. Implementing storage battery would also enable the consumer to procure a larger solar PV panel.

FIGURE 26: CONSUMPTION VERSUS SOLAR PV PROFILE



Source: Lightsource data

[79] UKPN, Low Carbon London DSR trials

This improved intra-day management can complement the additional seasonal flexibility provided by greater interconnection with Europe.

In line with the EC's vision of a European 'super grid', interconnectors have key role to play in *inter-seasonal* demand management and system balancing. Interconnectors enable a partial alternative to large-scale centralised generation by importing electricity when UK demand exceeds UK supply; particularly on grey, cold and still winter days. Interconnectors also offer a flexible solution by providing energy when required, hence avoiding the need to build a large-scale plant that needs to operate throughout the year to be financially viable.

Interconnection capacity in the UK is currently at 4GW and is expected to increase by 10GW by the early 2020s with significant capacity provided by nuclear power from France and hydropower from Norway. Alongside the deployment of new low carbon plant, interconnectors can provide low carbon options to complement the growth in decentralised energy.

This vision of an affordable, secure, low carbon energy system with widespread deployment of decentralised energy is not yet realisable without transitional arrangements. There are several barriers to overcome which are discussed in the following section.

5 BARRIERS TO DECENTRALISATION

Although the economics of decentralised energy have improved in recent years and are expected to become increasingly attractive as trends in falling costs and technology breakthroughs continue, there are several barriers that could slow the transition to more decentralisation. This section sets out the main barriers to decentralised energy under three broad categories.

- Regulatory and policy barriers;
- Network constraints; and
- Demand side constraints.

5.1 REGULATORY/POLICY BARRIERS

5.1.1 IMPACT OF SIGNIFICANT TARIFF CUTS

Ahead of reaching grid parity, the benefits of declining costs for solar PV have been successfully realised in the UK through various subsidy mechanisms. This has enabled consumers to adopt solar PV technology at affordable prices contributing to decarbonisation in the UK. The three main subsidy mechanisms from the Government are:

- Feed in Tariffs: Introduced in 2010. A consultation reviewing the future of Feed-in Tariff scheme was published in August 2015. DECC has proposed very sharp cuts in the generation tariffs from January 2016, with a 90% cut in the generation tariff for residential customers. This consultation closes in October 2015.
- Renewables Obligation: The Government closed the RO to large scale solar earlier this year. It has also announced that the RO will be closed for small scale solar (<5MW) from April 2016, a year earlier than planned.
- Contracts for Difference: Applies only to large-scale solar and allocated via auction. In the recent CfD auction, 39MW of solar PV capacity was awarded at a strike price of £79.23 per MWh which will be operational in 2016/17. However, the removal of levy exemption certificates under the Climate Change Levy is expected to result in some of these solar CfD projects, including the Lightsource contract for 14.7MW, ceasing to be viable from the perspective of developers and thus the termination of a number of awarded CfDs.

FIGURE 27: GENERATION TARIFFS FOR SOLAR PV UNDER THE FEED-IN TARIFF SCHEME

GENERATION TARIFFS

	DEC-10	DEC-11	DEC-12	DEC-13	DEC-14	DEC-15	JAN-16(P)
p/kWh							
0-4kW	42.60	42.60	16.11	15.54	14.61	12.47	1.63
4-10kW	42.60	42.60	14.60	14.08	13.24	11.30	1.63
10-50kW	37.11	37.11	13.59	13.12	12.32	11.30	3.69
50-100kW	37.11	21.41	12.00	11.58	10.58	9.63	2.64
100-150kW	34.65	21.41	12.00	11.58	10.58	9.63	2.64
150-250kW	34.65	16.90	11.48	11.08	10.05	9.21	2.64
250kW-5MW	34.65	9.58	7.41	7.14	6.48	5.94	1.03-2.28

Note: All tariff rates are displayed in p/kWh at 2015/16 values. The 'higher rate' is used if applicable. January 2016 figures proposed by DECC.

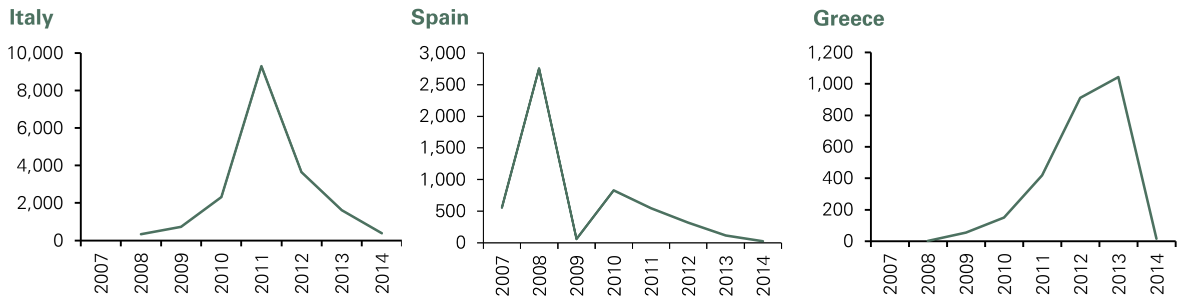
Source: DECC, Consultation on a review of the Feed-in Tariffs scheme, August 2015 and Ofgem, Feed-in Tariff scheme, July 2015

Successful subsidy mechanisms work in tandem with falling costs of solar PV in the market. Subsidies spur investment in the sector and incentivises the consumer to adopt the technology while flexibly adjusting downwards to accommodate decreasing solar PV costs. Any unexpected and significant cuts in the subsidy might push the market to a 'cliff-edge'.

The UK Government has proposed very sharp cuts in the tariffs for solar PV in its FITs consultation published on 27 August 2015. This reflects a desire to bring spending on renewable support back down towards the Government's LCF limit of £7.6 billion pa in 2020/21 (in 2011/12 prices). The consultation proposes reducing direct support to zero for residential deployment by 2019, effectively closing the FIT scheme introduced in 2010.

In other countries where cuts of this nature have been made, like Spain, Italy and Greece, the market for solar PV and decentralised energy has collapsed. In Spain where cuts of this nature were made in 2008, solar PV deployment year on year decreased from 2,758MW in 2008 to 60MW in 2009.

FIGURE 28: PV INDUSTRY 'CLIFF-EDGE' IN ITALY, SPAIN AND GREECE (YOY PV MW DEPLOYED)



Source: SolarPower Europe (formerly European Photovoltaic Industry Association)

Having a cliff-edge in the UK solar industry as similar to the countries above would risk a collapse in the supply chain which will ultimately increase the cost of restarting the industry in a subsidy-free world. Alternatively, a smooth transition towards grid parity would sustain the industry's supply chain in benefit of the UK economy.

Sustaining the supply chain with clear signals and a stable framework would improve global investors' confidence in the UK. This is evident as the UK has attracted over £50 billion in electricity infrastructure investment since 2010 as a result of its Electricity Market Reforms (EMR) and regulatory regime for network investment (RIIO).

The Partners associated with this report recognise the need to reduce costs to consumers as far as possible. Whilst not agreeing with cuts of this severity or speed, we have sought to take as given the envelope of spend projected on solar FITs to 2020/21 as a starting point for considering what other policy changes could facilitate the transition to widespread deployment of decentralised energy described above in a world without long-term support.

5.1.2 STORAGE

With the upcoming widespread commercialisation and deployment of storage technology across a plethora of applications, the UK Government and regulators will need to develop a clear regulatory framework on energy storage.

