Distributed generation and demand study - Technology growth scenarios to 2030

South west licence area

January 2016

Final version- Revision A

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2.1 Strategic grid investment

In response to increasing levels of grid constraint within the distributed network across the UK, Ofgem and DECC have invited Distributed Network Operators (DNOs) to consider a more proactive approach to anticipatory grid investment to support the future growth of distributed generation (DG).

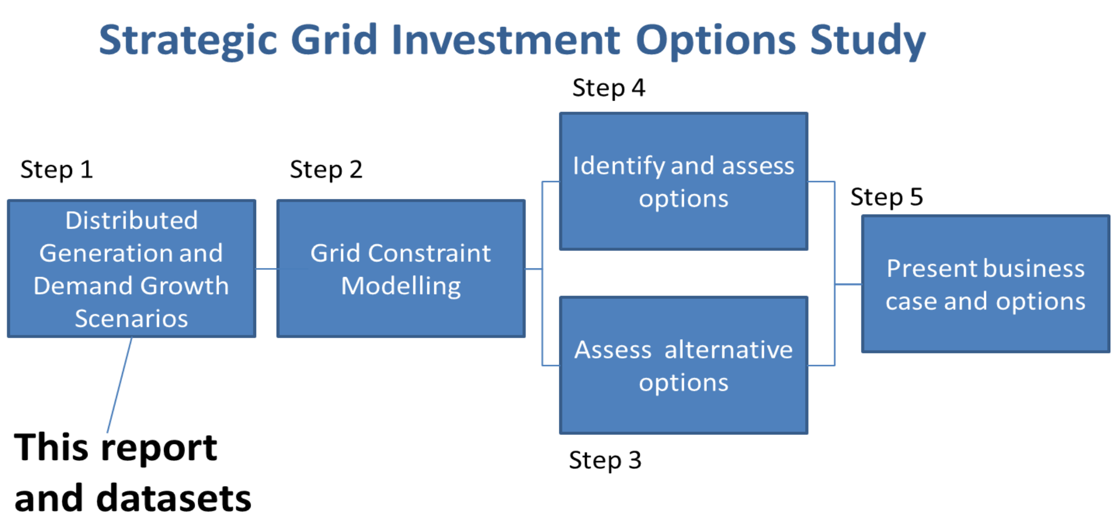
The "Next Step" guidelines[1] issued by Ofgem as part of the "Quicker and more efficient connections" consultation state that, in the future, anticipatory investment to support electricity generation may be undertaken by DNOs in cases where there is a strong evidence base to support investment, backed by local stakeholders, and a low risk of stranded or non-value added investment. Grid investment should also be considered alongside other solutions to grid constraints, such as effective queue management, flexible connection agreements and demand side response.

The guidelines have identified three potential models under which costs of anticipatory investment could be recovered. These include:

i) cost recovery from all customers (socialised)
ii) cost recovery from subsequent connection customers, and
iii) costs funded by 3rd parties on behalf of future customers (from whom they recover costs).

As a next step, Ofgem has now invited DNOs to come forward with their own proposals, and case studies, identifying potential grid reinforcement options with supporting evidence.

Pre-empting this development, Western Power Distribution has begun a **Strategic Grid Investment Options Study** for the south west licence area. The study methodology has four keys steps:



[1] Next Steps – Quicker and more efficient grid connections

This report with the accompanying datasets is the output of the first step in the methodology: to assess the future distributed generation and demand growth scenarios from the current 2015 baseline to 2030. It is intended that this analysis will provide input that will then enable WPD to model future grid constraints and identify potential investment options.

Technologies covered by the analysis include energy generation technologies, energy storage and demand technologies:

Key distributed generation, storage and demand technologies assessed

Electricity Generation Technologies

- Solar PV – ground mounted
- Solar PV – roof mounted
- Onshore wind – large scale
- Onshore wind – small scale
- Anaerobic digestion – electricity production
- CHP
- Heat pumps (communal/commercial)
- Hydropower
- Emerging and new DG technologies
  - Geothermal
  - Tidal stream
  - Wave energy
  - Floating wind
- Conventional and STOR DG capacity
  - Gas, diesel and gas CHP

Electricity Demand Technologies

- Electric vehicles
- Heat pumps (domestic)

Energy (electricity) storage

- Energy storage 'network support'
- Energy storage 'generation support'
- Energy storage 'own use'

Not assessed – tidal range and offshore wind, both of which it is assumed would connect directly to the transmission network.

2.2 Distributed generation and demand growth scenarios

Forecasting the long term growth of any generation or demand technology is extremely difficult and complex owing to the multiple variables that can affect the market and determine growth. Historically, the industry and government agencies have failed to anticipate the rapid growth of solar PV, while at the same time overestimating the growth rate of electric vehicles and heat pumps.

The approach taken to assess distributed generation and demand technology growth in the south west has been to take, as far as possible, a bottom-up approach to quantify the current baseline and the short term pipeline projection for each technology. An overall scenario based growth projection to 2030 was then estimated, based on the four Future Energy Scenarios (FES)[2] that have been developed by the National Grid.

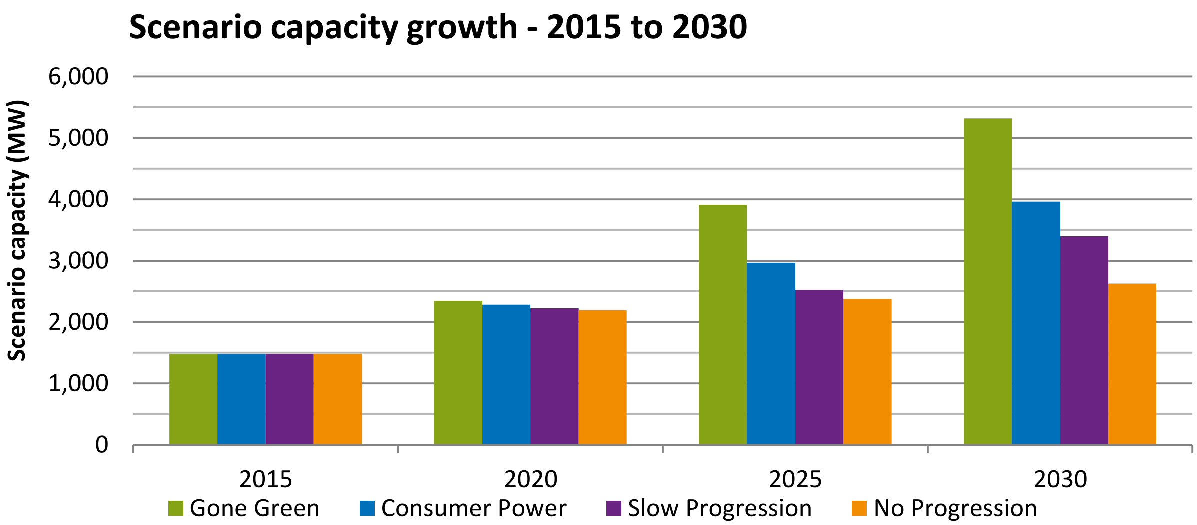
Focusing on the specific geographical region of the south west, with access to existing baseline data and a good knowledge of the local industry and growth factors, enabled the analysis to be taken down to the Bulk Supply

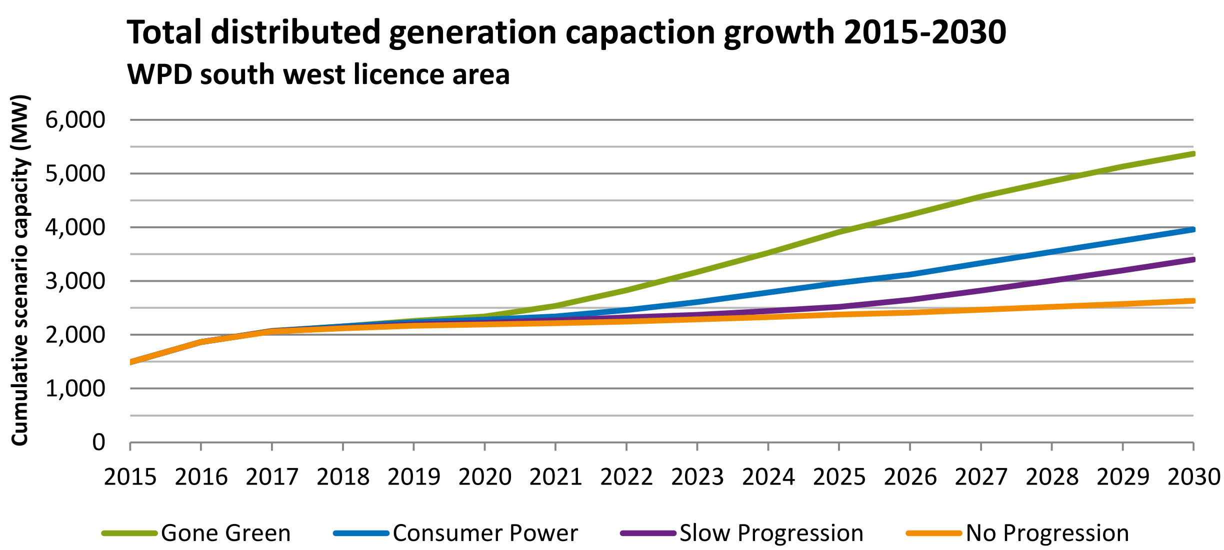
[2] National Grid Future Energy Scenarios 2015

Point (BSP) area level, which is the key level at which strategic investment decisions are likely to be taken by DNOs.

The results of the assessment, which are presented in each of the technology chapters below, and the accompanying datasets, provide a projection of annual capacity deployment, by technology and by FES, for the period from 2015 to 2030.

The summary results of the distributed generation scenarios are shown in the table below and show a growth from a current (October 2015) baseline capacity of circa 1.5 GW to circa 5 GW by 2030 under the most ambitious Gone Green scenario. Growth estimates for the other scenarios, Consumer Power, Slow Progression and No Progression are lower. However, even under the lowest No Progression scenario, there is an expected growth pathway to 2.5 GW of distributed generation capacity by 2030.





Storage, heat pumps and electric vehicles growth summary

Technology	Scenario	2020	2025	2030
Heat pump capacity (MW_{th})	Gone green	120	383	884
	Consumer power	123	294	632
	Slow progression	97	241	518
	No progression	60	109	177
EV peak demand (MW)	Gone green	11	15	33
	Consumer power	11	42	91
	Slow progression	7	8	16
	No progression	5	12	24
EV numbers	Gone green	30,625	100,126	197,334
	Consumer power	30,625	100,126	197,334
	Slow progression	18,464	48,812	101,199
	No progression	11,538	25,847	54,887
Own use storage (MWh)	Gone green	31	184	306
	Consumer power	33	138	327
	Slow progression	25	42	100
	No progression	5	9	17
Network support (MW)	Gone green	72	140	270
	Consumer power	35	120	247.5
	Slow progression	17.5	70	105
	No progression	0	17.5	35
Network support (MWh)	Gone green	216	420	810
	Consumer power	105	360	742.5
	Slow progression	52.5	210	315
	No progression	0	52.5	105

2.3 Growth factors and growth scenarios

For most technologies, the growth assessment has been split into three distinct pieces of analysis:

- **A baseline assessment** – taken as of end October 2015 – which has a high degree of accuracy based on Regen SW's project database, updated with the latest FIT and RO data and reconciled with WPD's grid connection database.
- **A pipeline assessment** – looking out to either 2017 or 2020 – which has a reasonable degree of accuracy since it is based on a good understanding of the current project pipeline, current market conditions including the policy changes that have been introduced since the June 2015 election, and reconciled with the DECC planning database and WPD's grid connection agreement database.
- **A scenario projection** – out to 2030 – which is based on the FES scenarios, assessed and interpreted to take into consideration the specific local resources, constraints and opportunities for each technology type in the south west of England.

The longer term growth projection to 2030 is subject to a number of growth factors, constraints and policy changes that have been captured within the FES Scenarios. Key areas of uncertainty and potential change include:

- The energy strategy of future governments and the degree to which renewable energy technologies are supported vis-à-vis other technology options, such as gas generation and nuclear.
- Relative market prices, including electricity wholesale price, underlying gas and oil price changes, and the relative Levelised Cost of Energy (LCOE) of different generating technologies.
- The timescales by which different technologies reach 'price parity', the point where deployment of new generation capacity is no longer reliant on direct subsidies.
- The effectiveness of the government's current drive to increase gas power generation, as a replacement for coal, and the potential roll-out of new nuclear.
- The rate of adoption of technology development and innovation, especially in those new technology areas such as energy storage, marine energy and electric vehicles.
- The impact of new pricing and business models, including the potential for integrated solutions, including generation, energy storage and demand side response.
- Adoption of an effective carbon price – as per the Committee on Climate Change 5th Carbon Report[3].

[3] Committee on Climate Change 5th Carbon Budget Report

Distributed generation capacity growth by technology type (MW) – 2015 to 2030

Technology	Scenario	2015	2020	2025	2030
Solar	Gone green	1160	1769	3014	3800
	Consumer power	1160	1750	2299	3100
	Slow progression	1160	1689	1870	2520
	No progression	1160	1674	1812	2000
Wind	Gone green	237	332	522	800
	Consumer power	237	332	419	550
	Slow progression	237	332	396	550
	No progression	237	332	354	395
Marine	Gone green	0	24	88	415
	Consumer power	0	14	36	78
	Slow progression	0	12	30	70
	No progression	0	5	13	26
Anaerobic digestion	Gone green	33	56	94	131
	Consumer power	33	50	70	91
	Slow progression	33	50	70	91
	No progression	33	46	59	71
Geothermal	Gone green	0	17	36	52
	Consumer power	0	0	0	0
	Slow progression	0	17	17	17
	No progression	0	0	0	0
Energy from waste	Gone green	39	129	141	153
	Consumer power	39	124	124	124
	Slow progression	39	129	141	153
	No progression	39	124	124	124
Hydropower	Gone green	11	14	17	20
	Consumer power	11	13	16	19
	Slow progression	11	13	15	17
	No progression	11	13	14	14
Total	Gone green	1479	2343	3911	5370
	Consumer power	1479	2283	2964	3962
	Slow progression	1479	2224	2522	3418
	No progression	1479	2194	2375	2630

While specific drivers are best considered in detail on a technology by technology basis, there are some fundamental assumptions that are captured in the Future Energy Scenarios.

Under the Gone Green scenario, for example, it is assumed that future government policies are consistent with the decarbonisation targets set for 2030 and 2050, and reinforced by the recent commitments made at the Paris COP. It is also assumed that market conditions, financial support and technology development is conducive to the growth of renewable energy distributed generation, allied to the growth of energy storage solutions and electricity demand technologies, such as electric vehicles and heat pumps.

The Consumer Power and Slow Progression scenarios have more modest growth projections in the south west, although the development of renewable energy technology and demand technologies is still strong. The Consumer Power scenario has a particular resonance with the south west of England since the scenario's emphasis on smaller scale generation and local supply through individuals, communities and other organisations is already a characteristic for many of the projects in the region.

Only under the No Progression scenario, a scenario in which there is a continued dependence on fossil fuels that would not be consistent with the UK's stated decarbonisation and climate change commitments, does renewable energy and distributed generation fail to show significant growth potential in the south west.

2.4 Impact and critical role of grid

In the next phase of the study, the distributed generation and demand growth scenarios will be used to analyse future grid capacity constraints to identify pinch points and options for strategic investment. Already, however, the scenario assessment has identified a number of factors that are pertinent to the discussion about grid investment and its critical role to sustain future generation growth.

The analysis of solar PV and the distribution of PV farms demonstrate clearly that access to grid is of paramount importance for PV project developers. The analysis of anaerobic digestion and marine energy also demonstrates that for new technologies, which are of strategic importance to the south west economy, access to grid will be vital to enable the first pilot and demonstration projects to be deployed.

2.5 Impact and role of new technologies and business models

A key theme that comes through the analysis is the potential 'disruptive' impact of new technologies and new business models. The chapter on energy storage, for example, identifies a number of new and emerging business models, under the headings of 'consumer support', 'generation support' and 'network support', which could revolutionise the way in which energy is used, traded and distributed.

Whether these business models come to fruition will depend partly on the development of technology – and technology costs – but also on how the market evolves commercially and in terms of its policy/regulatory framework. Already, however, we can see examples in other countries where energy storage is quickly becoming a critical part of the energy network.

The potential widespread growth of demand side technologies, such as electric vehicles, heat pumps and other forms of electric heat solutions, will also have far reaching impacts both on the supply of electricity and creating new opportunities for distributed generation.

Taken to another level, the emergence of integrated systems (sometimes described as 'multi-vector' infrastructure) combining electricity generation, heat, transport and energy storage solutions, may also significantly change the role of grid networks and network operators.

2.6 Geographic spread of distributed generation and demand technologies.

Alongside the technology dimension, a key challenge for the assessment has been to understand and forecast the likely geographic spread of generation and demand technologies across the south west licence area.

To do this, the study has used Geographic Information System (GIS) analysis to map existing capacity within the network BSP areas and then to forecast future growth, based on a number of geographic factors. The BSP level analysis has produced a further level of detail and a greater understanding of what factors determine where certain types of electricity generation technologies projects are likely to be located.

For ground mounted solar PV, for example, the overriding factor appears to be access to grid. For onshore wind, grid is important, but areas of high wind resource (velocity), undesignated land space and distance from dwellings are the key determinants of project location. Hence, onshore wind tends to be concentrated in a northern arc from Cornwall, through Torridge and North Devon.

For other technologies – heat pumps, roof mounted solar and AD for example – other factors come into play such as the relative density of households, off-gas grid properties, agricultural activity and even relative affluence.

For marine energy, and also geothermal, the overriding factor is the location of the energy resource and other spatial constraints that determine where projects can be built and therefore the location of grid infrastructure.