There is a lack of clarity around the definition of storage from a regulatory perspective, which is usually treated as a generation asset, potentially leading to confusion around regulatory treatment and remuneration and the existence of any ownership or operational restrictions. Storage is in a number of ways unlike a generation asset, as it merely time-shifts original generation and can export for a limited period only. In this context, DNOs should be allowed to secure additional non-regulated income from the provisions of storage related services provided. There are limited incentives for DNOs and TOs to actively expand storage capacity in the UK under the

RIIO-ED1 framework. The current regulatory environment does not optimise investment opportunities in storage over additional network reinforcement, as investing in storage would require the DNO to be confident of additional (non-regulated) income streams from provision of services to other market players.

For example, UKPN's Smarter Network Storage project expects to realise c.£2.5 million of system cost savings, predominantly from reductions in curtailment cost, peaking generation avoidance and carbon emissions reductions. However, whilst the 'network' expenditure (on storage) might be justified through cost-benefit analysis, it depends on either the DNO being allowed to recover non-regulated income from services provided, or, the additional expenditure being considered 'efficient' and fully allowed as RAB investment.

As a result, it is more challenging to make the business case for storage, which currently centres on the cost of avoided network reinforcement. One solution could be for cost-benefit assessments within regulatory frameworks to allow for the inclusion of whole-system benefits as part of the overall justification. This would allow DNOs to more readily justify the use of storage (or other flexibility) in certain circumstances without relying on the pure cost of avoided reinforcement alone. This approach has, to some extent, been adopted in the Californian storage mandate, where each project is to be justified with an economic assessment that incorporates system-wide benefits.

In addition, storage assets are not eligible for funding via the Capacity Market, as storage assets have a finite energy duration and thus fail to meet stress test requirements. Allowing storage to be funded through the Capacity Market would encourage investment in enhanced system flexibility, potentially reducing the need for peaking generation.

The current basis for setting transmission network charges imposes charges when energy is imported from and exported to the grid. Storage units are in effect double charged, whereas pure generation assets only have to pay grid charges once[80]. This does not reflect the value that storage can deliver to networks, as such inflows will typically be where demand is low and generation high, and outflows where demand is not met by available generation. Such double charging penalises developers of storage facilities at the transmission or distribution level.

ED1 does not fully monetise the benefits to system balancing and management of storage, in particular the flexibility benefits around system management. In addition, under the current regulatory framework, the incentives for DNOs to transition to a Distribution System Operator model and manage supply and demand at a local level are limited. This could deter investment and inhibit the scale of storage deployment in the short to medium term. However, the value of storing excess generation from variable renewables will only increase as the UK seeks to decarbonise its economy.

To date, DECC has remained committed to the financial support for the research and development of selected energy storage technologies. Through three routes under the Innovation Programme, DECC has provided over £56 million to energy storage research since 2012[81]. However, despite support on demonstration projects, the Government has not established any formal target or strategy to promote the commercial growth of energy storage. This could limit the levels of research and development expenditure and thus the development of the UK's supply chain. By contrast, California has set a mandated target of 1,325MW, with the result that several ambitious storage projects is currently underway.

Additionally, there is minimal legislation and regulatory oversight on the connectivity and implementation of energy storage on large-scale applications. This distorts the incentives on the various parties involved to implement storage optimally. Furthermore, there are

[80] http://innovation.ukpowernetworks.co.uk/innovation/en/Projects/tier-2-projects/Smarter-Network-Storage-(SNS)/Project-Documents/SNS_ElectricityStorageRegulatoryFramework_SecondReport_v1.0+PXM+2015-09-30.pdf

[81] Amber Rudd, Speech on energy storage innovation showcase, January 2015, https://www.gov.uk/government/speeches/energy-storage-innovation-showcase

currently limited Time-of-Use tariffs' in the consumer market which prevents a reliable price signal for consumers to utilise with energy storage.

Innovation in electricity storage is happening around the world. Although the UK market would not be the leading in innovation, the UK could capitalise on global innovation and the significant system benefits of solar plus storage by stimulating deployment, for example through a time-capped grant. Such funding was available in Germany in 2013, where PV owners of systems up to 30kW could obtain funding for up to €3,000 (c.30 per cent of battery storage costs at the time) where battery storage was deployed in conjunction with solar. The grant was designed in part to facilitate a fall in costs, at which point the grant would be no longer be available, and targeted between 20,000 and 30,000 homes. These incentives were justified on the grounds that they help reduce the costs of grid reinforcements and optimise the balancing of demand and supply across the grid.

Similarly, in the UK there are precedents where grants have been provided to kick-start the market in the UK. For example, in 2010 DECC provided a grant for the replacement of boilers, the boiler scrappage rebate. This provided support up to 118,000 homes to replace inefficient boilers, with grants of £400 per household. More recently, a grant has been made available by DECC to support the purchase of electric vehicles, covering 35 per cent of the cost of a car up to a maximum of £5,000. The grant will provide a minimum of £200 million of funding between 2015 and 2020 to reduce the cost of low emissions cars, for at least 50,000 cars[82].

5.1.3 SETTLEMENT

The current system and charges for residential settlement are prohibitive in offering true value for flexibility or reducing peak. For example, a domestic user of solar PV who uses no energy during the day or peak hours would still be typically settled on their 'consumer profile'. Settling consumption on a residential profile basis without the cost-effective ability for more accurate settlement prohibits innovation. A transition to half-hourly settlement facilitated by the roll out of smart meters is an essential prerequisite to suppliers introducing innovative Time-of-Use tariffs and encouraging demand side response initiatives.

Furthermore, tariff models and diversity are now discouraged under the RMR and white-label regime appears to discourage alternative presentation of tariffs. Whilst curtailing complexity offers benefits to a majority of residential consumers, those that engage with the energy market and demonstrate early adoption of new technologies requiring flexible tariffs are placed at a disadvantage. Equally, requirements to offer all consumers the same tariff need to be relaxed where suppliers wish to innovate and couple supply products with specific innovations or technologies installed in households. For example, to encourage peak shift or use of storage resources. As such, requirements to offer all customers the same tariff need to be relaxed where tariffs are coupled with specific innovations or technologies installed in households. More flexibility needs to be allowed to only provide such favourable tariffs when coupled to required technologies.

5.1.4 VALUING EXPORTED ELECTRICITY AND LOAD SHIFTING

Attaching a value to the avoidance of peaks on the electricity grid and thus reducing costs of network reinforcement may incentivise prosumers to invest and participate in distributed generation at a time when feed-in tariffs are expected to be significantly reduced from January 2016. There are a number of options for achieving this.

This value could be recognised through the introduction of a net metering scheme, where the exported electricity is valued at, or close to, the retail price of electricity, and rebates given off bills to reflect this, rather than the nominal tariff currently applied to exports. Net metering schemes along these lines are used in 43 US states and 10 EU members, including Belgium, Denmark, Netherlands, Italy, and Sweden.

82 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/307019/ulev-2015-2020.pdf

FIGURE 29: EXISTING NET METERING SCHEMES

MEMBER STATE	ELIGIBILITY	NET METERING PERIOD	ELECTRICITY COMPENSATION	CAPACITY CAP
Denmark	Non-commercial systems <6kW	Hourly	Retail price	N/A
Netherlands	Connection size <3x80A	Yearly	Retail price	N/A
Sweden	Connection size <100A	Yearly	Tax reduction: 0.60 SEK/kWh (up to 30 MWh/y)	For up to 30,000kWh, or 18,000 SEK pa
Italy	<500kW	Yearly	Net billing – remuneration based on time of use tariff	N/A
Greece	<20kWp	Yearly	Retail price	N/A
Hungary	<50kW, connection size <3x63A	Monthly, half yearly or yearly	Retail price	N/A

Source: European Commission, Best Practices on Renewable Energy Self-Consumption, July 2015

A critical issue for suppliers, often with regional customer bases, is how the costs of net metering (i.e. payments for generation exported to the grid) are distributed. The costs could be paid for by the relevant suppliers, however this would be to the disadvantage of suppliers with a high proportion of customers with solar. Alternatively the costs could be spread across all suppliers, which could reflect the system-wide benefits associated with avoiding peak generation.

A more optimal solution could be the introduction of separate import and export tariffs (facilitated by smart meters) that would reward imports and exports of electricity only when it is beneficial to the system as a whole.

Alternatively, the value that storage brings to the system could be properly recognised through targeted products offered in the balancing mechanism and/or capacity market that incentivise the aggregation of demand side response from the residential and C&I sectors that utilise storage technologies. Such products would increase competition between products in the balancing market/capacity market and help stimulate behavioural change to realise the full potential of storage technologies.

5.1.5 EU TRADE POLICY

The Minimum Import Price (MIP) is the minimum allowed price applied to all solar cells and solar panels imported from China into the EU. These EU duties were implemented in December 2013 and are due to expire in December 2015 in response to anti-dumping and anti-subsidy policies. Should the MIP be renewed, UK consumers will have to implicitly pay a premium for solar PV slowing down gains from decentralised energy. This adversely affects the solar industry as a whole and unnecessarily prolongs the period for which subsidies are required to achieve the equivalent benefits of simply removing the MIP.

5.2 NETWORK CONSTRAINTS

5.2.1 ALIGNING INCENTIVES OF DNOS

With the evolution of the sector towards decentralised energy, the involvement of DNOs are currently limited. DNOs will need to be properly incentivised to facilitate decentralised energy, for example by ensuring that sufficient network connections are built to ease any local grid constraints.

The recent shift to a 'Totex' regulatory regime in theory, incentivises DNOs to be indifferent to Capex and Opex solutions and hence is focussed on minimising the distribution network cost. However, towards a more service-oriented decentralised network, DNOs should be encouraged to source a variety of solutions through competitive means to take on a more active role in network management. Possible improvements to optimise the functions of a DNO include:

- Strengthening the incentives for implementation of cost effective smart grid measures.
- Enhance market integration across sectors with responsive demand in an increasingly decentralised low-carbon world.
- Update distribution network design standards to promote new technologies that may postpone or replace traditional network reinforcements. There is evidence on several successes in DSR and storage demonstration projects.
- Improve planning under uncertainty through a formalised methodology to evaluate investment options.
- Develop an anticipatory investment framework.
- Co-ordination of infrastructure deployment across sectors to allow different sectors to invest at the same time, thereby sharing some costs.
- Whole systems approach to distribution network planning to manage the synergies and conflicts between distribution network, energy supply, transmission network, and EU interconnection.
- Provisions to manage increased risk and complexity associated with deployment of new technology.
- Resolve voltage standards, harmonics and fault level issues to manage the integration of different technologies. In the long term, the displacement of central, synchronous generation by embedded generation and interconnection could present new challenges with the level of harmonics.
- Emerging role of the regulator in the design and oversight of the investment framework to ensure proper incentives are given to network operators.
- Strategically sited electrical energy storage could provide DNOs with an opportunity to contract for network support services, such as N-1 contingency capacity and reactive power support, where that would avoid or defer more expensive network reinforcement (either demand or generation driven)

5.2.2 CONNECTIONS POLICY

The regulatory framework supports the development of connections of low carbon technologies to the distribution network. RIIO-ED1 is outputs-based and designed to incentivise the development of timely and cost-effective connections by DNOs, where the benefits of any new connection to customers can be clearly demonstrated. Incentives are based on the time taken for a DNO to provide a quote to applicants for new connections.

Competition has also been introduced to the connections market to ensure that the costs of connection, which can fluctuate significantly based on region and customer location, remain fair. The market is estimated by Ofgem to be over £500 million per annum.

There has been a significant increase in the number of connections to the network since 2012, as the costs of decentralised energy have fallen and Government support through feed-in tariffs has encouraged the development of local generation. Connections have increased from c.7,000 in 2011 to 687,000[83] in 2014/15.

The increase in the number of decentralised generation connection requests has placed considerable strain on the distribution network that was originally designed to accommodate one-way power flows to supply demand. As a consequence, DNOs are increasingly challenged to incorporate demand for distributed generation connections to the grid. Limited capacity is an increasingly key constraint for DNOs. For example, in April 2015, Western Power Distribution (WPD) announced a three to six year delay for generator connections requiring works at high voltage, as significant network reinforcement is required in its 82km 'F-route' to support increased connection requests.

To improve efficiency of the connections application process, the re-introduction of feasibility assessment fees to reduce the number of speculative applications should be considered. Where such fees are incurred, they would be offset against the cost of accepted connection offer.

The increased strain placed on distribution networks has the potential, if not matched by the requisite investment in network reinforcement, to slow the development of distributed generation in the UK as export to the grid for medium-size projects will not in many instances be feasible given available network capacity.

5.2.3 QUEUE MANAGEMENT AND SPECULATIVE CONNECTIONS

The increased number of connections is complicated by an associated increase in the numbers of 'speculative' connections. Speculative connections are applications for generation assets that are not yet built and which might not yet have planning permission or financing in place to connect to the network. In some cases, connection applications are submitted to DNOs by developers where the likelihood of project implementation is relatively low.

Only 20 per cent of the applications made to UKPN result in a connection. Even fewer applications made to Electricity North West (ENW) result in a connection (just 10 per cent), and up to 40 per cent of its connection requests are deemed to be purely speculative.

As at 1 March 2015, in WPD's South West region, connected generation capacity was 1.38GW, with an additional 2.63GW of generation offered but not yet connected, against a maximum demand of 2.53GW. 65 per cent of the total 4.01GW generation in the South West is thus notional, and only a proportion will actually be built and connected.

As required by Ofgem's distribution connections policy[84], connections are serviced on a first come, first serve basis. This inhibits the ability of DNOs to service genuine connection requests with increased delays for connection of distributed generation projects into the grid. This in turn can discourage the integration of distributed generation into the distribution network and reduce electricity exports, reducing the financial returns available.

5.2.4 FLEXIBLE CONNECTIONS

A potential solution to limited capacity in distributed networks is active network management by DNOs, including the introduction of contract-based 'flexible connections', whereby a DNO would have the right to curtail generation to mitigate capacity constraints at the distribution level. For solar (with a load factor of c.11 per cent, rarely exporting at full capacity) the curtailment impact on annual volumes exported is low, and hence the approach is entirely appropriate. Such network management is consistent with the smart grid concept, and would allow each local network to support additional distributed generation.