Key growth factors by technology

Technology	Key growth drivers	Basis of forecasted BSP distribution
Onshore wind	• Planning policy • Local support • Government support • Grid availability • Price parity	• Positive local authority planning environment • Resource assessment. Includes environmental and technical factors, such as AONBs, wind speed and noise separation distances • Cumulative impact and historic trends
Ground-mounted solar PV	• Planning policy • Government support • Grid availability • Price parity and technology innovation • New business models	• Resource assessment. Includes environmental and technical factors, such as National parks, grade of agricultural land and proximity to grid
Rooftop solar PV	• Price parity and technology innovation • New business models	• Historic trends • Number of buildings
AD	• Planning policy • Local support • Government support • Grid availability • Price parity	• Agricultural land distribution
Hydropower	• Environmental constraints • Local support • Grid availability • Price parity • New business models	• Historic trends • Hydropower resource assessment - an analysis of all obstacles on a river, including available head and flow rate
Heat pumps	• Government support • Technology performance • Price parity • Public awareness	• Distribution of off gas houses • Distribution of on gas houses • Historic trends
Energy from waste	• Government support • Grid availability • Price parity • Availability of waste	• Population centre numbers
Consumer own use energy storage	• Cost reductions and/ or subsidy • Public awareness • High numbers of PV and other DG projects • Increasing electricity prices • Time of use tariffs • Growth of private wire applications	• Distribution of current rooftop PV systems for retrofit installations • Distribution of projected rooftop PV systems for new build installations
Electric cars	• Public awareness • Cost reductions • Electric car infrastructure • Technology innovation	• Total number of households • Historic trends of domestic solar PV uptake within a BSP
Geothermal	• Government and policy support • Investment and innovation • Grid availability	• Geothermal potential based on temperature of rock
Marine	• Government and policy support • Investment and innovation • Success of pilots • Grid availability	• Energy resource availability • Marine spatial constraints • Ports and infrastructure • Demonstration zones

3 Introduction and study objectives

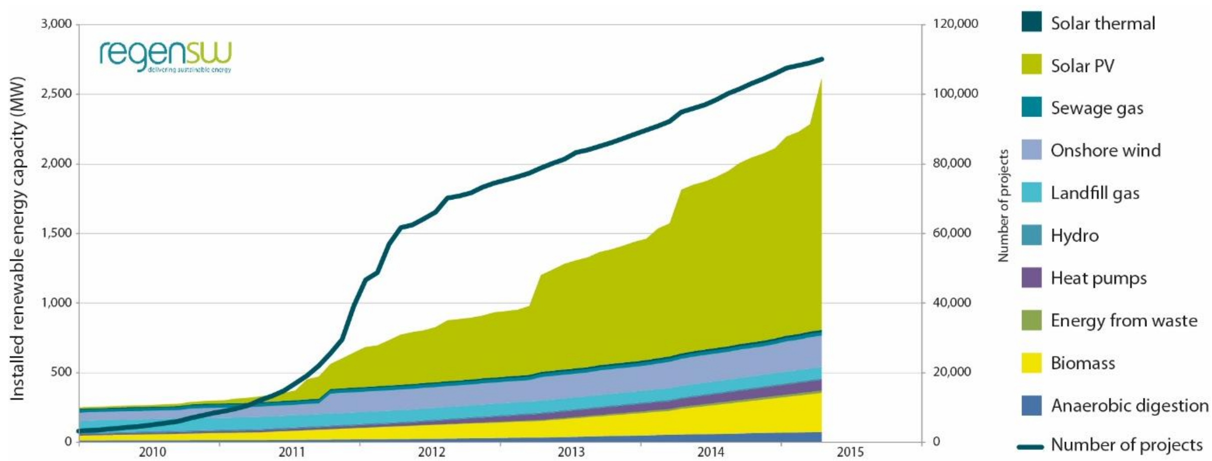
3.1 Context - growth of distributed generation

In common with other DNOs, in the past three years WPD has seen a significant growth in both connected distributed generation (DG) capacity and accepted connection agreements for distributed generation technologies.

The rapid growth of DG capacity (connected and accepted for connection) has exceeded the level that was estimated in WPD's 2013 business plan and now means that WPD is managing a high number of grid capacity constraints across all its licence areas.

The south west licence area has seen a significant level of DG growth across all renewable energy technologies, but particularly through the rapid growth of solar PV and wind farms. As figures from the Regen SW Renewable Energy Progress Report show, renewable electricity capacity has grown exponentially since 2011 and jumped by 88 percent in the year from 2014.

South west renewable energy capacity growth – source: Regen SW Progress Report 2015

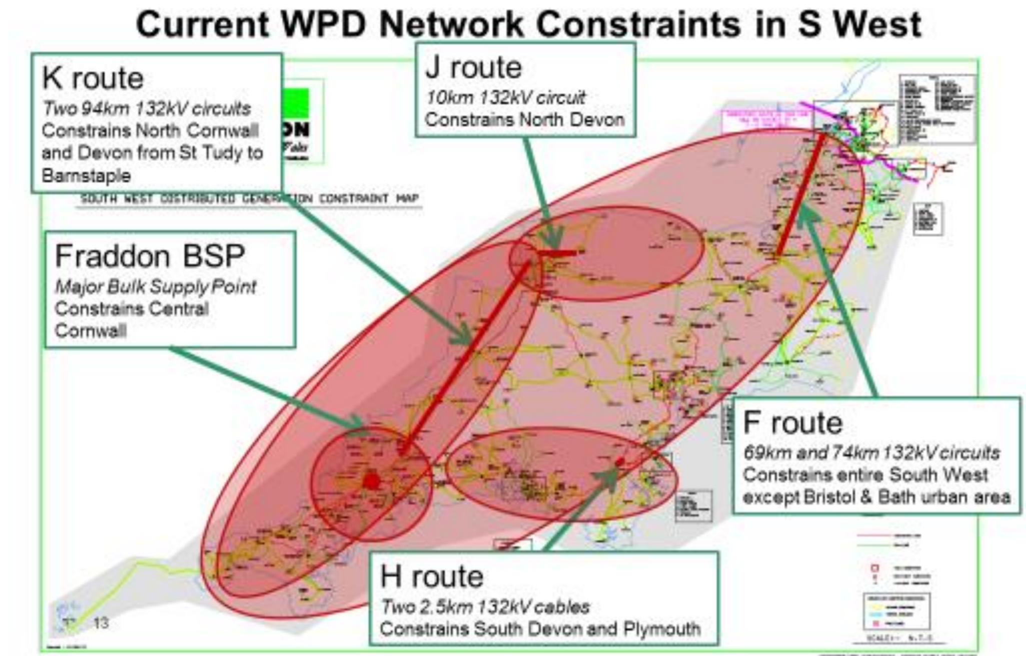


3.1.1 Grid Constraints

The increase in distributed generation, without a significant rise in electricity demand, has resulted in much of the available capacity in the distributed electricity network being allocated at all voltage levels, including up to the 132 kV network.

While the south west of England is not unusual in having a number of grid constraints, the grid situation in the region has been exacerbated since the region has a number of pinch points that affect the transmission of electricity out of the region. Specifically, there are two national grid lines and one WPD line that carry power into (and increasingly out of) the south west.

The “F” route (WPD 132 kV WPD line that runs from Bridgwater Grid Supply Point (GSP) to Seabank GSP in the Bristol docks area), has reached capacity and is one of a number of constraints across the network that WPD is currently managing.[4]



As a consequence, WPD have announced that a delay of three to six years will be included in new connection offers for all generation projects seeking to connect to the grid requiring works at High Voltage (HV) level (i.e. 6.6 kV or 11 kV) or above. The restrictions apply to the entire WPD south west region below Bristol and Bath.

3.1.2 Managing existing grid constraints

Both WPD and Ofgem are looking at a number of measures that could mitigate or alleviate the current grid constraints and in February 2015 Ofgem also issued a consultation on “Quicker and More Efficient Distribution Connections”.

Potential measures include more effective queue management (managing the pipeline of projects with or awaiting grid connection agreements), and encouraging project developers to collaborate together in a consortia to share grid reinforcement costs and realise economies of scale.

The picture in the south west is complicated by the large number of projects that are currently in the pipeline, either having accepted a connection agreement (committed) or with a connection agreement offer (offered).

[4] See WPD’s published note on south west grid constraints http://is.gd/UEWD7E

Western power distribution grid connection pipeline summary (Oct 2015)

Generation type	WPD – south west generator connections (MVA)			Total (MVA)
	Connected	Committed	Offered	
Photovoltaic	1,018.0	1009.2	511.5	2,538.7
Wind	200.6	241.9	45.8	488.2
Landfill and sewage gas, biogas, waste incineration	55.1	113.6	33.0	201.7
CHP	20.9	1.8	0.9	23.6
Biomass and energy crops	0.2	2.2	1.3	3.6
Hydro, tidal and wave power	2.5	3.0	-	5.5
Other generation	468.9	245.1	422.8	1,136.8
Total	**1,1766.1**	**1,616.7**	**1,015.2**	**4,398.1**

If all the ‘committed’ and ‘offered’ connections were indeed taken up, the distributed generation capacity in the south west would more than double from 1,766 MVA to 4,398 MVA. This outcome is unlikely since many of these projects will not proceed and are likely to drop out of the pipeline owing to planning or other commercial issues. The drop-out rate is itself likely to increase as the result of recent policy changes introduced this year such as the reduction and removal of subsidy support and new planning restrictions. Understanding the potential rate of drop out and managing the queue of remaining projects has therefore become a key priority.

WPD is also rolling out a range of alternative connection offers including ‘timed connections’ and ‘constrained connections’, which can allow connection agreements to be made but with constraints on the time or voltage outputs. This reduces the income from generating plants by restricting their export, but can be feasible for some generation technologies.

WPD is also beginning to roll out more sophisticated ‘active network management’ connections. These rely on WPD having real time information on the grid to allow generators to connect to the network and generate, but be disconnected when there is an actual problem.

In the longer term, the deployment of smart grid solutions, including demand side response, will help to reduce supply/demand imbalances in the grid. Energy storage solutions are also developing rapidly and are becoming commercially viable.

Summary of WPD Grid mitigation measures:

- Queue management/capacity recovery
- Alternative connection agreements – timed and soft-intertrip
- Active Network Management(ANM)
- Consortia/grid collaboration agreement with Regen SW
- Smart solutions ,such as demand side response (sunshine tariff) e.g. WREN Sunshine Tariff project
- Energy storage solutions – pilot projects e.g. SoLA Bristol
- Strategic grid investment options

3.2 Strategic grid reinforcement

Smart solutions, energy storage and network management will help to alleviate grid capacity constraints; however, there is a recognition that significant grid reinforcement, and investment in grid infrastructure, will still be required to allow the UK to transition towards low carbon and distributed generation technologies.

The existing business plans and regulatory environment in which the DNOs operate allow for a very limited amount of strategic grid reinforcement. It is also still the case that, in principle, any grid reinforcement must be borne directly by energy generators. While this approach has limited the potential cost to consumers of grid reinforcement, it has also inhibited long term strategic investment to meet future requirements and has arguably prevented DNOs taking advantage of significant economies of scale.

There is a growing recognition that the current approach is no longer fit for purpose and that there is a need to look at new business models that would allow DNOs to carry out strategic reinforcement where there is clear evidence of future demand. As a result, Ofgem have now added to their consultation a question on whether the rules should be changed to enable DNOs to carry out strategic reinforcements based on evidence of demand and to address the corollary question of "who should pay?"

DECC Secretary of State, Amber Rudd, has also indicated that in future strategic or pre-emptive investment may be supported - "*Earlier this year, Ofgem through its Quicker and Efficient Connections consultation, set out* ***options for enabling more anticipatory investment****, which could help speed up connection times by creating capacity earlier, and sought views on other ways of improving the connection process."* Amber Rudd to ECC Select Committee September 2015.

3.3 Building a case for strategic grid reinforcement

In anticipation that the rules and regulatory model governing grid reinforcement may be changed, WPD have begun to develop an approach to identify, assess and provide a business case justification for future strategic reinforcement proposals.

While grid reinforcement decisions will need to be justified on a case-by-case basis, it is likely that the starting point to identify strategic investment options will be to identify the grid network areas with:

1. Currently low or no spare capacity
2. A viable network reinforcement opportunity
3. High potential for growth of future distributed generation
4. Least risk of investment regret or stranded assets
5. A strong supporting business case for investment, potentially backed by local stakeholders
6. A clear model for cost recovery

To identify and provide an evidence base to support strategic investment options, WPD has set out a 5 Step methodology.

Strategic grid investment business case development	
Step 1. Distributed Generation and Demand Growth Scenarios (this report)	Assessing the potential growth in DG and demand by technology type, BSP location and year , by scenario
Step 2. Grid constraint modelling	Identifying thermal, voltage and fault level constraints that result from scenario modelling
Step 3. Identify and assess options • **Estimate the capacity provided by these solutions** • **Assess cost/timescale of these solutions**	Identify and cost a small number of potential grid reinforcement strategic investments Identify future network solutions (including required National Grid electricity transmission upgrades)
Step 4. Assess alternative options	Assess the potential for DSR, energy storage or generation constraint take up, given the cost of network solutions
Step 5. Present business case and options	Present business case and recommended investment options

The analysis presented in the remainder of this document is focused on the first step of this approach. It is intended to allow WPD to assess future potential growth of distributed generation and demand, providing the key inputs to help WPD identify areas of the network (at BSP level) that require grid reinforcement and to make a business case for 'least risk' investment.

4 Distributed generation and demand – growth scenarios methodology overview

4.1 Objectives and output

The overall objective of the DG and Demand Growth Scenarios Assessment is to assess the potential deployment of distributed generation and new electricity demand technologies in the WPD south west licence area from 2015 to 2030, using as a starting point the Future Energy Scenarios (FES) developed by the National Grid.

The end output of the assessment is a number of data sets accompanied by an analytical report, which gives an annual capacity growth projection from 2015-2030 by BSP area and technology type, including:

- Current (2015) distributed generation capacity connected
- Pipeline analysis of DG capacity up to 2020
- Scenario analysis of DG technology capacity growth from 2020 – 2030 building on the FES
- Scenario analysis of potential future demand from 2015-2030 (including heat pumps and electric vehicles) building on the FES

Where appropriate, GIS based maps have also been provided to illustrate the geographic spread of technology growth.

4.2 Assessment scope

4.2.1 Definition of distributed generation

For the purpose of this assessment, the definition of Distributed Generation is all electricity generating projects connected at the 132 kV network and below.

The impact from the growth of other types of large scale generation such as large scale Biomass CHP, Gas Powered, Nuclear, Tidal Lagoons and Offshore Wind farms connecting directly to National Grid Electricity Transmission owned assets will need to be assessed on an individual basis.

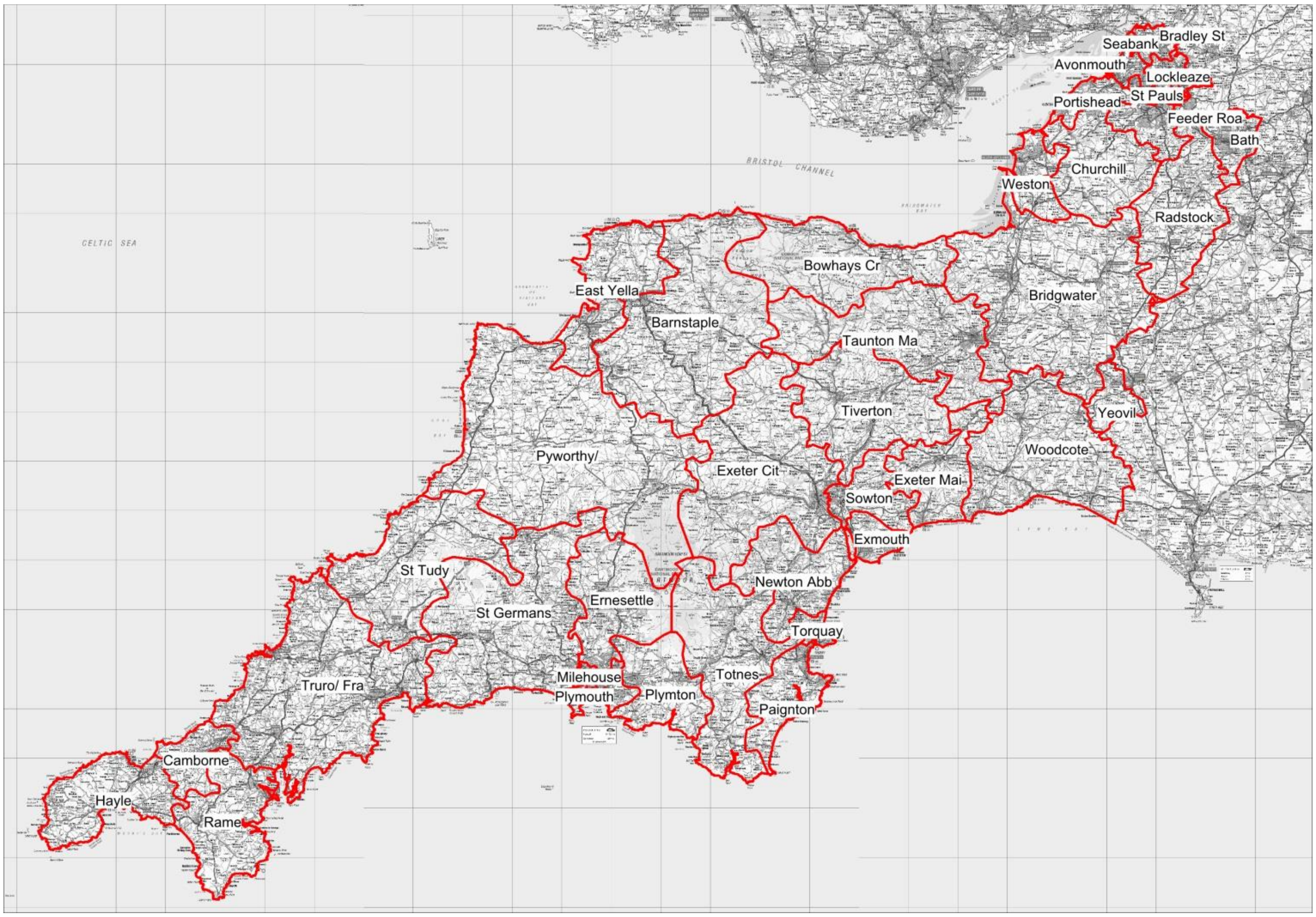
4.2.2 Geographic scope and Bulk Supply Point (BSP) mapping

The assessment scope is based on the WPD licence area, but, with further development, it could be applied to other licence areas.

The methodology is intended to support strategic investments that are likely to be made to the 132 kV network (and potentially some 33 kV substations) and is therefore intended to support analysis at the BSP level, or in other words the main interface between the 132 kV network and the 33 kV network.

There are currently over 40 BSPs, which have been grouped into 38 BSP areas. The BSP Areas form the main geographic breakdown for demand and generation analysis. The south west licence area and BSP areas are shown in the map below.