UKPN has recently completed its 'Flexible Plug and Play' project, a trial covering 15 connection (54.4MW). The introduction of flexible connections allowed an additional 100MW to be connected to the network, with savings to customers of £44 million over three years. UKPN is beginning to offer flexible connections

[83] http://www.energynetworks.org/modx/assets/files/events/dgfora/2015/DGF2015_London_Presentation_reduced.pdf

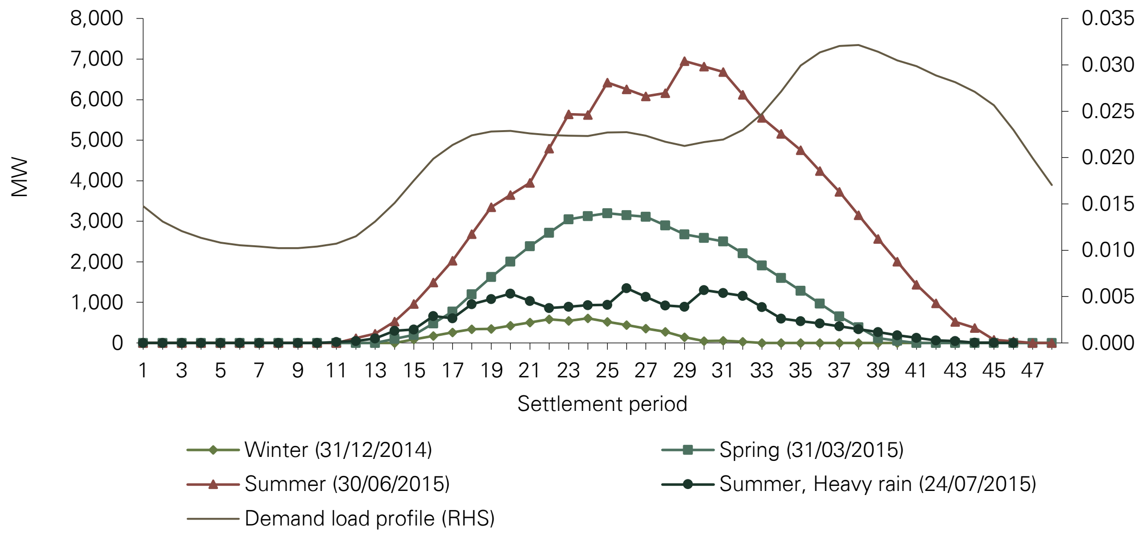
[84] https://www.ofgem.gov.uk/ofgem-publications/87259/guideelectricitydistributionconnectionspolicy.pdf

more widely, and flexible connections could be a viable mechanism for reducing connection delays.

5.2.5 VARIABILITY OF SOLAR PV

Similar to onshore wind generation, solar energy is highly variable both intra-day and across seasons. This is evidenced in Figure 30 which shows the limitations to solar PV during winter and in poor weather. High solar PV capacity increases the frequency and size of imbalances between supply and demand of electricity. When PV is not generating, extra capacity is required particularly in the evening when there is a combination of no sunlight and peak demand. Variable renewable generation will also require additional flexible generation to respond quickly to imbalances in the wholesale market.

FIGURE 30: SOLAR PV GENERATION DATA



Note: Some of the difference in generation can be attributed to the increase in installed capacity.
Source: Elexon data, August 2015

5.2.6 PROVISION OF FLEXIBILITY SERVICES

Until now, flexibility has mostly been provided by increasing or lowering supply – e.g. from gas peaking plants or hydro plants – to meet capacity requirements, maintain system balance and manage imbalance (cash-out) risks. Flexibility in energy systems will become increasingly critical as demand is expected to increase over the medium term, more generation is established at a distributed level and an increased proportion of generation is variable. Energy systems that can rapidly respond to fluctuations in supply and demand will enable the integration of renewable technologies without recourse to expensive peaking plants, avoid investment in potentially unnecessary large-scale plant and defer grid reinforcement.

Large industrial users currently provide DSR, typically for system balancing purposes – such as when reserves are running low and the system operator is seeking to reduce demand in the system – or for avoiding high transmission charges (triad avoidance). Also a small portion of domestic consumers have been providing flexibility, for example consumers on Time-of-Use tariffs with radio-tele-switch controlled demand such as electric storage and water heating (e.g. E7).

Ofgem recognises that more could be done to enable consumers and new technology to realise their flexibility potential, to bring more benefits across the value chain and in addressing the barriers currently in place which include:

- **Regulatory barriers:** These include a lack of clarity of the role and responsibilities of parties in using and providing flexibility, and gaps or deficiencies in the regulatory framework, for instance around the definition of storage.
- **Commercial barriers:** Even where the role of parties may be clear, there may be no (or only limited) commercial incentives on parties to use. Equally, the technical and

commercial details of flexibility products/contracts may not align with providers' requirements or abilities (e.g. in the case of C&I customers, storage providers, and aggregators).

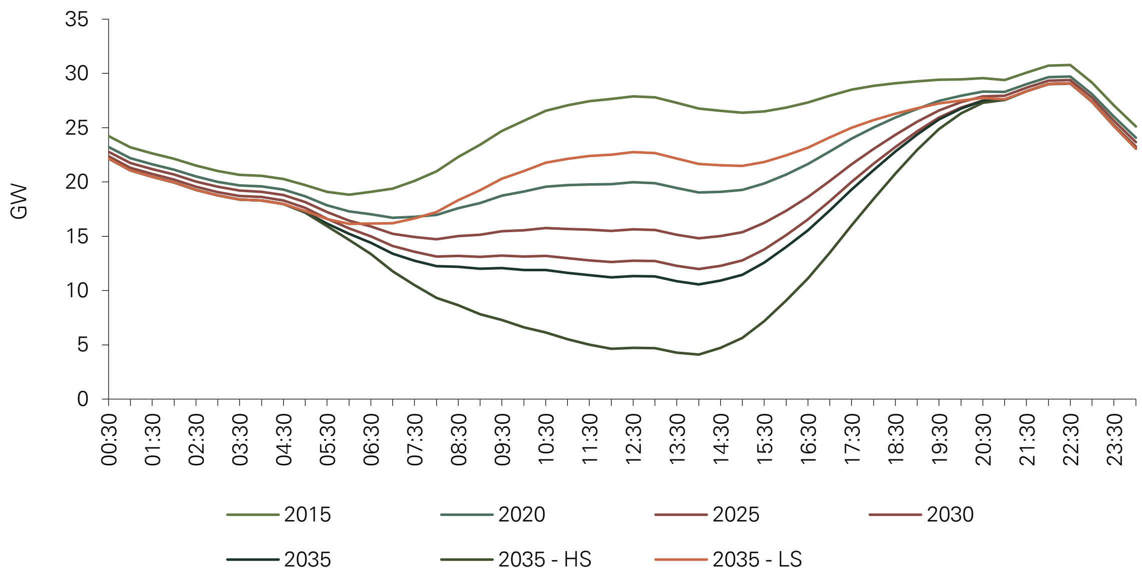
- **Structural barriers:** These include costs relating to investment, R&D, and economies of scale for some providers of flexibility. The complexity of market arrangements for suppliers and others, and the uncertainty of response, may increase the cost of procuring some forms of flexibility.

5.2.7 IMPACT OF SOLAR PV ON THE TRANSMISSION NETWORK

National Grid's Future Energy Scenarios, published in July 2015, illustrates the significant impact the continued development of solar PV could have on demand on the transmission grid.

Fluctuations in solar PV capacity are expected to change the summer demand profile and result in a suppression of transmission demand at peak times by 2035. National Grid expect intra-day transmission demand to fluctuate by c.12GW in 2015, increasing to c.19GW by 2035. Even in 2015, the impact on demand can be observed with a less obvious peak.

FIGURE 31: IMPACT OF SOLAR PV ON SUMMER TRANSMISSION DEMAND, CONSUMER POWER SCENARIO



Source: National Grid, Future Energy Scenarios, July 2015

There will be increasing risk of negative wholesale prices should there be an oversupply of renewable energy. Recently in 2013, there have been four half-hours in the UK with negative prices. This has increased to 26 half-hours in 2014 and 48 half-hours so far in 2015[85]. This is discussed further in the Germany case study, where there are regularly negative wholesale electricity prices as a result of high solar deployment.