Bulk Supply Point areas (BSPs) areas within the south west licence area



4.3 Methodology - overall approach

The methodology to assess potential DG and demand growth for each technology is broken down into three phases:

Stage 1
Current baseline

Stage 2
Pipeline projection
Near term
(where possible to 2020)

Stage 3
Growth scenarios
Longer term (to 2030)

Current data
Use and validate existing DG capacity and demand data to set baseline

Pipeline projection
DG projects w/connection agreement and in planning system
Growth estimate for small scale FIT and new projects
Demand projection

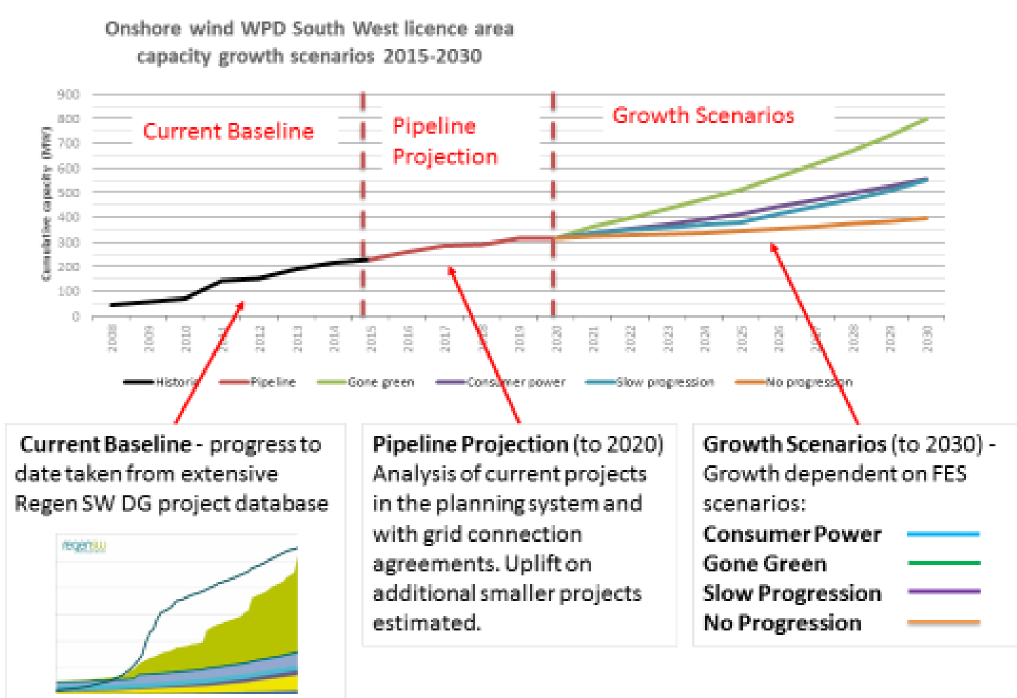
Long term energy potential
- Long term energy assessment
- Developable resource
- Market Assessment
- Demographics
- New technology potential

Analysis by:
1) Technology type
2) BSP Areas
3) GIS mapping
4) Historic growth trend

Constraints/ factors:
1) Grid constraints
2) Policy - RO/CFD/FIT cap and subsidy
3) Planning system
4) Technology (TRL)

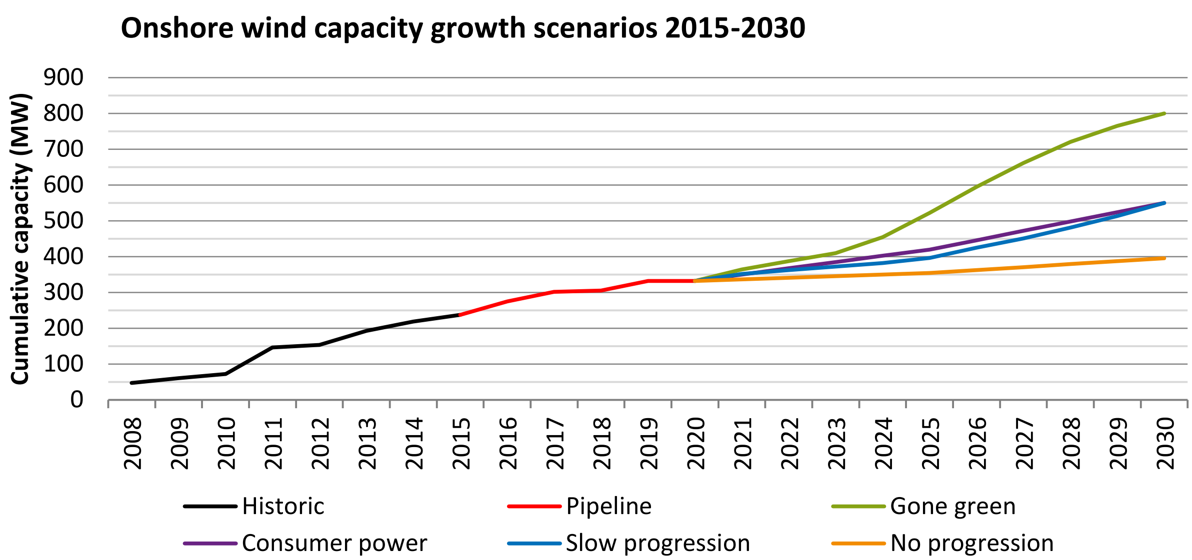
Apply future energy growth scenarios factors:
1) Gone Green
2) Consumer Power
3) Slow Progression
4) No Progression

Methodology overview- example onshore wind



5 Onshore wind – technology growth scenarios

5.1 Summary onshore wind growth scenario 2015-2030



Baseline, pipeline and scenario capacity summary

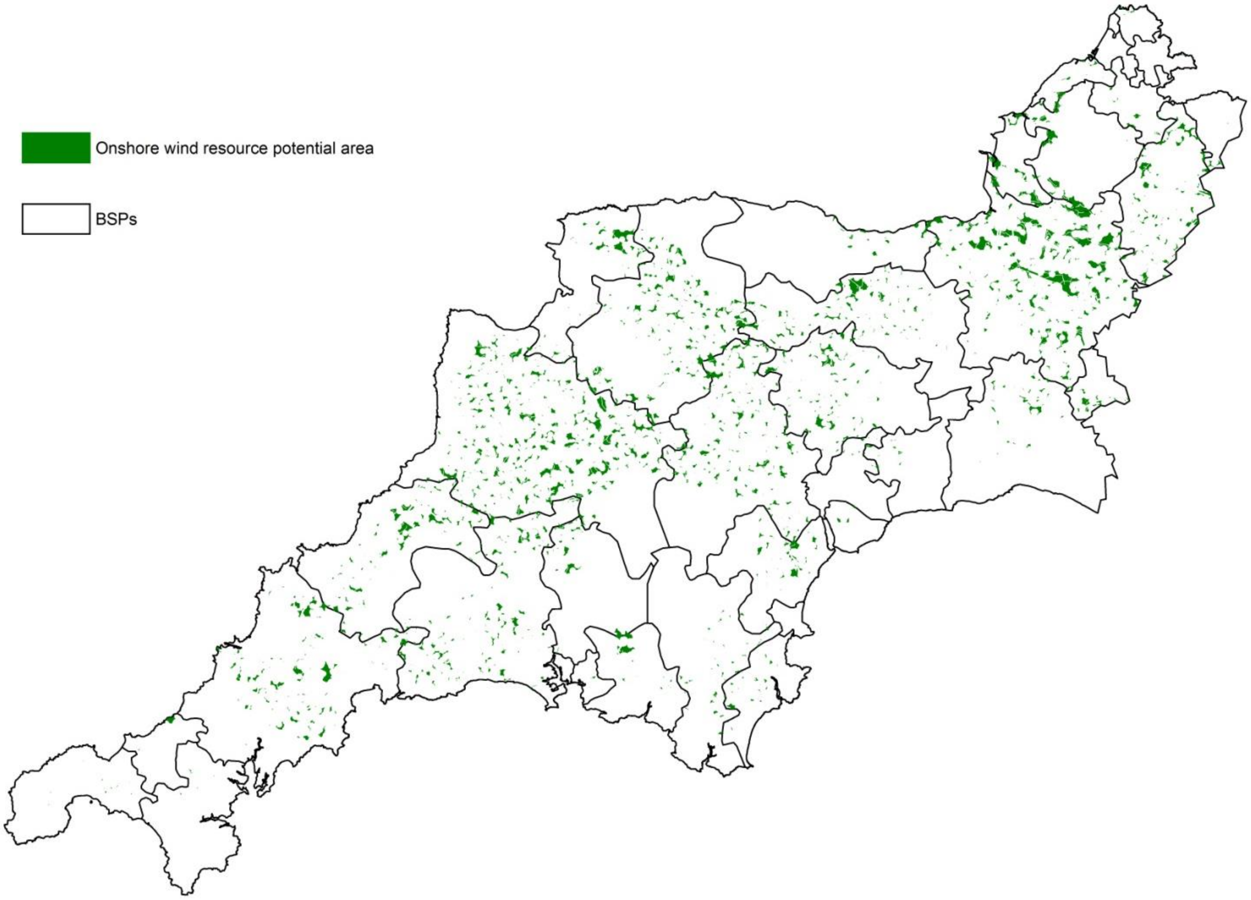
Scenario	2015 baseline (MW)	2020 pipeline (MW)	2020 to 2030 Projection (MW)	Total (MW)
Gone green	237	95	451	800
Consumer power	237	95	218	550
Slow progression	237	95	201	550
No progression	237	95	63	395

5.2 Onshore wind – future energy potential

The GIS map below identifies potential onshore wind development areas by BSP area. Potential development areas have been identified based on key criteria which include:

- Wind speed/wind resource
- Minimum distance from dwelling
- Environmental and landscape designations

Potential wind development areas by BSP within the WPD south west licence area



The analysis shows that there are approximately 2,000 potential onshore wind development zones – shown as green areas. These range in size from small single site zones of 0.01 km² to zones of 10 km² and above which could accommodate larger wind farms, or multiple smaller wind turbines.

Given the constraints applied, the total developable area in the south west is just under 500 km², which represents less than 4 percent of the total land space.

Developable zones are highly concentrated in those BSP Areas that have a combination of high wind resource and are relatively unpopulated. The top 10 BSP Areas account for over 84 percent of the developable land space and tend to follow a northern swathe across Cornwall, North Devon and Somerset.

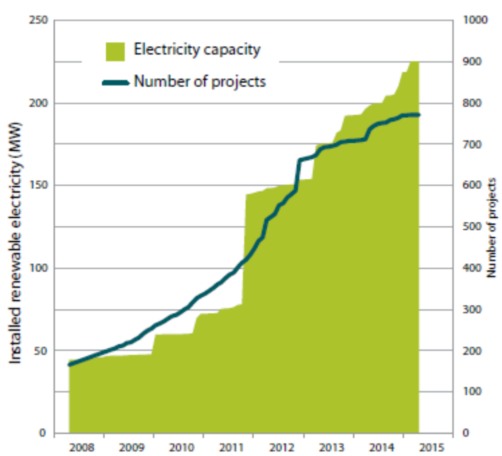
If fully developed, the developable areas in the south west could theoretically host an onshore capacity of over 4 GW. However as the analysis in this chapter shows, under no future scenario is the south west expected to reach this theoretical capacity.

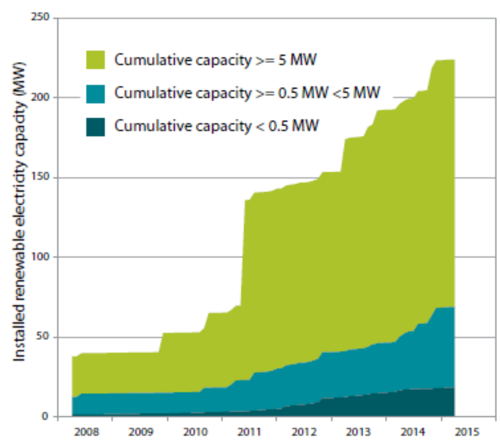
5.3 Historic growth and baseline capacity (October 2015)

Baseline as of October 2015	Capacity
Total UK onshore wind installed capacity	Approximately 8.5 GW
England and Wales installed capacity	Approximately 2.7 GW
WPD south west area installed capacity	Approximately 237 MW

Despite being one of the first regions in the UK to host a commercial windfarm, the development of onshore wind in the south west has been variable. The WPD south west area currently has 237 MW of installed capacity, representing 8.5 percent of the England and Wales installed capacity.

Trends in the growth of onshore wind in the south west of England

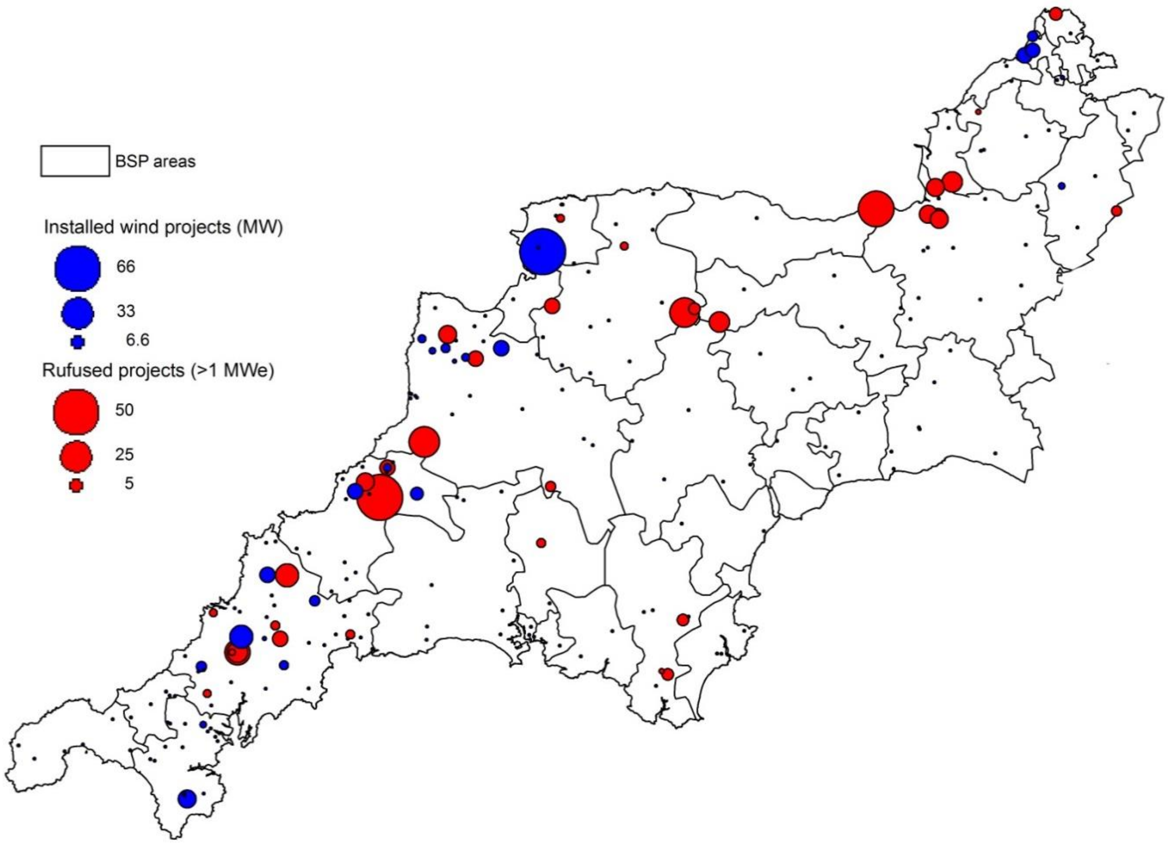




The majority of projects have been small single turbines, however, historic deployment rates have varied year-on-year and have been influenced by a small number of larger windfarms such as the 66MW Fullabrook wind farm in North Devon.

The map below shows the location of larger onshore wind projects that have been successfully built (blue) and those that have been rejected or withdrawn in the planning process (red). The map demonstrates the expected trend that developers have tended to concentrate on sites across the north of the region where there is better wind resource, more open land space and proximity to main grid connections.

Operational and rejected at planning onshore wind farms



5.4 Pipeline projection to 2020

Based on an analysis of the DECC planning database and WPD connection agreement data, it is expected that a further 95 MW of onshore wind could be added by 2020. This projection is based on those wind farms that:

- are already under construction or have both planning permission and grid connection agreement
- one larger project which is currently in appeal but the developer is reasonably hopeful of winning
- plus an estimate of 15 MW of small scale wind projects.

The build out of most pipeline projects is expected to take place before March 2017, when the grace period for schemes supported under the RO scheme expires.

Owing to recent changes in planning guidelines and curtailment on ROs, there are proposed projects totalling 54 MW currently without planning or in appeal that are not expected to be built by 2020.

It is also assumed that the Government will continue to heavily restrict access to Contracts for Difference (CfD) for onshore wind and, even if allocations for CfD are permitted, auction processes will mean that any available CfDs will likely go to higher energy windfarm sites in Scotland.

Beyond the immediate pipeline therefore, the outlook for onshore wind in the south west to 2020 is extremely low.

5.5 Scenario growth analysis 2020-2030

5.5.1 Overall onshore wind DG growth by scenario

Based on the anticipated scenario factors described below, the overall DG growth for onshore wind by scenario is shown in the table below.

	Baseline 2015	Pipeline 2015 to 2020			Scenario 2020 to 2030			Project size split		2030 total capacity (MW)
Scenario	Total baseline capacity (MW)	Total pipeline capacity (MW)	Large scale (MW)	Small scale (MW)	Total scenario forecast (MW)	Small scale (MW)	Large scale (MW)	Small scale (%)	Large scale (%)	
Gone green	237	95	80	15	451	113	338	25	75	800
Consumer power	237	95	80	15	218	152	65	70	30	550
Slow progression	237	95	80	15	201	80	120	40	60	550
No progression	237	95	80	15	63	13	50	20	80	395

Key points to note:

- All scenarios show a slowdown in onshore wind deployment from 2017 to 2023 reflecting recent policy changes.
- Gone Green - it is anticipated that the south west would have a higher deployment of onshore wind compared to the historic trend and regional share. This reflects the fact that there is greater resource potential in the south west than has been historically exploited.
- No Progression - the south west would have a lower level of deployment when compared to other UK regions reflecting that the south west has a challenging planning environment and tends towards smaller projects.
- Slow Progression and Consumer Power result in a similar total capacity deployed, but the mix between larger scale and smaller scale is different for the two scenarios

5.5.2 Scenario factors impacting future onshore wind growth in the south west

FES Scenarios - Implications for onshore wind in the south west	
Consumer Power • Medium growth scenario • Higher proportion of smaller single turbine projects – individual landowners, farmers and community groups • Wind cost parity (SW) reached circa 2023-25 • SW growth slightly less than national FES growth scenario • Higher proportion of small wind projects • Projects focused in high resources areas but relatively distributed across BSP areas	**Gone Green** • Highest overall growth scenario • Both larger and small scale wind projects • Positive planning environment • Finance available • Wind cost parity reached 2020 • High carbon price • SW growth slightly above UK FES growth scenario and south west historic trend
No Progression • Lowest growth scenario • Poor planning and economic environment • Growth would be very slow to 2023 with an increase post 2024 as price parity met • Lead time in planning becomes a significant factor for any new projects to enter pipeline in the period to 2030 • Growth would be more weighted to economically viable (i.e. larger in prime resource areas) projects, though limited by planning	**Slow Progression** • Medium growth scenario • Positive planning environment • But poor economic and finance outlook • Wind cost parity (SW) reached 2024/25 for best resource areas • Higher proportion of larger wind farms • SW growth slightly less than UK FES • Projects focused in high resources areas in most attractive BSP areas

5.6 Key growth drivers and constraints in the south west to 2030

5.6.1 Planning constraints

The government issued a ministerial statement on 18 June 2015, stating that *"local authorities should only grant planning permission if:*

- *The development site is in an area identified as suitable for wind energy development in a Local or Neighbourhood Plan; and*
- *Following consultation, it can be demonstrated that the planning impacts identified by affected local communities have been fully addressed and therefore the proposal has their backing."*

To date, onshore wind sites are not included in the vast majority of local plans. Some local authorities are beginning to consult on onshore wind inclusion – for example North Devon and Cornwall – and there is some transitional provision allowing approvals where the development plan does not identify suitable sites. Community owned and backed schemes may also be considered more favourably.

However, there will inevitably be a hiatus and increased lead time before new projects can apply under the revised rules.

- Gone Green and Slow Progression Scenarios – it is assumed that planning guidelines support green energy deployment and planning authorities positively include onshore wind in local plans. This will take some time to work through the planning system and therefore successful project applications will begin to pick up after 2023.

- Consumer Power and No Progression Scenarios – planning guidelines continue to restrict onshore wind developments and except for schemes under Consumer Power that are community based or brought forward by small individual landowners, gaining planning permission for larger onshore wind farms is extremely difficult.

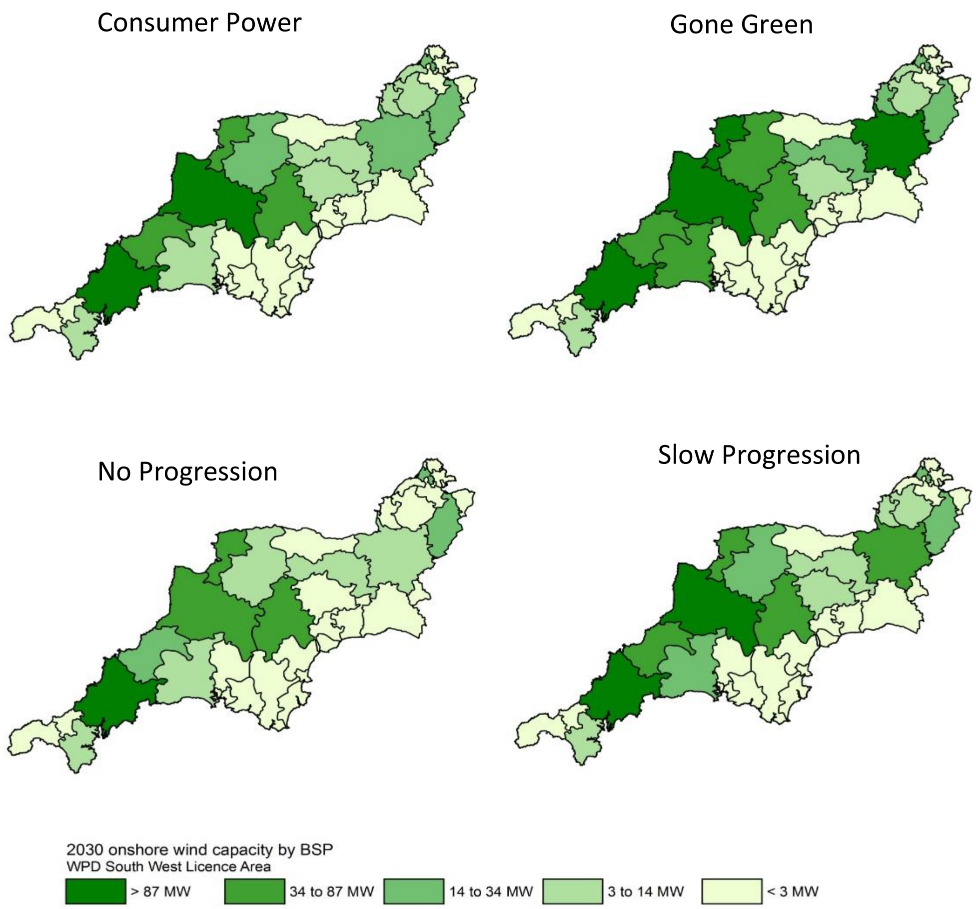
5.6.2 **Financial and cost of energy environment**

The government has announced that it intends to end all subsidies for onshore wind. This will have an immediate impact on the project pipeline to 2020, but will not have a significant impact beyond 2020, since the onshore wind industry is expected to reach price parity with other forms of low carbon energy and is expected to operate in a post subsidy environment.

The future development of onshore wind is therefore most likely to be impacted by the timing in which parity is reached, electricity wholesale price and the underlying cost of carbon and operation of carbon pricing.

- Gone Green – price parity is reached by 2023 (arguably this could come earlier) owing to reduced onshore wind costs, rising wholesale price driven by fossil fuels and/or the effective operation of a carbon price mechanism.
- Consumer Power – price parity is reached circa 2025 owing to falling onshore wind costs, technical innovation and rising wholesale prices driven by economic growth and consumer demand
- Slow Progression – price parity is reached mid-decade owing to falling onshore wind costs and operation of market carbon pricing mechanism.
- No Progression – price parity is barely reached by 2030 owing to low wholesale price due to lower economic growth, slow technology development and lower fossil fuel prices

5.7 Geographic distribution of onshore wind across BSPs



The onshore wind DG growth scenarios datasets contain a breakdown of growth by BSP area that represent a best estimate of the likely spread of onshore wind capacity; but the figures given are indicative only.

The factors that have been used to estimate the geographic spread of DG growth by BSP include:

- Available developable land space
    - which includes factors such as wind resource, environmental designations and technical factors
- Historic wind deployment trends
- Cumulative impacts
- Planning environment is different is each scenario
- Mix of larger scale v smaller scale wind – based on scenarios

For the baseline analysis and pipeline forecast to 2020, the distribution of onshore wind DG capacity by BSP area is accurate. However, it is difficult to give a precise forecast of the future geographic spread of onshore wind to 2030 by BSP area. Especially for the lower growth scenarios, the choices of individual landowners, project developers and variation in the planning system will have a significant impact.

Across all scenarios, it is expected that onshore wind DG growth will tend towards those BSP areas which have: a) good wind resources and b) larger areas of available land space and c) proximity to available grid. Other factors such as having proactive local authorities and local plans with positive policies in place will also have an impact.

It is also likely that future wind farm applications will tend to follow existing geographic patterns; this is because of repowering of existing sites (although this will be relatively small in the period to 2030), and the potential to resubmit wind farms applications if planning conditions improve under Gone Green and Low Progression scenarios.

A counter factor is that some BSP areas are now approaching the point where it is becoming more difficult to secure planning owing to cumulative impacts.

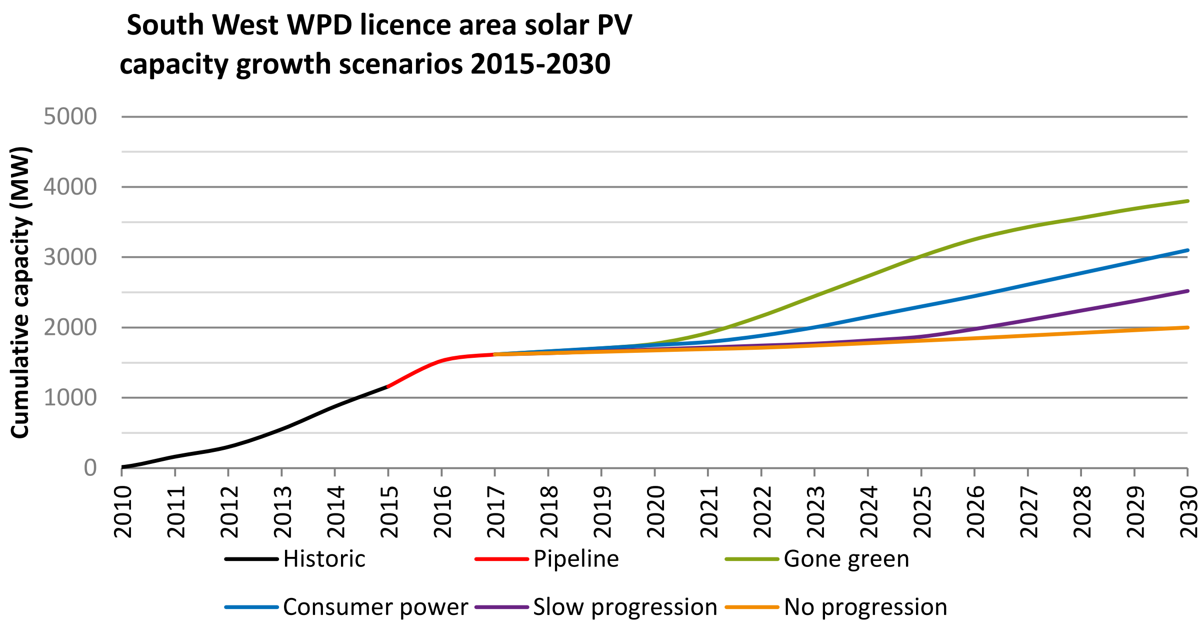
By contrast, BSPs with low wind resource and limited land space will continue to be difficult areas for windfarm development.

Scenario specific impacts on geographic spread:

- Gone Green – has the broadest BSP geographic spread reflecting the highest overall growth and mix between larger and smaller scale projects, with new projects in areas which have hitherto been difficult to develop (e.g. Somerset)
- Consumer Power – reflects a broader spread with proportionally more small scale developments reflecting the choices of individual landowners, farmers and communities
- Slow Progression and No Progression have a higher concentration of wind farms in the most attractive BSP Areas, reflecting financial drivers and the retrenchment of the industry

6 Solar PV - technology growth scenarios

6.1 Summary distributed generation growth scenarios 2015-2030



Baseline, pipeline and scenario capacity summary

Scenario	Baseline capacity 2015	Pipeline projection to 2017	Total scenario forecast to 2030	Total (MW)
Gone green	1160	456	2183	3800
Consumer power	1160	456	1483	3100
Slow progression	1160	456	903	2520
No progression	1160	456	383	2000

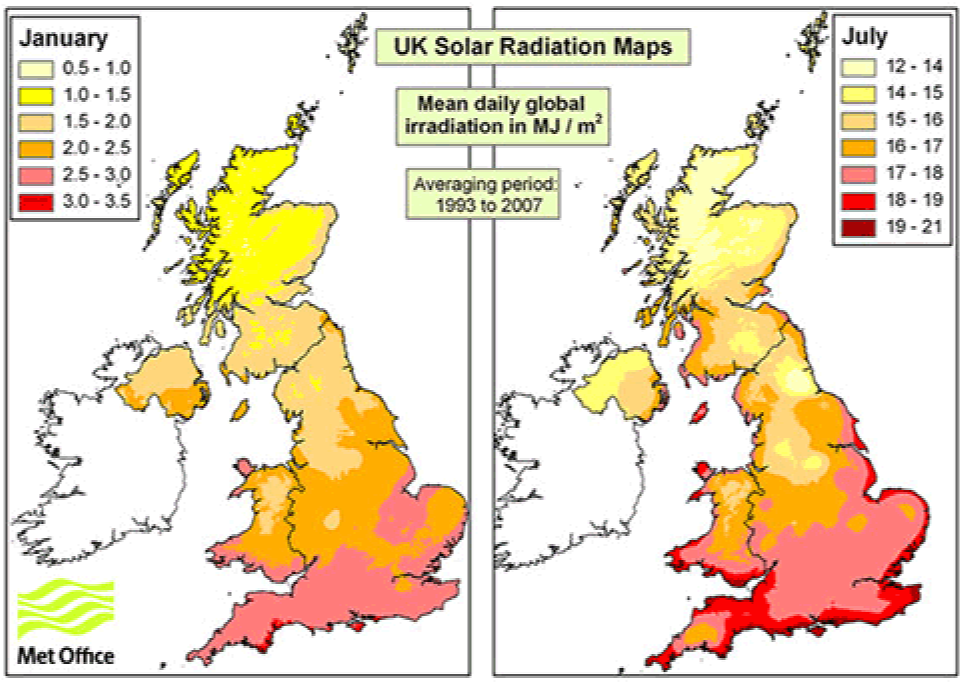
The chapter contains an analysis by license area and BSP areas of:

- The future energy potential of solar PV in the south west licence area
- The historic growth and current (Sept 2015) baseline
- The pipeline projection of projects to 2017
- Scenario based growth forecasts to 2030

6.2 Solar PV – future energy and growth potential

The solar irradiance map of the UK shows that the south west of England is the most attractive solar resource area of the UK. It is no surprise therefore that the south west has been an early adopter of both roof and ground mounted PV systems and has seen the highest levels of growth in the UK.

UK solar radiation map



6.2.1 Ground mounted PV resource areas

The theoretical energy potential of ground mounted solar PV greatly exceeds what could realistically be developed under any future development scenario. Even under the highest 'Gone Green' scenario, only 2.5 percent of the potential 'PV resource area' would be required to reach a PV installed capacity of 3,800 MW in the south west WPD licence area by 2030.

6.2.2 'Developable' PV land space

Both ground mounted and roof mounted solar projects are generally viable across the entire SW region. An exception to this is some of the higher ground areas of Bodmin Moor, Exmoor and Dartmoor, which, as well as being designated areas, have a slightly greater than average cloud cover.

Unlike onshore wind therefore – where access to good wind resource is the primary driver for site selection – for ground mounted solar PV the primary considerations are:

- Available land space – non-designated, brownfield or lower grade agricultural land, flat/unshaded or south facing
- Access and proximity to grid at a reasonable connection cost

Additional considerations may include:

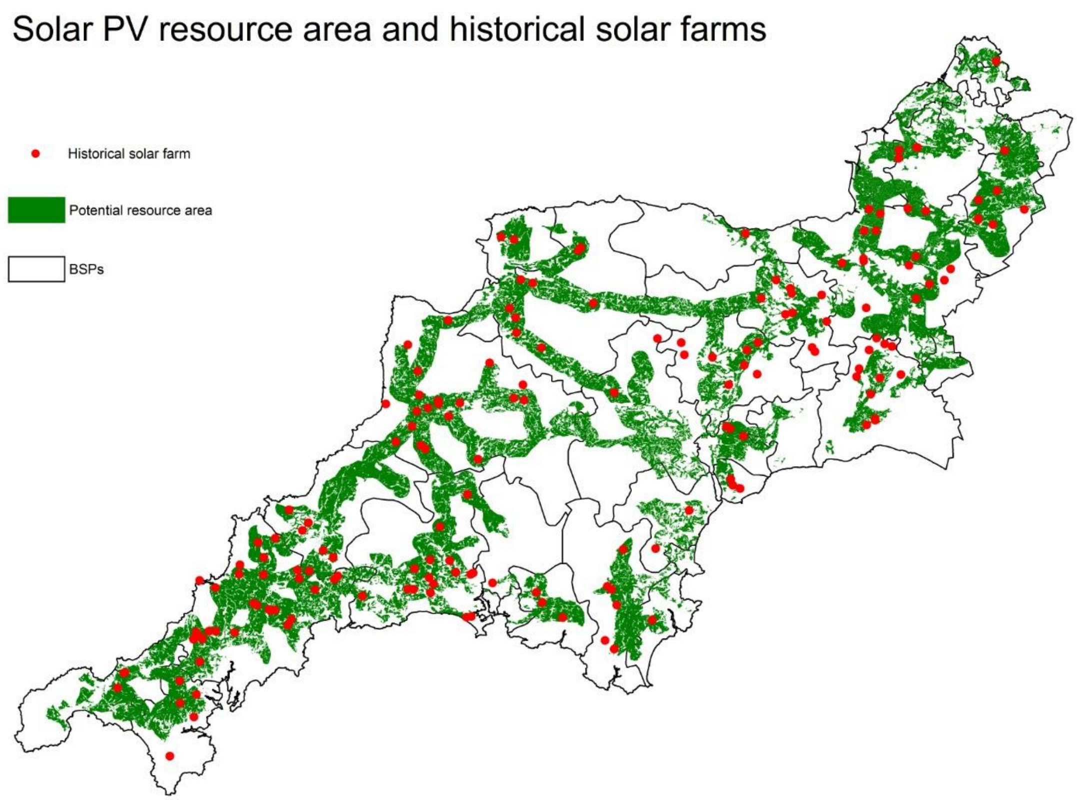
- Coastal areas and areas with higher wind - which are cooler – have a slightly higher energy generation efficiency.
- South facing land would be an advantage in terms of energy generation – however, from a visual impact consideration lower lying flat land, not shaded by trees but potentially 'nestled' into the landscape is more developable.
- Ground mounted PV adjacent to major roads in rural areas is also attractive both from the perspective of vehicle access and also because these tend to correspond to lower grade agricultural areas, less sensitive landscapes and lower housing density. "A" roads like the A30, for example, also tend to follow the major infrastructure/transport routes including grid.
- Planning rules, protocols, local authority and community engagement impact

Given the widely available solar resource and the general availability of PV developable land space, the critical driver for the development of historic solar PV systems has been access to grid.

The importance of grid availability is one reason why WPD has experienced a very high number of grid connection agreement applications in the pipeline, as PV developers first try to secure an acceptable grid connection before proceeding with full planning, raising finance and other project development activities. This also explains why there has been a progression of PV projects up the SW Peninsula as grid capacity constraints and reinforcement costs have been encountered.

The map "Solar PV resource area and historical solar farms" below shows an analysis of potential 'PV developable' resource areas based on the following constraints:

- Non-designated land areas – AONB, SAC, SPA, RAMSAR, Heritage Coasts etc.
- Physical constraints – woodland, rivers etc.
- Agricultural grade 3a or below
- 25 m from residential properties
- 2 km distance to 33 kV (or higher) network as a proxy for grid connection costs.



The occurrence of existing ground mounted PV farms – shown as red dots – shows that there is a very strong correlation between the location of PV farms and the developable resource areas when a 2 km / 33 kV grid proximity criteria is included. The small numbers of PV farms that fall outside this grid proximity criteria tend to be the smallest solar farms that have typically found a sweet spot next to the 11 kV network.

The resource assessment above suggests that there could be over 1,000 km² of 'PV developable' land space within the WPD south west licence, which could, in theory, host over 40 GW of ground mounted solar. In reality only in the order of 22 km², just over 2 percent of the total developable resource area, has so far been developed. This is equivalent to less than 0.16 percent of the total land in the south west licence area.

6.2.3 Solar PV planning constraints

Unlike onshore wind, the deployment of solar PV has been less impacted by planning constraints. With planning lead times typically less than six months, and a relatively high success rate (circa 40%), developers have been able to bring forward PV schemes with some confidence of success.

In part this is because well sited solar PV farms have an inherently lower planning and environmental impact – less visual impact and less impact on birds, bats etc – than wind turbines. Solar farms are also relatively easy to decommission and so landscape issues are reversible. It is also partly explained by the fact that many local authorities adopted positive planning protocols and guidelines for developers, which has helped ensure that the majority of PV farms are appropriately located.

Cumulative impacts are, however, beginning to become an issue and the number of high-visibility PV farms, along the A30 in Cornwall for example, is beginning to increase public and local authority concern. As a result, Cornwall Council has now produced an annex to its planning protocol that deals explicitly with cumulative impacts.

http://www.cornwall.gov.uk/media/10355161/Renewable-SPD-2014-Annex-3.pdf

It is difficult to assess whether cumulative impacts will in time create a hard planning constraint. Most of the assessment criteria is subjective and the reality is that – with the exception of one or two 'hot spots' - the percentage of developable land space that has been given over to PV farms is extremely low when considered at BSP area, local authority or at a regional level.

Planning constraints to PV farms based on cumulative impacts are therefore likely to be localised and are unlikely to significantly affect the long term growth at a BSP area or regional level.

In the scenario modelling, we have experimented with two types of cumulative impact factors:

- Based on an arbitrary cap of 2.5 percent of the 'PV developable' land space corridors (excluding land orientation) utilised within a BSP. This is equivalent to approximately 9.5 percent of the total 'PV developable' land and 0.6 percent of the total BSP area.
- Based on a maximum number of 2 to 3 PV farms within a 10 km^2 area

It was found that while these cumulative impact constraints do affect the siting of PV farms within a small geographic area, they do not constrain the overall growth of PV within the broader growth scenarios, and within individual BSPs.