[85] Elexon data, as at August 2015

5.3 DEMAND SIDE CONSTRAINTS

5.3.1 TECHNOLOGICAL CONSTRAINTS

To implement effective DSR capability, it is important to have a widespread deployment of smart meters. The roll of smart meters is in its early stages – of the 53m smart meters (including gas meters) due to be installed by 2020, only c.1.5m have been installed to date. Uncertainty surrounding compliance obligations, as well as lack of familiarity with the metering market has hitherto deterred investors other than the entrenched players (Macquarie Energy Leasing and Calvin Capital). However, these barriers are expected to fall away over the next 12-18 months.

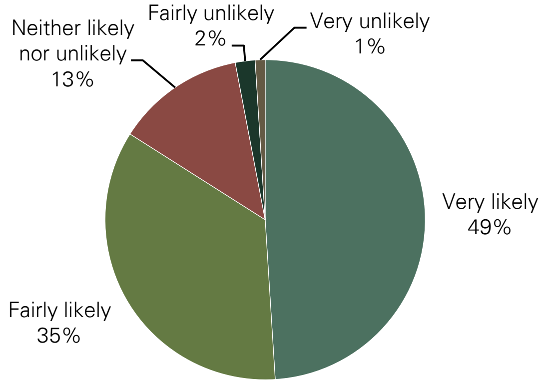
The current model of smart meters is compliant with GB-approved Smart Meter Equipment Technical Specifications (SMETS) which allows for Time-of-Use tariffs. This enables the capability of recording consumption to up to 48 registers for electricity and 4 registers for gas per day. However, successful implementation of ToUTs for residential customers will also require increased customer engagement.

5.3.2 CONSUMER BEHAVIOUR

The success of initiatives such as demand side response, smart technology such as smart meters and domestic generation is dependent at least in part on the level of consumer engagement with load-shifting initiatives. Engagement to date has been low, but decentralised energy provides an opportunity for consumers to empower themselves, take control of their own energy security and lower their bills.

There are positive signs that consumers will engage fully with smart meters. In a recent survey carried out by Populus on behalf of Smart Energy GB[86], 84 per cent of people with a smart meter responded that they are likely to recommend one to others. Consistent messaging is now required to explain the benefits that a smarter energy system can bring.

FIGURE 32: LIKELIHOOD TO RECOMMEND A SMART METER TO OTHERS (SMART METER CUSTOMERS)



Source: Smart Energy GB, Smart energy outlook, September 2015

[86] Smart Energy GB, Smart energy outlook, September 2015, http://www.smartenergygb.org/sites/default/files/Smart%20Energy%20Outlook%20September%202015_0.pdf

6 POLICY RECOMMENDATIONS FOR DECENTRALISED ENERGY

6.1 POLICY RECOMMENDATIONS FOR SUPPORTING DECENTRALISED ENERGY

Steps need to be taken to overcome these barriers and facilitate the transition to this lower cost, more decentralised vision of the energy system of the future. The package of measures described below draws on the experience of other countries where decentralised energy is growing, and takes as given the envelope for spending on FITs the Government has proposed under the Levy Control Framework. Without these (or similar) facilitating measures, the progress towards a decentralised energy system is likely to be stalled.

KEY RECOMMENDATIONS

1. **Re-profile FITs spend within the overall Levy Control Framework envelope**
   a. *Without* increasing the total spend on solar FITs proposed under the LCF to 2020, set higher tariffs in the short term to allow the industry to make a quicker transition to a world without FITs.

FIT TARIFFS

	CUSTOMER TYPE	2016/17	2017/18	2018/19	2019/20
<4kW	Residential	7.0	6.0	5.0	0.0
4-50kW	C&I	6.5	5.25	4.25	0.0
50-250kW	C&I	5.5	4.25	3.25	0.0
250-1000kW	C&I	3.0	1.75	0.75	0.0

   b. For residential customers (with <4kW systems), the tariff would need to be 7 p/kWh in 2016/17, 6 p/kWh in 2017/18 and 5 p/kWh in 2018/19, before falling to zero from April 2019. The proposed tariffs for C&I customers are also shown in the table below.
   c. Offsetting savings could be made by closing the scheme *earlier* than proposed in the DECC consultation document (2020), as well as reducing FITs support for ground-mounted solar and large-scale roof-mounted solar (>500kW), and other technologies, like micro wind turbines, which have less potential for further cost reduction and being part of a 'whole house solution'.
   d. The proposed residential tariffs set out above would need to be higher than recommended if they were implemented in isolation, without the other supporting measures listed below.

2. **Introduce a time-limited deployment grant to kick-start the battery storage market**
   a. Implement a *time-limited* scheme for the deployment of battery technologies linked to solar PV installation, along the lines of the scheme used in Germany, where batteries linked to solar get a 30 per cent rebate[87]. In principle, this would also be similar to the scheme currently running in the UK for stimulating the take-up of electric vehicles.
   b. Provide grants of c.£300 per kWh of discharge capacity available to residential customers to install battery

[87] http://www.bmwi.de/EN/Topics/Energy/Storage/funding-for-decentralized-energy-storage.html

storage technologies as part of a 'smart whole house' solution, with a cap on total spend to 2020 of c.300 million. So, for example, a 3kWh battery system would be eligible for a deployment grant of £900. The deployment grant per customer could be capped at £1,500.

c. This would be paid for by re-directing existing innovation funding from UK and EU innovation funding sources.

3. **Recognise the value created for the electricity grid of widespread deployment of battery technologies**
   a. With widespread deployment of storage, peaks on the electricity grid can be avoided and hence grid reinforcement costs can be reduced. With storage, the value of exported electricity from decentralised generation can reflect demand on the system (rather than being supplied at times of limited use e.g. middle of a summer's day).
   b. This value that storage brings to the system needs to be properly recognised through targeted products offered in the balancing mechanism and/or capacity market that incentivise the aggregation of demand side response from the residential and C&I sectors that utilise storage technologies. Such products would increase competition between products in the balancing market/capacity market and help stimulate behavioural change to realise the full potential of storage technologies.
   c. These steps would need to be facilitated by the introduction of Time-of-Use tariffs and half-hour metering for domestic customers, by 2018/19, as recommended by the Competition and Markets Authority.

4. **Incentivise DNOs and the TSO to support deployment of decentralised energy**
   a. Provide a regulatory mechanism that permits DNOs and TSOs to own and operate electrical energy storage as a regulated network asset, whilst also providing non-regulated services to other market players. Introduce regulatory settlements for DNOs and National Grid that incentivise the growth in decentralised energy and recognise the network cost savings that can result as a result of lower peak demand on the system.
   b. Introduce grid access rules for customer sites that enable two-way flows to help manage the system in 'smart' way to avoid bottlenecks.
   c. Implement a storage-specific and flexible grid connection application process, instead of a conventional generation application as used for wind and solar.

IMPACT ON BILLS

We believe these changes can be made within the existing LCF limits proposed by Government to 2020/21 and within existing Government spending envelopes, by refocussing existing funds towards the key technologies.

We also estimate that these policy changes can help deliver savings over the medium term:

- With regards the LCF limits to 2020, DECC has stated in its consultation on FITs that a maximum of £100 million of additional expenditure is available for new deployment up to 2018/19. Assuming increased self-consumption rates as a result of storage, it is estimated that about £60 million would be required to support the deployment of 100,000 3.5kW solar PV units per annum totalling 1.1GW over this period at these tariffs, well within the overall LCF cap.
- Over the longer term, it should result in a significantly lower LCF in the 2020s than the previous DECC forecasts, which imply LCF spending rising to about £15 billion per annum (in real 2011/12 prices) by 2025.