6.2.4 Conclusion

Given a widely available solar resource, large quantity of PV developable land space, low planning impact, short lead times, an established technology and a highly scalable supply chain, the future growth of solar PV in the south west will be largely determined by:

- Project economics – whether, through subsidy or in the future price parity (rising wholesale, carbon price and/or falling PV costs), PV projects can generate a sufficient return on investment
- Availability of grid – at a reasonable connection cost

Unfortunately, from a modelling and forecasting perspective, the absence of other significant constraints lends itself to quite a binary growth projection, which makes it more difficult to forecast accurately future generation growth. If the economics of projects are favourable then the PV generation growth, and demand for additional grid capacity, will be very significant. If, on the other hand, there are periods when project economics do not work then generation growth could stall.

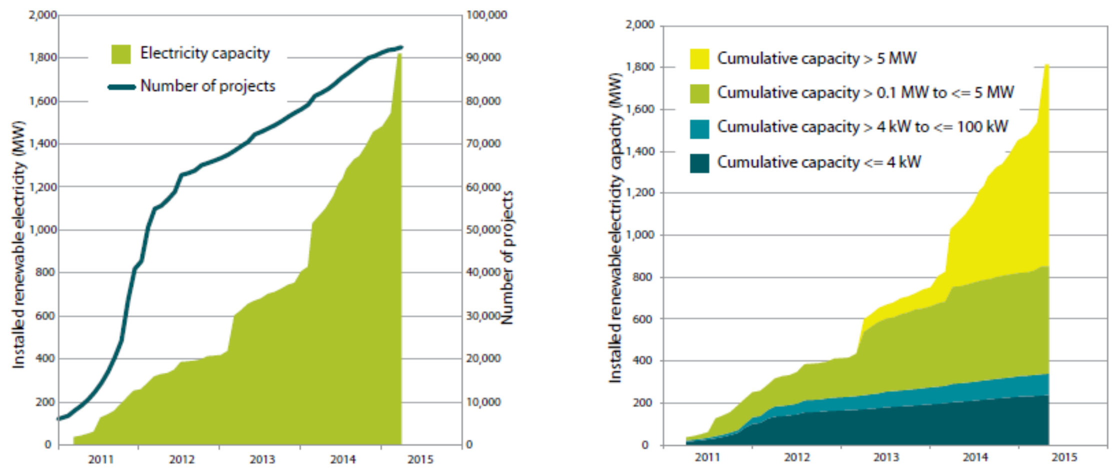
6.3 Historic growth and baseline capacity (October 2015)

The rapid growth of PV across the south west peninsula, and across the southern UK, has been one of the key features in the growth of renewable energy in the last 5 years.

The overall growth in PV capacity across the south west has been exponential and looks, at first sight, to have been continuous. In fact, there have been a number of distinct waves of PV growth:

- The first wave from 2010-2012 was the initial surge of smaller scale roof-top PV that was mainly domestic and driven by the initial high FiT subsidy offered
- The second wave was larger ground mounted PV of >0.1 MW to 5 MW again supported mainly by the FiT
- The third wave we have seen, which began to take off from mid-2013 was for very large PV farms of > 5 MW supported by the RO scheme.

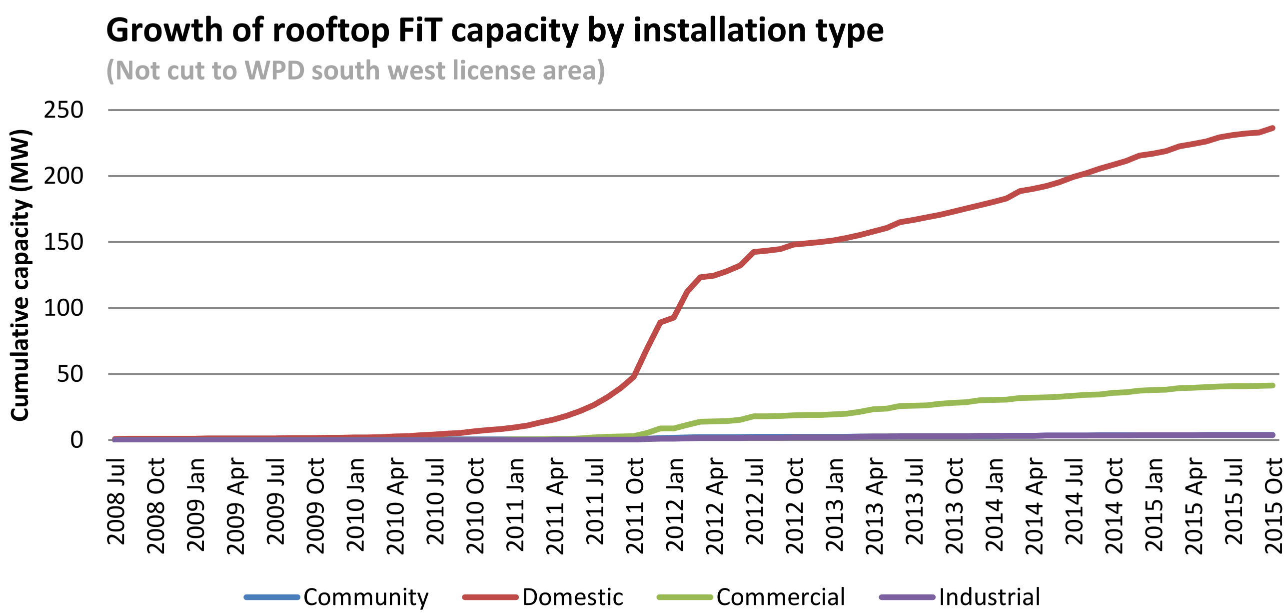
Trends in the growth of Solar PV 2010-15 in south west England



Source: Regen SW Progress Report 2015

Even within these waves, the PV market has been volatile and highly sensitive to the relative influences, and interplay, of falling PV costs offset by falling levels of subsidy.

Within the roof mounted PV market, for example, there was a significant spike in PV growth for domestic systems over the winter months of 2011/12 to beat the first major cut in the FiT. Growth then, to some extent, switched to commercial and industrial rooftops, where economies of scale allowed projects to proceed at a lower tariff level.



6.3.1 Geographic spread of existing baseline projects by BSP area

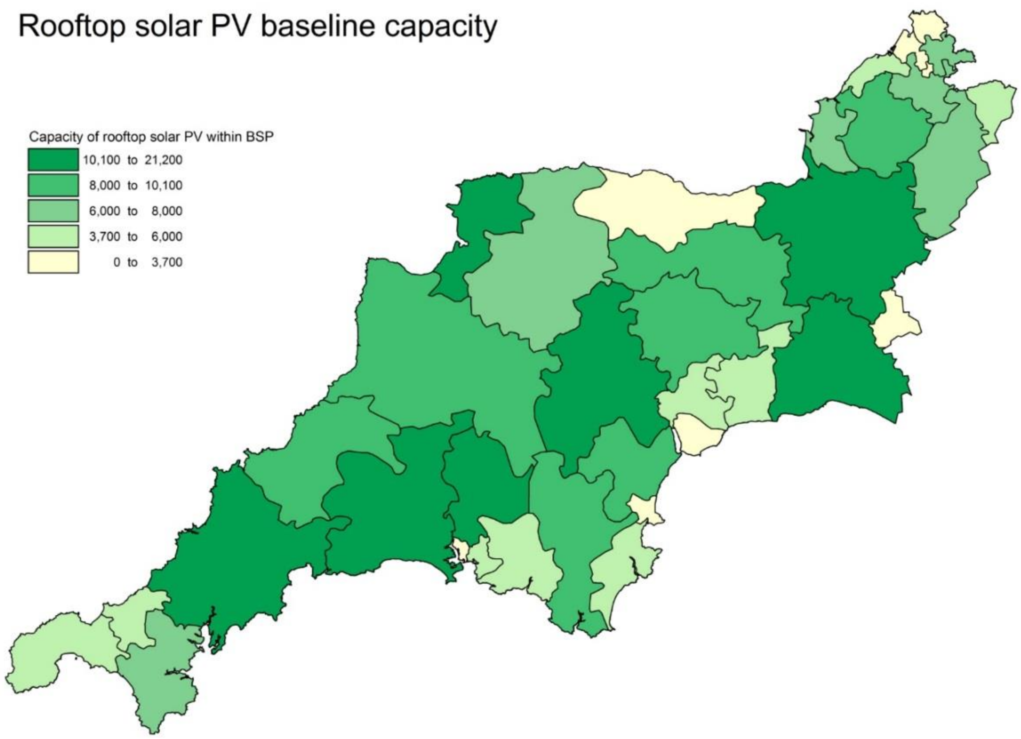
As discussed above, the geographic spread of ground mounted PV has tended to focus on those areas of PV developable resource that is close to the grid. As the map below shows, there is a high correlation between the location of PV farms and grid proximity.

The historic data also shows that there has been a general progression of PV farms starting in Cornwall in 2012/13 and then moving up the Peninsula and along the south coast into Devon, Somerset, Dorset and Wiltshire. In large part, the progression of solar farms has been the result of developers encountering grid constraints and higher reinforcement costs.

Notable areas without ground mounted PV farms, including Bodmin, Dartmoor and Exmoor, are explained by a combination of environmental designation, visual impact and relatively higher cloud cover reducing solar radiance.

The top 10 BSPs account for approximately 67 percent of the total ground mounted capacity, demonstrating a lower concentration of projects than for onshore wind.

Rooftop solar PV has followed a similar geographic distribution across the BSP areas, although there has been a more pronounced focus in areas to the south of the region and a higher concentration in urban areas such as Plymouth and Exeter. There is a higher concentration of rooftop solar PV in more affluent areas, although this has been mitigated by social landlord and community housing schemes in urban areas.



6.3.2 Solar PV pipeline projection to 2017

Since the beginning of 2015, the PV industry has been impacted by a number of changes to subsidy levels and announcements related to energy policy.

These measures include:

Closing of the RO to PV schemes affecting larger ground mounted schemes over 5MW

1) The RO will be closed to new PV schemes from 1 April 2016, except those that have qualified for a 12 month grace period,which can be built by 31 March 2017.
2) In order to qualify for the grace period, projects will:
    a. Need to register under ROCs on or before 31 March 2016
    b. Have to have submitted a planning application on or before 21 July
    c. Have a grid connection agreement
    d. Confirmation of land rights
3) Projects falling outside of the 22 July planning application submission deadline will need to be built by 31 March in order to receive ROCs.

Reduction in the FIT – affecting schemes up to 5MW

4) Significant reduction in the available FiT for PV schemes meaning that schemes which have not pre-accredited must be built by 31 Dec 2015 to receive a higher FiT rate.

5) Schemes that have pre-accredited before 1 October 2015 do qualify for a higher FiT but must be built by:
    - 1 April 2016 for domestic and commercial schemes
    - 30 September 2016 for community based schemes

Whereas in the past, cuts to subsidy in one area have to an extent been offset by falling costs in other areas, these broad measures are expected to significantly impact the pipeline of PV projects coming forward for both rooftop and ground mounted schemes.

As a result, it is expected that there will be a rush of projects energised before 1 April 2016 with some community energy projects built by 30 September 2016. After 2016, however, PV projects will have to be built without subsidy, and growth rates will depend on factors such as price parity under the future energy scenarios. For this reason, the pipeline analysis for PV runs to 2017 (not 2020).

Given the cuts in subsidy and the milestone dates that must now be achieved, it is expected that a high proportion of the projects that currently have a grid connection agreement will now not be built within the pipeline period before 1 January 2017.

6.3.3 Solar PV pipeline analysis

	WPD Grid Connection		DECC Planning Database		2017 Pipeline Analysis	
Project Scale	**No. Projects**	**Capacity**	**No. projects**	**Capacity**	**No. projects**	**Capacity**
'Ground' Projects < 1MW	136	958	186	1,124	78	439
'Roof' Project < 1 MW	46	14	NA	NA	NA	23

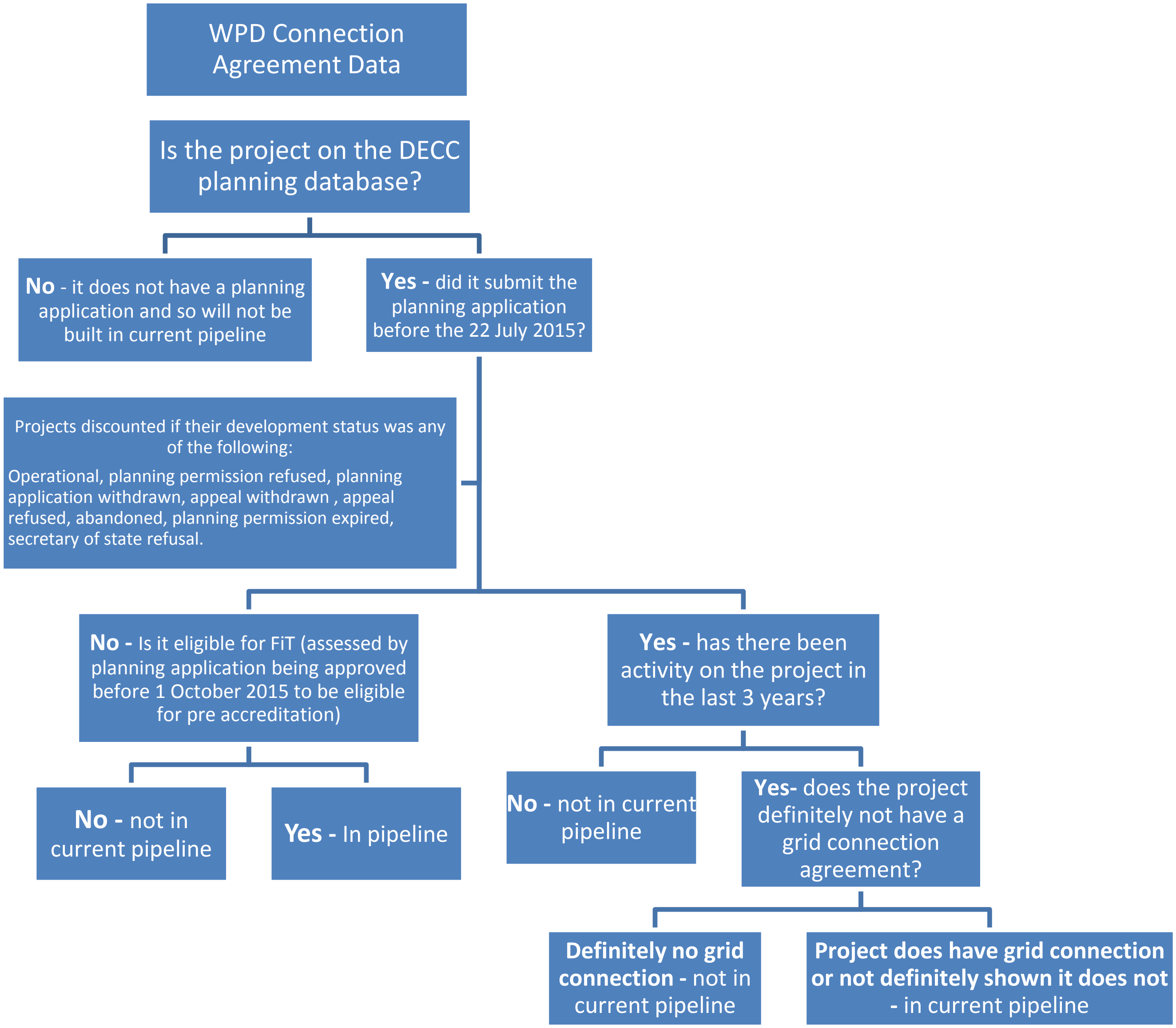
The WPD Connection agreement database (Nov 2015) has 136 projects greater than 1 MW with a total capacity of just over 957 MW. This is broadly similar to the DECC planning database, which holds projects with a capacity of 1124 MW.

However, both databases contain a significant number of projects that are unlikely to be built within the pipeline period because they:

a) Have had their planning rejected
b) Have not yet submitted a planning application
c) Have had planning and a grid connection for some time (over 3 years), but for a variety of reasons have not proceeded to construction

(Note: the initial analysis suggests that there are very few projects (perhaps none) which have planning, or indeed have submitted a planning application, without having an accepted grid connection agreement in place. This supports the earlier conclusion that securing a grid connection is a key priority for project developers and generally precedes a planning application.)

The analysis of the pipeline has used a 'logic tree' approach to assess the pipeline of projects that are most likely to be built by 2017.



The result of the logic tree approach, combining data from the DECC planning database, FiT accreditation data and analysis of WPD's connection agreement data, gives an expected short term pipeline for (mainly) ground mounted over 1 MW of **439 MW** installed by end 2016. This number is an upper estimate and includes 115 MW that is still in planning, awaiting a decision, or has gone to appeal.

The final pipeline figure may therefore be closer to 350 MW.

The analysis of those projects in the DECC planning database has been broken down into the following categories:

Status on DECC database	Total capacity (MW)	Notes
Awaiting construction	35.5	Current pipeline 2015 to 2017. Projects in the 'In planning', 'Appeal', and 'Granted' categories are expected to fall, in particular the 'Granted' category as some of these projects are reasonably old so may not be going ahead.
In planning	80.4	
Granted	263.4	
Appeal	34.9	
Under construction	24.7	
Pipeline total	438.9	
Planning application in too late	45	Outside of pipeline
Refused	436.7	
Old projects inactive	25.9	
Planning application withdrawn	137.3	
Abandoned	40.5	
'Not included in pipeline' total	685.4	

6.3.4 Rooftop – domestic and commercial scale pipeline

There is currently a rush to install as much rooftop PV as possible ahead of the FiT degression deadlines:

- 31 December 2015 for non pre-accredited FiT schemes
- 31 March 2016 for pre-accredited schemes
- 30 Sept 2016 for community pre-accredited schemes

It is difficult to estimate how much PV will actually be installed during this frenetic period. During September 2015, a further 4 MW of rooftop schemes were added in the south west and it is expected that the pace of installation will continue and increase until 1 January 2016.

After 1 January 2016, installers will then be mopping up the remainder of the pre-accredited schemes until 30 September 2016 when the current pipeline ends.

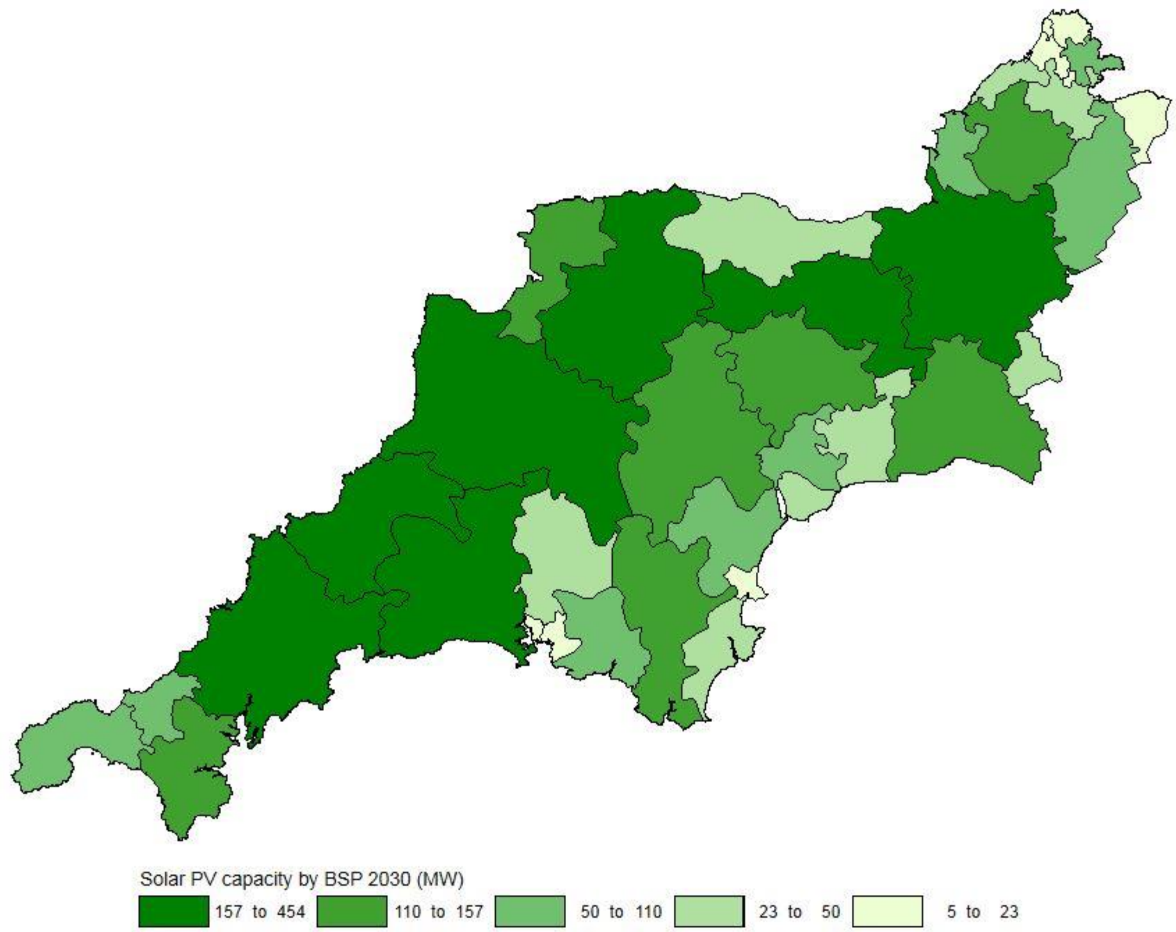
Given the lag in accessing data, it is difficult to accurately measure current installation levels. However, based on the trend from July to Sept 2015, we have estimated 17 MW of smaller <1MW schemes could be installed by the end of 2016 with the bulk of this installation coming in the period between October 2015 and March 2016.

Point to note: the WPD grid connection dataset holds 14 MW of mainly rooftop <1 MW schemes. This would be a sub-set of the total rooftop schemes, since many smaller domestic (<10 kW) and commercial schemes (<50 MW) do not require a grid connection agreement and are therefore not in the in the WPD dataset.

6.3.5 PV pipeline analysis by BSP area

The breakdown of pipeline projects by BSP is given in the attached datasets and shows a similar concentration to the historic baseline with the top 10 BPSs accounting for 64 percent of capacity.

Geographical distribution of solar PV capacity in the Gone Green scenario



6.4 Solar PV scenario growth analysis 2017-2030

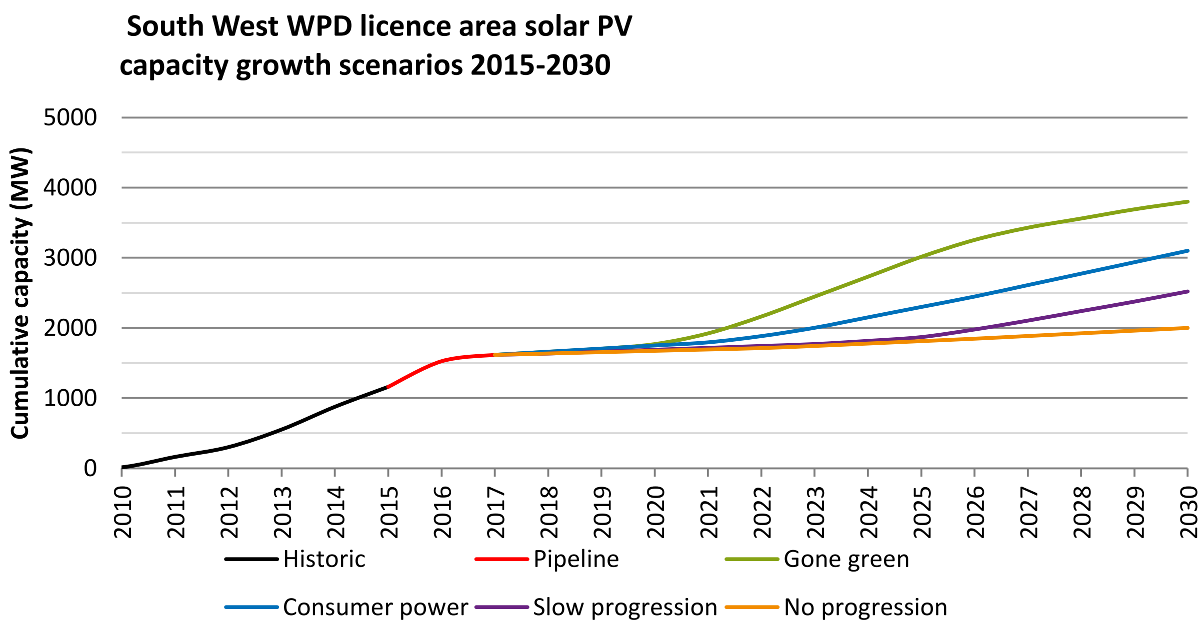
6.5 Overall solar PV DG growth by scenario

As we have seen in the past 5 years, solar PV has the potential to be a disruptive technology, if the economic factors supporting projects are favourable. Post 2017, with potentially zero subsides available, solar PV is entering a difficult period and it is expected that there will be a significant fall in installations. However, with relatively short lead times, and the potential for further falls in panel and inverter costs, solar PV could bounce back and grow rapidly in the next decade if grid 'price parity' is reached.

Energy storage could also have a significant impact on PV project finances by allowing projects to better harness 'own use' energy, increase capacity utilisation and potentially exploit energy price markets. The potential impact and growth of energy storage is discussed in more detail in section 7.

The timing of when price parity could be reached, and the impact of energy storage, is not yet clear and this is reflected in the future energy growth scenarios.

The overall growth for solar PV by scenario is shown in the graph and table below.



Summary table of total PV installed by 2030 by scenario

Scenario	Baseline 2015 capacity Total 2015 baseline (MW)	Ground mounted (MW)	Rooftop (MW)	Pipeline 2015 to 2017 capacity Total 2017 pipeline (MW)	Ground mounted (MW)	Rooftop (MW)	Scenario 2017 to 2030 capacity Total scenario forecast (MW)	Ground mounted (MW)	Rooftop (MW)	Project size split Ground mounted (%)	Rooftop (%)	2030 total capacity (MW)
Gone green	1,160	901	259	456	439	17	2,183	1,790	393	82	18	3,800
Consumer power	1,160	901	259	456	439	17	1,483	890	593	60	40	3,100
Slow progression	1,160	901	259	456	439	17	903	741	163	82	18	2,520
No progression	1,160	901	259	456	439	17	383	314	69	82	18	2,000

Key points to note:

- In all scenarios, it is anticipated that there will be significant slowdown in PV deployment growth post 2017. This would seem to be inevitable, given the cut to available subsidies, plus the budget cap which has been placed on new schemes under the LCF. Already developers and installation companies within the south west are preparing for a downturn in activity. The key uncertainty therefore is how quickly growth would recover under the four future energy scenarios.

- Under no scenario is it expected that subsidy levels will be significantly increased – growth will therefore be predicated on PV achieving energy price parity – see below.
- Gone Green – under this scenario it is anticipated that growth of PV would begin to recover quite quickly in the south west, given its good resource levels and by the mid part of the decade would approach the overall growth level experienced from 2010-2015.
- Consumer Power – growth is slower than in Gone Green and price parity does not impact until 2020/21. Technology innovation and new 'own use' business models favour rooftop and building fabric PV installations for consumers, businesses and communities.
- Slow Progression – growth is slower and price parity does not impact until 2022/23. Lower technological innovation favours larger scale ground mounted solar.
- Slow progression and Consumer Power result in a similar total capacity deployed, but the mix between larger scale and smaller scale varies.

6.6 Scenario factors impacting future solar PV growth in the south west

FES Scenarios - Implications for solar PV in the south west	
Consumer Power • Medium growth scenario • Technological innovation • New business models and storage support 'own use' • Rooftop and building fabric schemes • Price parity reached circa 2020/21 for larger rooftop and own use schemes • Higher proportion of rooftop projects • Very large ground projects focused in high resources areas	**Gone Green** • Highest overall growth scenario • Price parity – first projects 2018/19 • Falling PV costs • Technology innovation • High carbon price • Growth rates approach peak seen during 2010-15 • Both larger and small scale PV projects • Positive planning environment • New business models including energy storage
No Progression • Lowest growth scenario • Poor planning and economic environment • Growth would be very slow 2020-25 with a slight increase post 2025 as price parity met • Limited growth would be more weighted to economically viable projects – very large or 'own use'. • Some municipal and community schemes	**Slow Progression** • Medium growth scenario • Positive planning environment • Less domestic rooftop projects due to lower prosperity • But poor economic and finance outlook • Price parity reached 2023 • Projects focused in high resources areas but relatively distributed across BSP areas

6.7 Key growth drivers and constraints in the south west to 2030

6.7.1 Grid price parity

In a post subsidy environment, the growth of solar PV will be primarily driven by its ability to compete with other energy generation technologies. There is some discussion about what price parity means in practice, but for the purposes of this paper it is the point where solar PV projects can be built without a direct revenue subsidy or grant.

In this regard, PV has already seen a significant fall in costs and is now approaching the point where very large ground mounted schemes (>10 MW), without significant grid reinforcement costs, could become viable without subsidies by 2020.

Roof mounted schemes have traditionally been more expensive but a combination of new technology – especially for new build – plus energy storage enabling 'own use' business models could enable larger roof mounted schemes to be viable.

Factors which could contribute to solar PV achieving price parity are listed in the table below:

Potential factor enabling PV price parity	Likely scenario			
	GG	CP	LP	NP
Falling international PV panel and inverter costs – potentially due to reduction in import duties and also manufacturing innovation and economies of scale	X	X	X	X
Falling installation costs – potentially due to increased supply chain competition in a falling market		X	X	X
Rising electricity wholesale price – potentially driven by economic growth , increased demand and/or falling supply	X	X		
Technological innovation – especially for rooftop and building fabric PV technologies	X	X		
New business models – 'own use' enabled by energy storage	X	X	X	
New business models – 'capacity utilisation' enabled by energy storage	X		X	
New business models – 'energy market' enabled by energy storage	X			
Lower grid reinforcement costs – enabled by pre-emptive investment	X		X	
Lower grid reinforcement costs – enabled by 'smart' solutions, active grid management and demand response solutions etc	X	X		
Impact of an effective carbon price	X		X	
Residual subsidy – potentially a minimum price 'guarantee' mechanism	X		X	
Innovative integrated systems – PV linked to electric vehicle charging for example	X	X		

6.7.2 Solar PV with energy storage

The development and growth of energy storage solutions is discussed in Section 6.

For solar PV especially, given its relatively low capacity factor, energy storage solutions supported by new business models could open up a range of new commercial opportunities for new and existing PV plant.

Exactly how and how quickly energy storage technologies will impact the energy market is unclear, but a number of technologies and models are already being considered.

The rapid growth of own use energy storage solutions is a real possibility and evidence from the US and Germany suggests that storage solutions will increasingly be offered as part of a standard PV or small scale wind package. Evidence from the German Solar Trade Association suggest that 70 percent of solar installers are now offering energy storage solutions as part of a standard PV package and that the proportion of new domestic PV storage systems will grow by 50 percent with one in three installations now taking storage options. In part, the high growth in Germany has been driven by very high electricity prices; however, with falling costs, energy storage solutions could equally grow here in the UK.

6.8 Geographic distribution of solar PV distributed generation 2030

The maps below show, the potential geographic distribution of both ground and rooftop solar PV under different development scenarios.

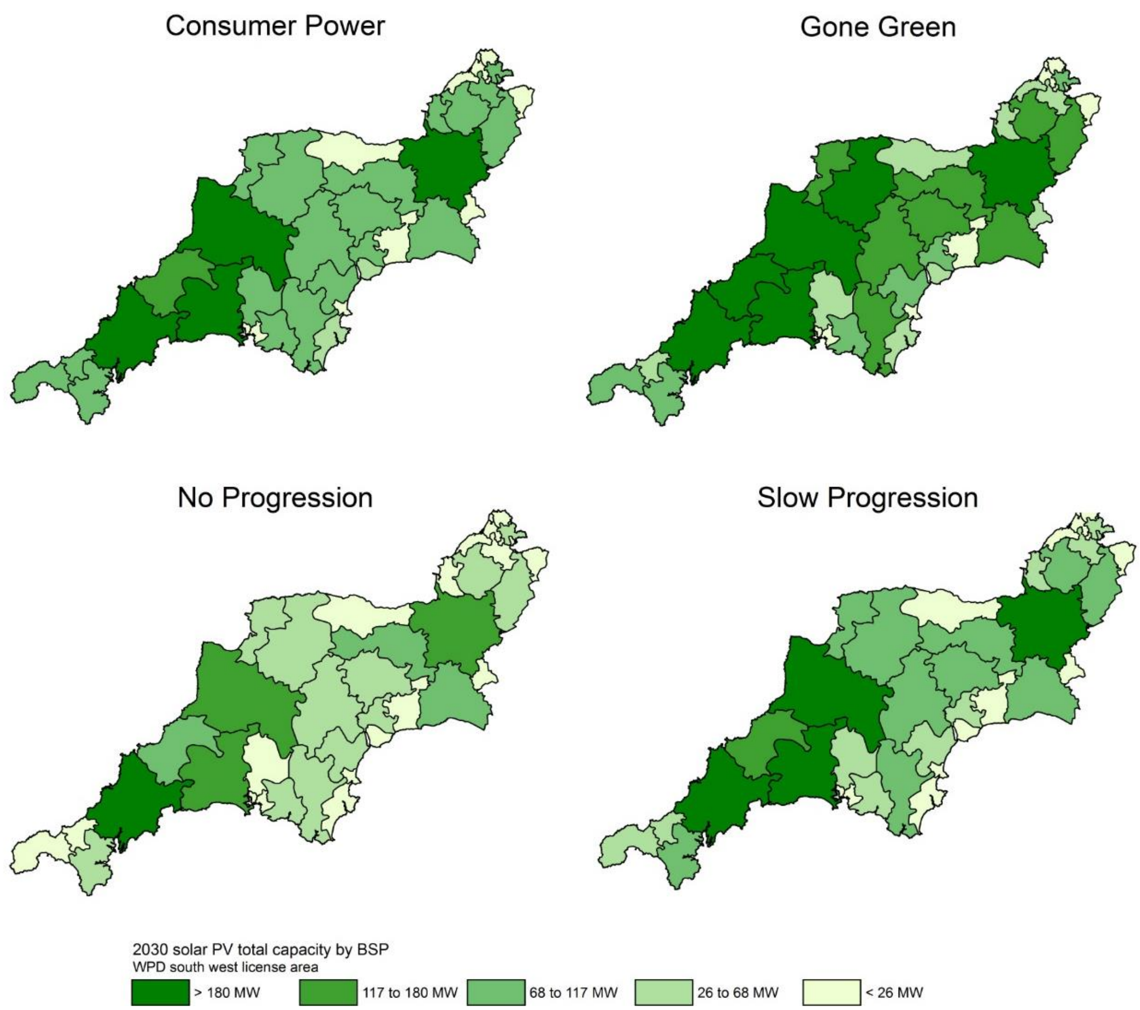
As discussed above, the distribution of solar PV is less constrained than onshore wind and therefore there is less obvious concentration of projects within specific geographic areas.

Nevertheless, the BSP areas which are likely to see the highest levels of ground mounted deployment will be those with :

- Developable PV land space
    - which includes factors such as lower grade agricultural land, environmental designations and technical factors
- Close proximity to grid at a reasonable connection cost

For roof mounted PV, the key drivers will be the number of domestic and commercial properties within the BSP areas.

Solar PV capacity geographic distribution by scenario



Ground mounted distribution

The distribution of the forecast capacity by BSP is based on resource potential alone, including proximity to grid which was found to be the most important factor for siting a large ground mounted project. Planning has been found to be a minor factor in the current climate and so has not been deemed to be a factor holding back the development of solar in any BSP, in the way that onshore wind is affected geographically by planning issues.

Rooftop distribution

The projection is allocated to BSP based on the combination of two factors: the BSP's current performance, and the number of buildings within the BSP. It does not currently include a distribution by BSP based on a split between domestic and commercial due to time constraints. Also because domestic account for the overwhelming majority of total capacity, it was considered sufficient to allocate by dwellings, since more dwellings would also mean more commercial opportunities.