APPENDIX 1 **OTHER PROJECTIONS**

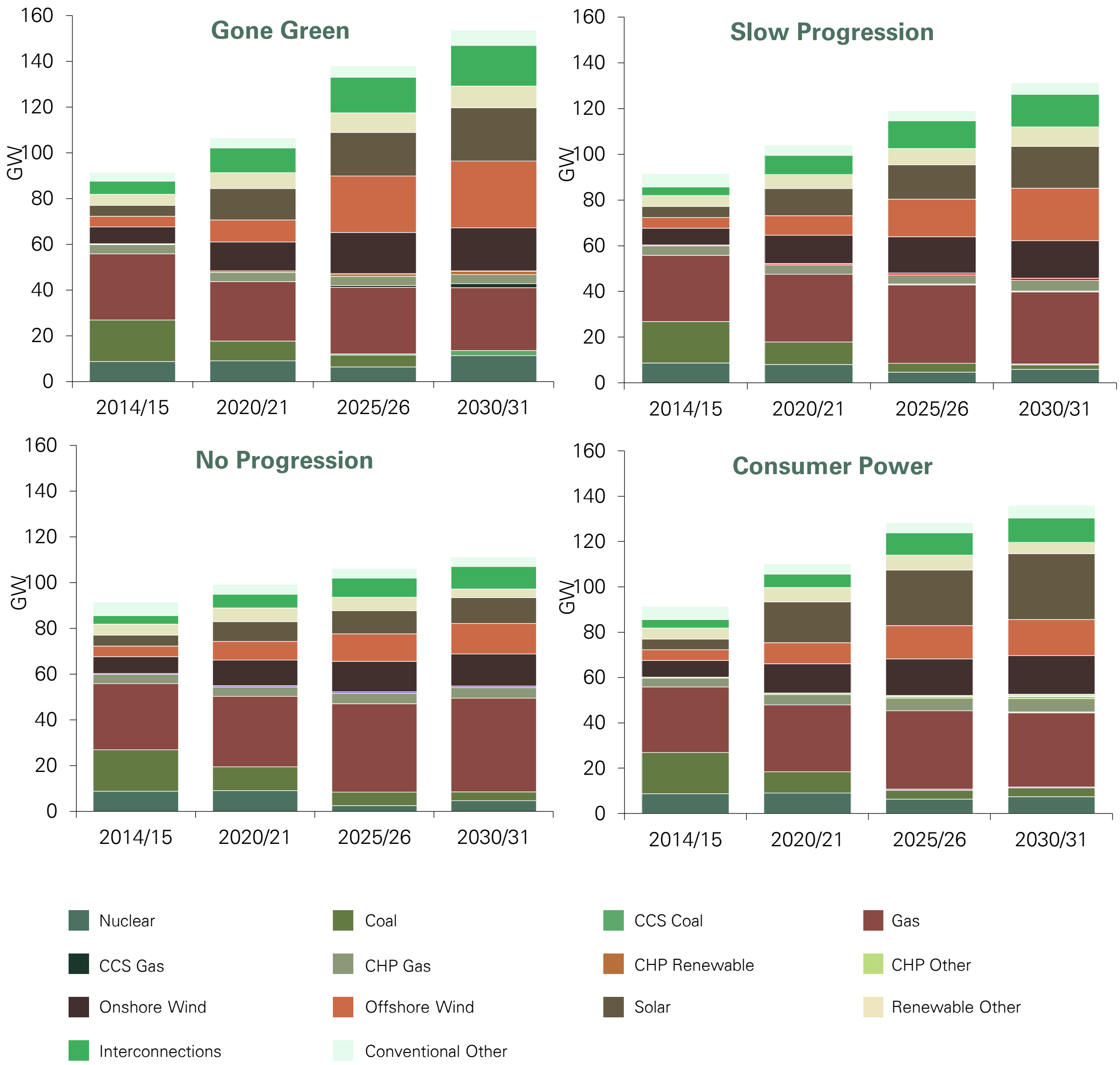
NATIONAL GRID'S 'FUTURE ENERGY SCENARIOS'[88]

INSTALLED CAPACITY PROJECTIONS

The figure below shows the projections in installed capacity across various scenarios. The Consumer Power scenario is based on more decentralised energy and hence has the highest projected installed solar PV capacity.

In all scenarios, a relatively diverse mix of generation up to 2030 is expected. While all scenarios are expected to see a strong increase in renewable capacity, only the Gone Green scenario is expected to meet decarbonisation targets on time. This involves increasing the current renewable capacity by 60GW to 2030/31, which is a more ambitious projection than DECC's 2014 estimates.

FIGURE 33: INSTALLED CAPACITY PROJECTIONS



Source: National Grid, Future Energy Scenarios, July 2015

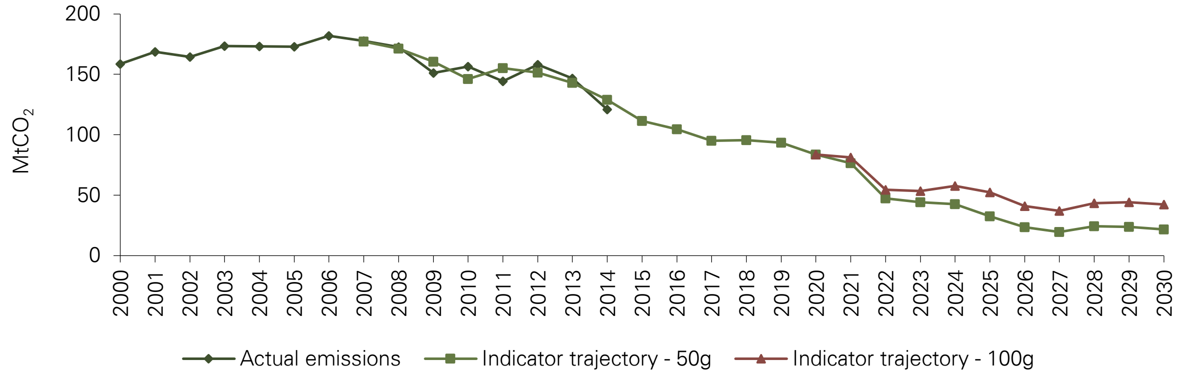
[88] National Grid, Future Energy Scenarios, http://fes.nationalgrid.com/

COMMITTEE ON CLIMATE CHANGE PROJECTIONS

The Committeee of Climate Change projection of carbon emissions[89] makes clear that further action will be required by Government in order to meet the most cost-effective pathway for hitting the 4th Carbon Budget and 2050 target.

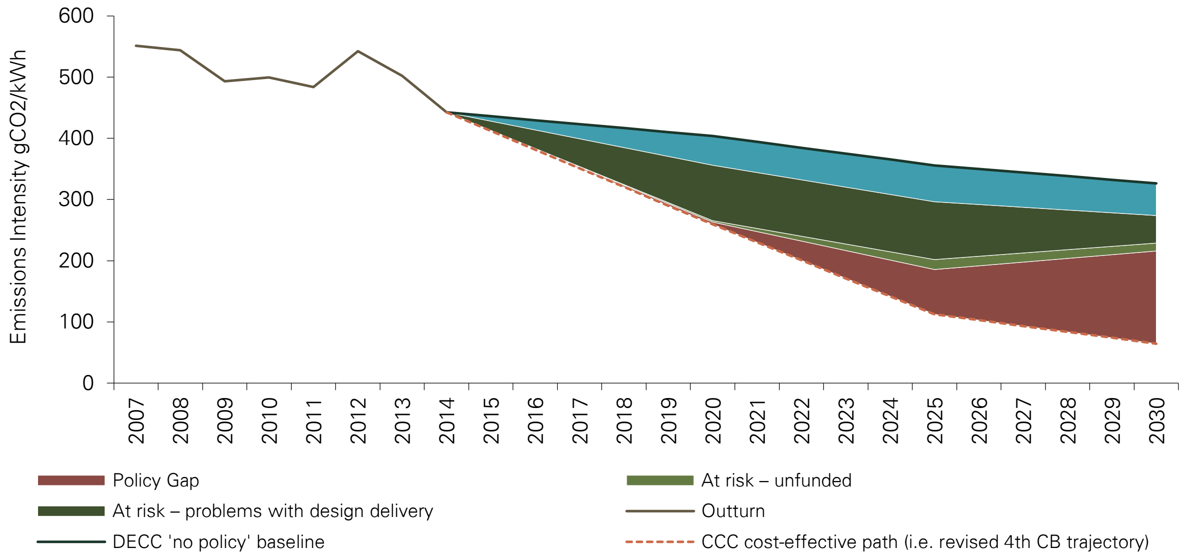
In order to meet decarbonisation targets, the CCC has noted that "key areas for future technology development include heat storage and system integration. New technologies, business models and financing mechanisms can open up new markets and guide investment". The CCC has also emphasised that continued Government support is required for a "locally-led delivery" in decarbonisation.