7 Offshore energy – technology growth scenarios

7.1 Offshore energy scope and context

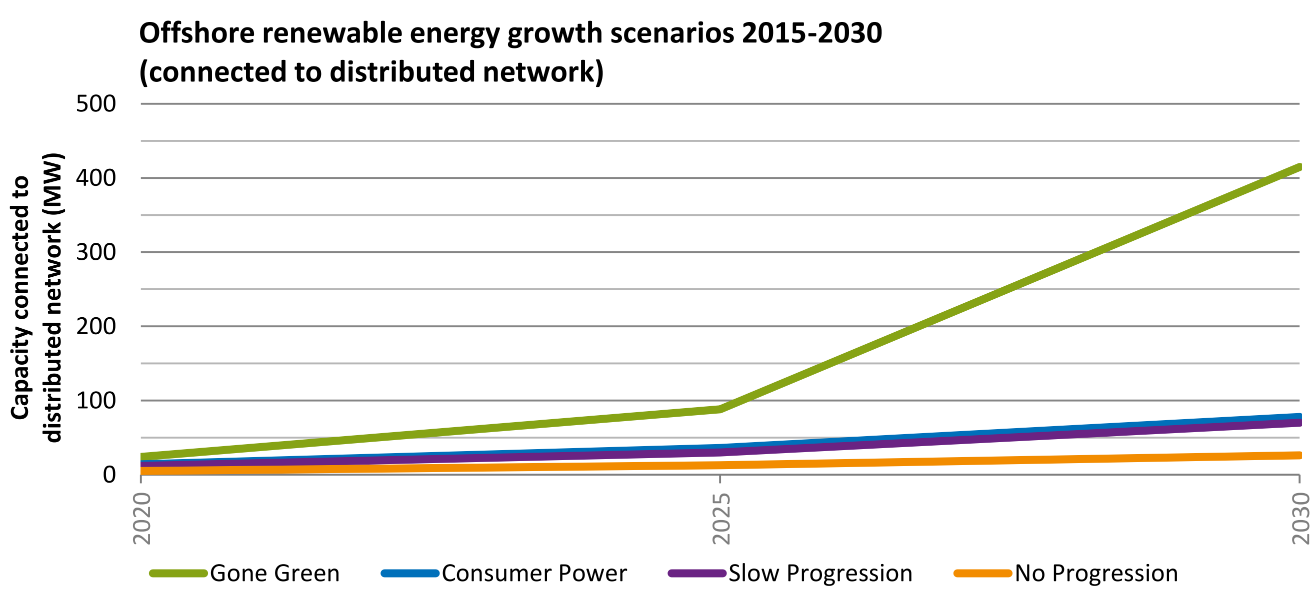
This section of the report covers the future distributed energy generation scenarios for offshore renewable energy in the WPD south west licence area to 2030. These technologies include:

- Wave energy
- Tidal stream energy
- Floating wind – demonstration and pilot projects

For the purpose of this analysis, it is assumed that if any large scale offshore wind or tidal range (lagoon) project is constructed in the period to 2030, they will connect directly to the National Grid Transmission network and so would not be considered as distributed generation. The analysis presented below draws heavily on a number of existing reports, including:

- South West Marine Energy Park "Statement of Ambition" to 2030 paper
- Cornwall and IoS Marine Renewable Energy Roadmap 2015-2025
- Offshore Renewable Energy Resource and Deployment Report 2010

Summary offshore energy generation growth scenario 2015-2030



7.2 Offshore energy – future energy potential

Offshore energy, and especially opportunities in the emerging technologies of wave energy, tidal stream and floating wind is a strategic priority for the south west of England. To support the development of the sector, significant investment has been made in providing demonstration sites (Wave Hub, Fab Test and Lynmouth), research facilities and supply chain development. To date, over £100m has been invested to develop the sector and it has been estimated that the industry could support over 3000 jobs by 2030.

The Offshore Renewables Resource and Deployment Report (ORRAD) published in 2010 presented an in-depth analysis of the potential energy generation from wave, offshore wind and tidal stream projects in the south west.

The ORRAD baseline scenario gave a headline estimate of over 9.2 GW capacity of offshore wind and marine energy that could be installed within a 50 km distance from shore. Further capacity in deeper water sites further out in the Celtic Sea and Western approaches was identified, but not assessed.

The breakdown of potential capacity by technology type was given at:

- 1.2 GW wave energy
- 4.4 GW intermediate offshore wind
- 2.5 GW deeper water floating wind
- 1.1 GW tidal stream

Subsequent to the ORRAD report, it has also been estimated that tidal range could provide an additional 6.4 GW capacity if tidal lagoons were built at Bridgwater (3.6 GW) [5]and West Somerset (2.8 GW)[6].

However, while the energy potential of offshore renewables in the south west is huge, the build out of very large offshore projects in the region is unlikely to happen until after 2030. The two largest projects planned in the region, the Atlantic Array Wind Farm (1.2 GW) in the Bristol Channel and Navitus Bay (970 MW) off the coast of Dorset have now been withdrawn.

Tidal stream and wave energy technologies are still in a period of technology development and demonstration and so, while there are a number of projects currently in the pipeline at demonstration sites such as Wave Hub, the initial deployments are likely to be of relatively small scale pilot projects, followed by larger commercial and full scale projects in the period out to 2030.

[5] Severn Estuary Tidal Power Study 2010
[6] Longbay Seapower Prospectus

Likely build out of Wave and Tidal Stream projects

Deployment period	Type of project	Scale of projects
2015-2020	Demonstration and pilot project	1 MW-3 MW demonstration 1-10 MW pilot arrays
2020-2025	First commercial projects	10-30 MW
2025 onwards	Full commercial projects	30-100 MW plus

This build out approach does, however, mean that many early projects will most likely connect to the distributed energy network – at key coastal substations. Since these first projects are critical to supporting future industry growth and the economic stimulus the sector is expected to provide, access to the grid will be of critical importance for project success and delivery. The importance of grid has, therefore, been highlighted in the Strategic Economic Plans produced by the Cornwall and IoS and Heart of the South West LEPs and in several industry papers.

7.3 Offshore energy scenario growth analysis 2015-2030

7.3.1 Overall offshore renewable energy DG growth by scenario

Based on the anticipated scenario factors described below, the overall DG growth for offshore renewable energy technologies by scenario is shown in the table below.

Scenario	2020 (MW)				2025 (MW)				2030 (MW)			
	Wave Energy	Titdal Stream	Offshore Wind (Floating)	Total (MW)	Wave Energy	Tidal Stream	Offshore Wind (Floating)	Total (MW)	Wave Energy	Tidal Stream	Offshore Wind (Floating)	Total (MW)
Gone green	20	4	0	24	50	23	15	88	250	75	90	415
Consumer power	10	4	0	14	20	6	10	36	30	18	30	78
Slow progression	10	2	0	12	15	5	10	30	25	15	30	70
No progression	5	0	0	5	10	3	0	13	15	11	0	26

Key points to note:

- Capacity estimates are for distributed network connected projects and exclude very large scale offshore wind and tidal range projects, which would most likely connect to the national grid at substations such as Alverdiscott, Indian Queens, Hinkley and Yelland
- Scenarios include the planned pipeline of projects at Wave Hub, including developers Wello, Carnegies, Seatricity, Seabased and potentially others
- Wave Hub already has a connection agreement in place with WPD
- The Hayle BSP area includes the Isles of Scilly – The IoS could potential host the first wave energy projects

7.3.2 Scenario factors impacting future deployment of offshore energy in the south west

FES Scenarios - Implications for Offshore Energy in the south west	
Consumer Power • Lower growth scenario • Marine energy continues to innovate and develop new technology • Pilot and demonstration projects are deployed at Wave Hub and Lynmouth • But sector fails to reach commercial scale by 2030 • Community and local wave and tidal schemes are deployed – North Cornwall, North Devon and IoS • Innovation export and specialist research sustains specialist companies	**Gone Green** • Highest overall growth scenario • UK exploits its position as leading centre for global marine energy • Investment support enables wave and tidal stream to achieve commercial potential • SW becomes a leading centre for marine energy • Pilot projects at Wave Hub and Lynmouth Demo Zone lead to first commercial arrays by 2025 • Isles of Scilly and North Cornwall deploy first commercial wave projects • Export opportunities sustain investment and economic growth • Floating wind technology becomes economically viable
No Progression • Very low growth scenario • Marine energy and innovative renewable energy technologies struggle to raise finance or gain funding support • Initial pilot projects do not progress to commercial scale • Innovation and economic opportunities are lost – potentially developed overseas	**Slow Progression** • Lower growth scenario • Poor economic and finance outlook • Marine energy and floating wind struggle to gain financial support • Pilot and demonstration projects are deployed • But UK fails to exploit its leadership position

7.4 Key growth drivers and constraints in the south west to 2030

7.4.1 UK and south west growth opportunity

The anticipated growth of marine energy and offshore wind in the south west of England will depend on a number of factors. These have been documented in a number of papers, including the south west Marine Energy Park Statement of Ambition and the Cornwall and IoS Marine renewables Roadmap. In summary, the key growth factors identified are:

- Technology development – proving the reliability and performance of new technology
- Success of a series of pilot and demonstration projects
- Access to resources including the planning and consenting process
- Access to finance – which will initially require collaboration between public and private sector investment
- Policy and political support for the sector – both in the UK and at an EU level

Under the Gone Green scenario, it is assumed that the factors described above are achieved. The industry is therefore able to progress from pilot and demonstration projects to the first commercial arrays by 2025. As already documented, it is very likely that the first Wave Energy projects will be built at Wave Hub with North Cornwall and the Isles of Scilly being prime areas for follow on developments. Tidal steam projects will most likely be built at small scale in the inner Bristol Channel and Severn Estuary.

The south west also has potential to deploy floating and deeper water wind technologies. However, with the withdrawal of the Atlantic Array windfarm, and the current focus on fixed wind projects in shallower waters, it is unlikely that large scale floating wind projects will be deployed in the south west in the study period. There is, however, potential for demonstration and pilot projects to be deployed, most likely off North Cornwall and in the outer Bristol Channel.

Under the Consumer Power and Slow Progression scenarios, the potential for large scale marine energy projects is limited. The industry may continue to deploy pilot and demonstration projects into the 2020s. The Consumer Power scenario also has the potential to support small scale community and corporate projects – especially for maritime communities, such as the Isles of Scilly.

Under a No Progression scenario, with poor financial and political support, there is very limited opportunity for marine energy, or any other innovative renewable energy technology to be developed. This would also imply that the UK loses its leadership position in the sector and the opportunity to export technology and capability to the global market.

Investment in marine energy, and the R&D capability that supports it, has therefore become a critical part of the wider growth of marine industries and the 'bluetech' sector in the south west. By supporting other strategic investments across the region, marine energy is helping to create high value engineering and scientific jobs and increase regional productivity.

7.4.2 Importance of grid for sector development

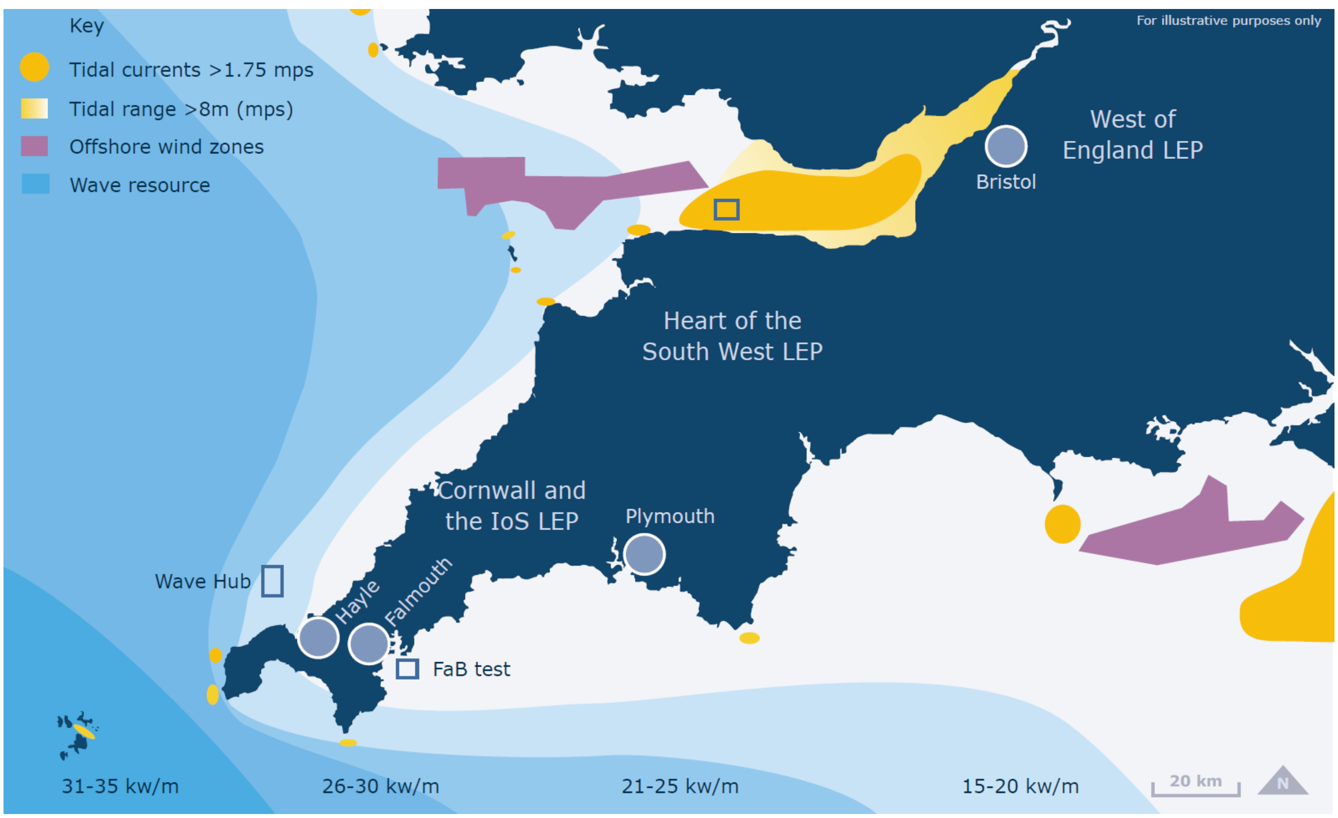
Although the anticipated capacity deployed for marine energy is comparatively low as compared to solar PV and onshore wind, the availability of grid connection in specific coastal locations will be critical for the strategic development of the marine energy sector.

This is partly because the choice of offshore location for marine and offshore wind is extremely constrained by the available resources, plus a variety of factors such as water depth, seabed conditions, shipping, environmental designations, MOD uses, fishing, leisure activities, distance from ports etc.

It is therefore likely that marine energy projects will quickly focus on a small number of viable grid connection points, see below.

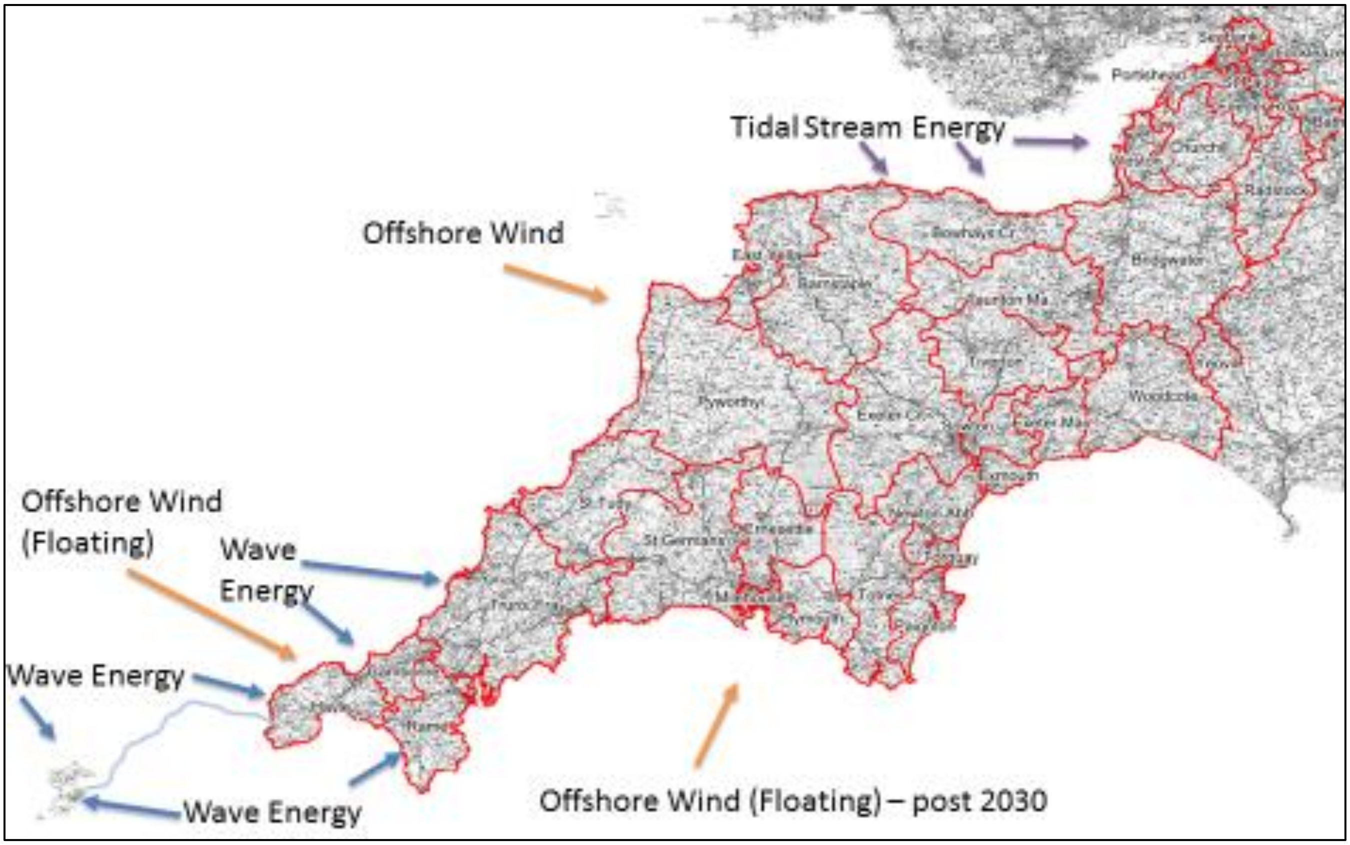
Of significant immediate importance are the connections at: Hayle and the link to Indian Queens; the Isles of Scilly and its interconnector to the mainland at St Buryan; and Lynmouth and its connection to Barnstaple.

7.5 Geographic distribution of offshore energy distributed generation



The graphic above gives an overview of the available marine energy resource in the south west of England. Tidal range and tidal stream energy is concentrated in the inner Bristol channel and Severn Estuary, with likely project locations off North Devon and Somerset. Wave energy resources increase towards Land's End and out into the Celtic Sea and Western approaches, with likely project locations off North Cornwall, around the Isles of Scilly and potentially south of the Lizard.