FIGURE 34: ACTUAL POWER SECTOR EMISSIONS COMPARED WITH CCC INDICATOR TRAJECTORY



Source: Committee on Climate Change, 2015 Report to Parliament, June 2015

FIGURE 35: CCC'S ASSESSMENT OF CURRENT AND PLANNED POLICIES IN THE POWER SECTOR



Source: Committee on Climate Change, 2015 Report to Parliament, June 2015

[89] Committee on Climate Change, June 2015, Reducing emissions and preparing for climate change: 2015 Progress Report to Parliament, https://www.theccc.org.uk/publication/reducing-emissions-and-preparing-for-climate-change-2015-progress-report-to-parliament/

APPENDIX 2 **CASE STUDIES**

GERMANY – SOLAR DEPLOYMENT

Germany is the one of the earliest adopters of renewable energy, including solar PV. Costs have been falling rapidly. The Fraunhofer Institute for Solar Energy Systems[90] calculates that up to the end of 2014, the cost of a 10-100 KW rooftop solar PV system has decreased at a compound rate of 9 per cent since 1990.

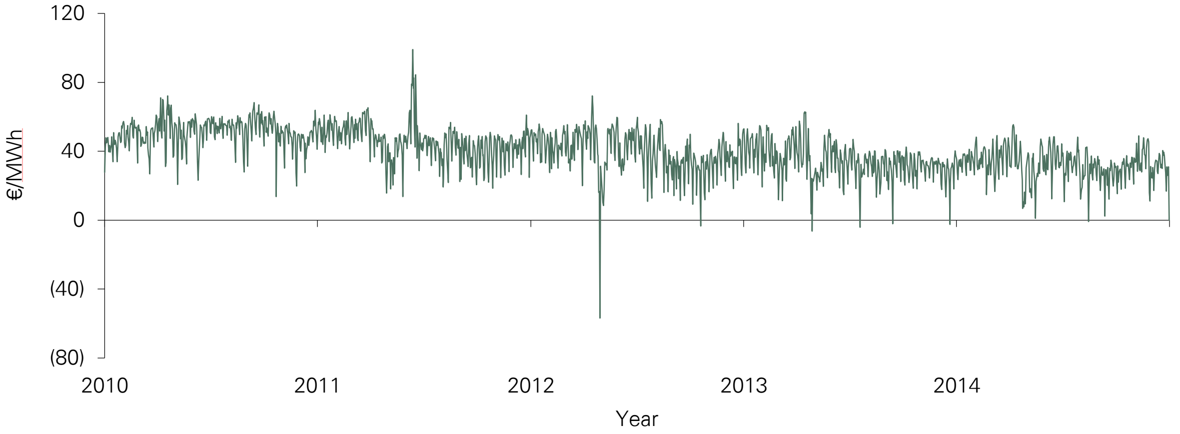
The German Renewables Energy Act requires that the grid prioritises renewables generation over other sources such as nuclear, lignite, coal and gas. The proportion of total production arising from renewables can fluctuate significantly, typically between 10 per cent and 50 per cent, and has been as high as 78 per cent.

The high proportion of solar and other renewable generation in the German market has resulted in a marked merit order effect. The prioritisation and increasing market share of renewables has reduced overall costs of generation, as the marginal costs of renewables generation are low due to zero fuel costs and relatively minimal operating costs. Based on 2011 data, the Fraunhofer Institute[91] noted that an "additional one gigawatt feed-in of PV power led to an average spot price decrease of 82 €ct/MWh".

Where renewables generation exceeds forecast levels, it has led to negative prices, as it can be more expensive to reduce planned conventional peaking plants' generation than to pay for (typically non-household) customers to use electricity. The chart below sets out average daily baseload German electricity prices over the last five years, which shows that even on a daily rather than an hourly basis, electricity has traded at negative prices on the spot market.

By October 2014, c.37 per cent of German solar installations were <10kW, highlighting the increasing extent to which solar PV is becoming decentralised. Incentivising increased deployment of smart meters and the implementation of smart initiatives such as demand side response and battery storage will allow consumers to reduce costs at a local level whilst maximising the efficiency of existing renewables generation capabilities.

FIGURE 36: DAILY BASELOAD ELECTRICITY PRICES IN GERMANY



Source: Thomson Reuters Eikon

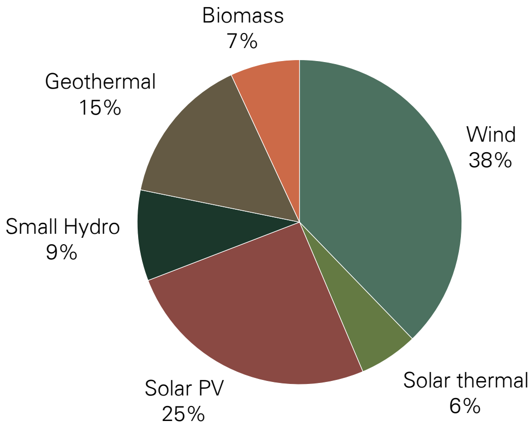
[90] Fraunhofer ISE, Photovoltaics Report, August 2015, https://www.ise.fraunhofer.de/en/downloads-englisch/pdf-files-englisch/photovoltaics-report-slides.pdf

[91] Fraunhofer ISE, Recent Facts about Photovoltaics in Germany, compiled by Dr Harry Wirth, May 2015, https://www.ise.fraunhofer.de/en/publications/veroeffentlichungen-pdf-dateien-en/studien-und-konzeptpapiere/recent-facts-about-photovoltaics-in-germany.pdf

USA – ENERGY STORAGE IN CALIFORNIA

The California Energy Commission monitors the progress of California's renewables programme and has recently highlighted the increase in utility-scale renewables capacity from 6,600MW in 2010 to 16,000MW in 2014[92].

FIGURE 37: CALIFORNIA RENEWABLES MIX – 2014



As a result of growth in its exposure to renewables, which is targeted to be 33 per cent by 2020 (2014: c.25 per cent), California Public Utilities Commission (CPUC) has set out one of the world's most ambitious plans for developing its energy storage capabilities. There is a state mandate for the three publicly owned utilities to develop 1,325MW of electricity storage by 2020[93]. Energy storage systems are to be procured through a competitive process, and 200MW of storage is to be tendered by the end of 2015.

In addition to the mandated 1,325MW programme for public utilities, customers are incentivised to utilise storage technologies through rebates via the Self-Generation Incentive Programme.

To date, South California Edison has awarded 250MW of storage contracts. San Diego Gas & Electric, meanwhile, has put out a request for offer for 25MW of storage, which could increase to 800MW and Pacific Gas & Electric has put out a request for offer for 74MW in two tranches. By contrast, currently the largest current single battery facility in the UK is the UKPN's 6MW/10MWh facility at Leighton Buzzard.

The CPUC's storage roadmap explains that the rationale for the project includes the increasing proportion of the generation mix derived from renewable sources, which are variable (depending on difficult to predict factors such as weather) and to improve certain around security of supply. Smart storage could, claims CPUC, also significantly reduce the costs of high demand, which is currently met by expensive peaking plants.

[92] California Energy Commission, Summary of Renewable Energy Installations

[93] California Public Utilities Commission, Decision 13-10-040, Adopting Energy Storage Procurement Framework and Design

APPENDIX 3 **FEED-IN TARIFF OVERVIEW**

The UK's FIT scheme was entered into law by the Energy Act 2008 and introduced by DECC on 1st April 2010 replacing the previous UK Government grant scheme. The purpose of the FIT scheme was to promote the use of and support small-scale renewable and low-carbon electricity generation technologies. The scheme is applicable to a number of technologies (Solar PV, Wind, Hydro, and Anaerobic Digestion (AD)) up to a maximum Total Installed Capacity (TIC) of 5MW and Micro Combined Heat and Power (micro-CHP) plants are also eligible up to 2kW TIC.

FITs are paid by licensed energy suppliers and comprise two elements being the generation tariff and export tariff. The generation tariff is the main component of the FIT payment and is paid to the generator based on the total output of their renewable energy system, regardless of whether they use all of the energy they have produced or divert electricity to the grid. The second component is the export tariff, often referred to as an 'additional payment', whereby the generator is paid for each kWh unit of electricity that is exported to the grid.

The FIT scheme has realised its objective (at implementation) of promoting the use of renewable and low-carbon electricity generation technologies. In fact, uptake of the FIT scheme in the UK has significantly surpassed the Government's expectations in terms of the number of installations and capacity. The scheme has exceeded, or will exceed by the end of 2015, DECC's projections from the 2012 Comprehensive Review for 2020/21 for Wind, Hydro, and AD and is expected to be within the Solar PV range. However, this higher-than-expected deployment has in turn led to costs exceeding DECC's projections for the same period. This has had a direct impact on the LCF as FITs along with other subsidies for renewable and low-carbon technologies are paid out of the LCF. DECC's latest forecasts for the LCF to 2020/21, confirmed in the Office of Budgetary Responsibility's (OBR) report, Economic and fiscal outlook – July 2015[94], reveal the LCF forecast expenditure to be at c.£9.1 billion against the limit of c.£7.6 billion (both figures at 2011/12 prices) thus a predicted overspend of nearly 20% is envisaged. The Government is determined to bring these costs under control to protect consumers.

In light of this, DECC has proposed radical changes to the FITs scheme. Most noticeably, a very sharp reduction (c.90%) in generation tariffs for Solar PV, Wind and Hydro technologies is being sought but there are no proposed changes to export tariffs at this stage. DECC is proposing to implement these and other strategies to limit the effects on consumers who ultimately pay for renewable energy subsidies. These strategies are detailed in the "Consultation on a review of the Feed-in Tariffs scheme"[95] published on 27th August 2015. For example, DECC is proposing a new 0-10kW banding with a generation tariff of 1.63 p/kWh, which is 87 per cent lower than the existing tariff (12.47 p/kWh) for a comparable installation. It is worth highlighting that only new installations, not existing installations, will be affected as the Government has committed to grandfathering generation tariffs. Depending on the size of installation the new generation tariffs proposed by DECC will be between 1.03 p/kWh – 3.69 p/kWh (figures in nominal terms) from January 2016. The consultation will be concluded at the end of October 2015.

[94] Economic and fiscal outlook (July 2015) (http://cdn.budgetresponsibility.independent.gov.uk/July-2015-EFO-234224.pdf)

[95] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/458660/Consultation_on_a_review_of_the_Feed-in_Tariffs_scheme.pdf

APPENDIX 4 **GLOSSARY**

Term	
ADE	Association for Decentralised Energy
C&I	Commercial & Industrial
CAES	Compressed Air Energy Storage
CCC	Climate Change Committee
CCGT	Combined Cycle Gas Turbine
CCS	Carbon Capture and Storage
CfD	Contract for Difference
CHP	Combined Heat & Power
CMA	Competition Markets Authority
DE	Decentralised Energy
DECC	Department of Energy and Climate Change
DNO	Distribution Network Operator
DSM	Demand Side Management
DSO	Distribution System Operator
DSR	Demand Side Response
ECA	Enhanced Capital Allowances
ECO	Energy Company Obligation
EMR	Electricity Market Reform
EV	Electric Vehicles
FIT	Feed-in Tariff
GHG	Greenhouse Gas
IPCC	Intergovernmental Panel on Climate Change
LCF	Levy Control Framework
LCNF	Low Carbon Network Funds
LCOE	Levelised Cost of Electricity
LoLE	Loss of Load Expectations
MIP	Minimum Import Price
NG FES	National Grid Future Energy Scenarios
Ofgem	Office for Gas and Electricity Markets
RHI	Renewable Heat Incentive

Term	
RO	Renewables Obligation
RTFO	Renewable Transport Fuel Obligation
Solar PV	Solar Photovoltaic
ToUT	Time-of-Use tariffs
TO	Transmission Owner
TSO	Transmission System Operator

APPENDIX 5 **ABOUT THE PARTNERS**

LIGHTSOURCE

Lightsource Renewable Energy develops and operates the largest fleet of commercial solar PV projects in the United Kingdom. Lightsource has established a proven and unrivalled track record in the design, installation and management of solar PV projects across the country. Headquartered in London with satellite offices based in Bath, Edinburgh and Belfast, the Lightsource team of 350 full-time specialists are on hand to manage the entire process of the project, ensuring a hassle free solution.

FORESIGHT GROUP

Foresight is a leading, independent infrastructure and private equity investment manager owned by its partners, who together have combined investment experience of over 200 man years across a wide variety of sectors. With current assets under management of over £1.5 billion, raised from UK and international private and high net-worth individuals, family offices, pension funds and other institutional investors, Foresight strives to generate increasing dividends and capital appreciation for our investors over the long term. Foresight has invested in the solar industry since 2008 – principally as equity investors. Foresight currently manages £1,009 million of solar assets across the group, with a team of 29 investment professionals.

GOOD ENERGY

Good Energy is the first dedicated 100% renewable electricity supplier and supplies over 55,000 electricity customers, 28,000 gas customers and support over 93,500 homes, business and communities generating their own energy. Good Energy sources energy from independent generators throughout the UK and owns four solar farms.

UKPN (DATA INPUT PROVIDER)

UK Power Networks (UKPN) is a distribution network operator that owns and maintains electricity cables and lines, maintains and upgrades power equipment and moves and connects new electricity cables across London, the South East and East of England. UKPN was awarded £13.2 million in 2012 from Ofgem's Low Carbon Networks Fund to develop the Smarter Network Storage Project in Leighton Buzzard.

UKPN has provided assistance on the network implications of integrating decentralised energy with the electricity power system, and the current regulatory and market issues which, if addressed, would permit electrical energy storage to play a wider role in maximising the efficiency of the whole electricity system.

TESLA (DATA INPUT PROVIDER)

Tesla is a technology and design company with a focus on energy innovation. In 2016, Tesla will release its Powerwall product, a home battery that can allow customers to store energy from their own generation.

Tesla provided data input on storage technologies.