Offshore energy - potential BSP area connections

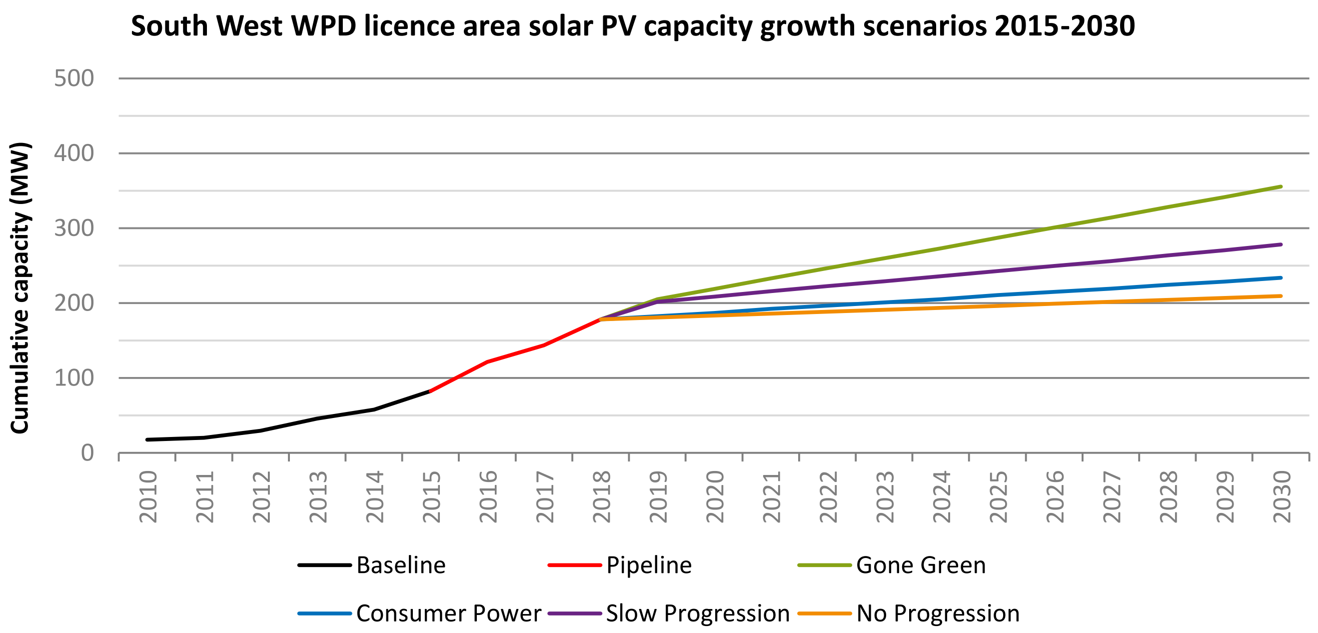


The most likely grid connection points are shown in the table below:

Offshore renewables potential grid BSP areas and connection points

Technology	BSP area/connection point	Future BSP area/connection
Wave energy	Hayle – Wave Hub/ Hayle Sub station Hayle – North Cornwall sub stations such as Pendeen/Geevor and St Buryan Hayle – Isles of Scilly St Marys and interconnector to St Buryan	Rame – Lizard sub stations such as Mullion Camborne and Truro/Fradden
Tidal stream energy	Barnstaple – Lynmouth/Lynton – North Devon demonstration Zone Seabank – Weston and other sites	Bowhays – Alcombe and Watchet
Floating wind	Hayle – Wave Hub/Hayle	Rame – Mullion East Yelland Truro/Fradden Pyworthy/North Tawton
Larger scale wind **Tidal range**	Potential National Grid Connection Points for future projects Alverdiscott East Yelland Bowhays Cross Hinkley	

8 Other generation technologies – growth scenarios



Summary scenario capacity by technology

Scenario	Baseline capacity 2015 (MW)	Pipeline projection to 2017 (MW)	Total scenario forecast to 2030 (MW)	Total (MW)
Gone green	82	96	126	303
Consumer power	82	96	56	234
Slow progression	82	96	83	261
No progression	82	96	31	209

8.1 Anaerobic digestion

8.1.1 Baseline capacity

There is currently 32.5 MW of anaerobic digestion (AD) in the south west licence area, as well as a pipeline of 8.3 MW. Current projects are distributed across the licence area, a trend that is projected to continue due to the distribution and abundance of available sites and variable fuel sources anaerobic digestion can use. One AD developer, whom was contacted for research, spoke of his knowledge of over 100 potential sites .

The south west AD supply chain is developing with increasing numbers of companies moving to the region. New technologies, higher efficiencies and improved techniques, as well as Feed-in Tariff and Renewable Heat

Incentive subsidy support, have all helped broaden the appeal and viability of AD developments. AD can benefit many different groups including farmers, industry, communities and local authorities.

However, despite the increased level of technology development and customer interest, the actual number of new projects coming forward is slowing down. This is because of an increasingly difficult development environment for AD due to:

- Grid constraints
- Policy uncertainty
- Dramatic Feed-in Tariff subsidy cut
- Removal of pre-accreditation from Feed-in Tariff
- Uncertainly around the RHI
- Uncertain local authority waste collection facilities

It is due to a combination of these factors that there are currently no AD projects in the planning system in the south west above 1 MW (DECC planning database). As a result of this finding, and the factors above, it is assumed there will not be any new projects beyond the 8.3 MW already in the pipeline. New projects shall only arise in the scenarios from 2018 to 2030.

Anaerobic digestion scenario capacity growth

Scenario	Baseline 2015 capacity (MW)	Pipeline 2015 to 2018 capacity (MW)	Scenario 2018 to 2030 capacity (MW)	2030 total (MW)
Gone green	33	8	90	131
Consumer power	33	8	50	91
Slow progression	33	8	50	91
No progression	33	8	30	71

8.1.2 Future growth potential

Despite the current slowdown in new projects and the ongoing limiting factors above, these limiting factors are expected to be mitigated in the future energy scenarios to varying degrees. This is thanks to the abundance of sites, variable fuel sources and multiple sectors AD is beneficial for.

As well as having increasingly variable and diverse fuel sources, AD is also suitable for a variety of different uses at different scales. Fully utilising the different combinations of heat, power, and gas generation at different scales, will help AD to become increasingly viable. It will also make the technology more efficient and cost effective.

Smaller scale AD is well suited for biomass drying, which allows plants to gain an extra revenue scheme for the heat that they generate from burning gas. AD development in the 200-500 kW scale is forecast to be a particular growth area in most scenarios as the technology improves and demand for biomass drying increases.

Larger scale AD projects are increasingly concentrating on the emerging market of gas to grid, over electricity export. There are now a number of these projects across the region. It is currently only viable for larger AD projects to buy the equipment required to export gas. Projects exporting gas to grid generally only generate electricity to meet the parasitic load, as more can be earned exporting the gas, than burning it for electricity generation.

The dominant scale for projects varies depending on the scenario. Under the Gone Green scenario, deployment is distributed across smaller farm scale and large scale projects, while the Consumer Power scenario only sees smaller farm scale projects increasing, and larger projects dwindling. The Slow Progression scenario sees similar growth to that seen today, while No Progression sees a slowdown in all scales, with larger scale projects generally the only viable projects.

In the scenarios analysis, new projects are distributed across the region based on the availability of agricultural land within the BSP. Current baseline deployment shows a strong correlation to the available area of agricultural land within a BSP.

8.2 Hydropower

8.2.1 Baseline capacity

There are currently over 100 hydropower projects in the WPD south west licence area, with a total capacity of 10.7 MW. The build out rate has been relatively modest; over the last five years, approximately 150-200 kW of hydropower has been installed in the south west licence area each year, in addition to the occasional large scale project. The majority of this capacity is in Devon and East Cornwall, with 70 percent of the capacity in five BSPs.

Hydropower is however appealing to community energy groups and landowners, who are attracted to generating energy from this very visible resource in their area. Hydropower is a well-developed technology, with an established supply chain and high public approval. It is a predictable and reliable renewable energy resource and is expected to play a role, albeit relatively small in terms of generation capacity, across all the future growth scenarios.

8.2.2 Future growth potential

There are a number of obstacles to future development. The Feed-in Tariff has failed to unlock growth in this sector as it has for other technologies, and in fact the development of new hydropower projects has slowed in the last few years for several reasons:

- Hydropower projects have long development times, due to the detailed technical feasibility studies needed, permitting requirements and high upfront capital costs.
- There are a number of site conditions that need to be right to make a scheme viable and sites with optimal conditions tend to have already been deployed.
- The Environment Agency introduced tighter permitting requirements in April 2014, which will affect the viability of certain types of schemes.
- It is already the case that some of the best river sites have been developed

Therefore, the projected annual installed capacity after 2018 for each scenario varies between 300 kW for Gone Green, and 100 kW for No Progression. The development of hydropower is anticipated to slow down in the late 2020's as the number of remaining viable sites is reduced.

Hydropower scenario capacity growth

Scenario	Baseline 2015 capacity (MW)	Pipeline 2015 to 2018 capacity (MW)	Scenario 2018 to 2030 capacity (MW)	2030 total (MW)
Gone green	11	2	7	20
Consumer power	11	2	6	19
Slow progression	11	2	4	17
No progression	11	2	1	14

In the scenarios analysis, new projects are distributed across the region based on past trends and the available hydropower resource within a BSP. The hydropower resource assessment is based on Environment Agency data, which details the location of all obstacles such as weirs, rapids and waterfalls, with the corresponding flow rates and available head.

8.3 Energy from waste

8.3.1 Baseline capacity

There are now four projects generating energy from our waste in the south west licence area, totalling 39 MW. There are four projects in the Pipeline, two of which are currently under construction and two more with planning granted, totalling 85 MW. There is only one project currently in planning, the 3 MW Barnstaple Devon Waste Management project.

There has been a move towards energy from waste as the landfill tax has made landfill prohibitively expensive. However, the maximum waste resource is a finite amount, unless the south west becomes a major importer of waste. The resource is also potentially a shrinking resource, as the emphasis on recycling, reusing and reducing waste increases.

There is a shift away from mass burn incineration to 'advanced thermal technologies' using pyrolysis and gasification - such as the New Earth plant at Avonmouth. These projects have, to date, attracted less opposition in the planning process and also offer the potential to operate at smaller scales which potentially make them more flexible in their deployment and enable greater scale. However, these advanced technologies could produce a gas product that would be used in the gas grid or in transport. The Geneco plant in Avonmouth that takes sewage and food waste has trailed producing gas for heating and transport applications. This technology could, therefore, reduce the impact of Energy from Waste in the planning system.

8.3.2 Future growth potential

No new energy from waste projects are anticipated in the Consumer Power and No Progression scenarios. Gone Green and Slow Progression are the two scenarios that are anticipated to have new projects, however, they are also the two scenarios in which the waste resource could fall, thanks to greater green ambition leading to more emphasis on recycling, reusing and reducing waste. As a result, the scenario based projections are relatively small compared to the Baseline and Pipeline, thanks to an anticipated slowdown in future project development. The current and pipeline energy from waste plants are in and around Bristol, Exeter, Barnstaple, Plymouth and Cornwall. The trend is for the plants to be near population centres. Therefore, future growth of plants is expected in the largest population centres that are currently without an energy from waste plant.

Energy from waste scenario capacity growth

Scenario	Baseline 2015 capacity (MW)	Pipeline 2015 to 2018 capacity (MW)	Scenario 2018 to 2030 capacity (MW)	2030 total (MW)
Gone green	39	85	29	153
Consumer power	39	85	0	124
Slow progression	39	85	29	153
No progression	39	85	0	124

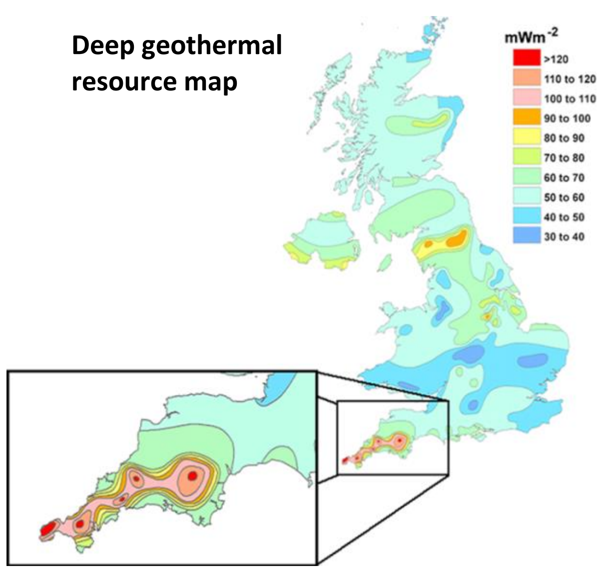
The major population centres lacking an energy from waste plant once the pipeline is built out would be Taunton, Bridgwater (plus Glastonbury), Bath, Newton Abbot and Western-super-Mare. These towns and cities all have a similar population (60,000 to 80,000). Analysis of the size of population served by existing energy from waste facilities showed that an approximate plant size of 5 MW would be suitable for each of these population centres. In addition, Exeter's current energy from waste plant takes waste from Exeter and the surrounding area; however, on the basis of the size of the plant compared to the population, there is scope for the area to build a larger plant.

If each of these population centres added a new 5 MW plant, and Exeter's current energy from waste plant were doubled, there would be 28.5 MW of new projects under the Gone Green and Slow Progression scenarios.

8.4 Deep geothermal

8.4.1 Baseline capacity

Deep geothermal resource map



Deep geothermal uses high temperature rocks (> 150 ^{o}C) at a depth of approximately four to five kilometres to produce surface heating, cooling, and steam generated power. This is achieved by injecting water down one well, and then abstracting it by another once it has been superheated by the rock. Deep geothermal projects can provide energy for up to 50 years.

While the technology concept is not new, geothermal energy has been extracted in Iceland and other countries for decades, its application in the UK and in deeper sites is ground-breaking. Cornwall previously had a deep geothermal project back in the 1970's – the "Hot Rock" project. Projects face a degree of uncertainty regarding the energy yield, and are therefore considered to be higher risk. This is one reason why they have been difficult to finance and will most likely require some level of grant/public funding.

WPD's south west licence area contains some of the UK's best deep geothermal resource due to high heat flow in the granite rock under the region, thanks to its volcanic past. The BSPs with the highest heat flows and most viable for deep geothermal are Hayle, Rame, Cambourne, Truro/ Fraddon and St Germans.

There are currently two such projects in development in the south west,. These are the 10 MW (55 MW heat) United Downs (GEL) and the 7 MW Eden (EGS) geothermal project. Both the current projects are within the Truro/ Fraddon BSPs. The current status of the projects is that they planning permission but are now in the process of raising finance and are looking for investment and grant funding from both the private sector and public sector sources.

A further challenge for deep geothermal is that it is currently within the Contract for Difference "Less Established technology" group but does not have a "minima" ring-fenced allocation. Unless DECC decides to set a minima allocation, it would in theory therefore have to bid in auctions and compete with offshore wind.

8.4.2 Future growth potential

There is quite a lot of uncertainty about the growth outlook for Deep Geothermal and until the two pilot projects are successfully built it is difficult to forecast a future growth projection. For the purpose of modelling it is assumed that that under:

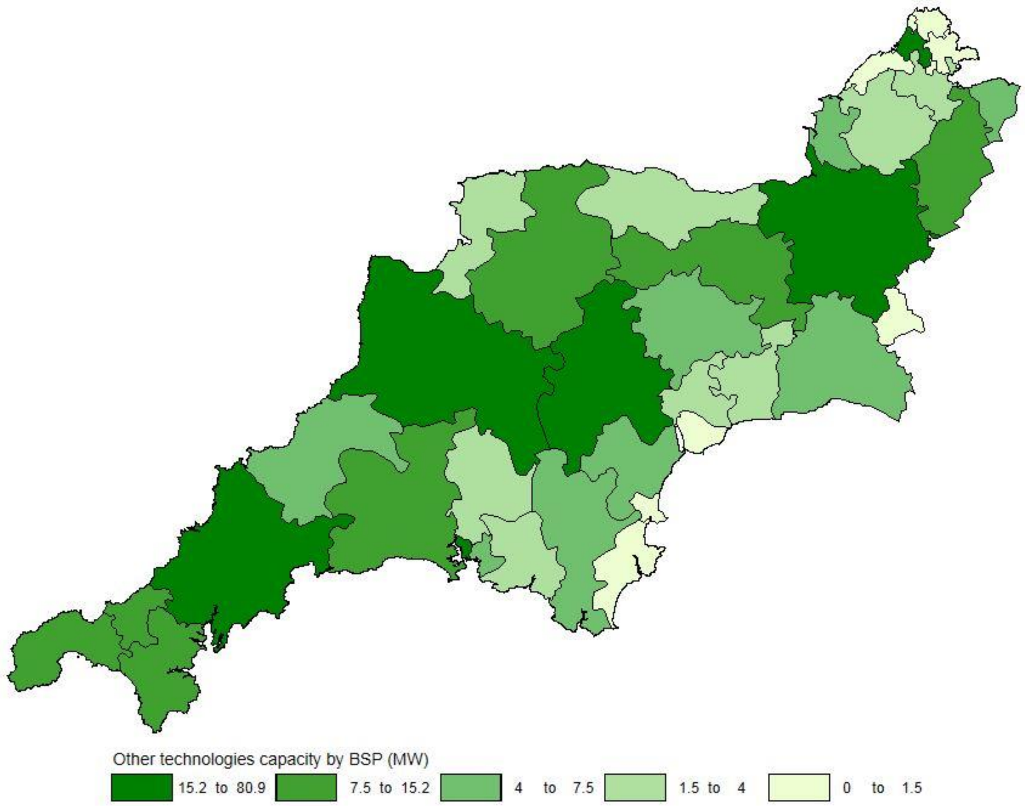
- Gone Green both pilots are built and their success leads to an expansion of Deep Geothermal projects delivering over 50 MW capacity by 2030. This forecast is based on each BSP with good resource having at least 1 project (circa 7MW) by 2030.
- Slow Progression it is assumed that the two pilots are built but this takes longer (into the mid 2020's) and further expansion is constrained.
- Consumer Power and No Progression scenarios, it is assumed that neither pilot is built.

Deep geothermal scenario capacity growth

Scenario	Baseline 2015 capacity (MW)	Pipeline 2015 to 2018 capacity (MW)	Scenario 2018 to 2030 capacity (MW)	2030 total (MW)
Gone green	0	0	52	52
Consumer power	0	0	-	-
Slow progression	0	0	17	17
No progression	0	0	-	-

8.5 **Other technologies capacity by BSP in 2030 in Gone Green scenario**

Geographical distribution of other technologies capacity in the Gone Green scenario



9 Energy storage – technology growth scenarios

Note:

Whilst not a distributed generation technology Energy Storage has been included in this study because of its potential synergy with, and impact on, other generation technologies such as solar PV and onshore wind. Energy storage also has a potential impact on future grid requirements, both as a means to better manage grid capacity issues and as a potential transformational technology that could change the way in which energy is used and traded.

The analysis below gives a very brief summary of the technology potential and possible growth projections. Energy storage covers a wide range of new technologies, functions and business models and is an extremely complex subject, requiring further examination. Some of the material below has been adapted from a wider study that Regen SW is conducting.

9.1 Summary growth scenarios

This section discusses the overall growth scenarios for three models of energy storage application in the south west.

- Consumer support – 'own use' energy storage.
- Generation/market support – 'curtailment, grid compliance and variable price' energy storage.
- Network support – 'network ancillary services' energy storage model.

9.2 Technology overview and growth potential

In the past 5 years, a significant amount of technology development and investment has been channelled into the energy storage sector and a number of new technologies are coming onto the market.

At the smaller scale, development has been driven by the need to provide high performance batteries for electric vehicles, which are now being offered for domestic and commercial applications. At a larger scale, the technology growth has been driven by a variety of factors including the need to overcome grid constraints and the opportunity to maximise revenue streams from variable generating plant.

Higher electricity costs in some countries – especially for remote and island communities - plus the exponential growth of variable generation technologies such as solar PV have also been key drivers.

Main energy storage types and example technologies

Storage type	Example technologies
Primary storage	Super-conductors magnetic ES Capacitors
Mechanical storage	Pumped hydropower, flywheels, compressed air
Electrochemical energy storage (batteries)	Classic solid state batteries Lead/acid, Lithium-Ion, Lithium-S, Lithium-Polymer, metal air Sodium-Ion, Sodium-Sulphur, Nickel-Cadmium and many others Flow batteries Vanadium rodox, Zinc – bromine
Chemical energy storage	Hydrogen, synthetic natural gas
Thermal energy storage	Heat – water, heat packed bed, molten salts and others

Energy storage costs have fallen significantly and are set to continue to fall into the next decade. Domestic batteries for home-use energy storage are currently quoted at £2-3k allowing a potential payback period of 7-10 years depending on their application. Domestic scale Lithium-Ion batteries, for example, are predicted to drop from US$500-700/kWh to US$200-300/KWh by 2020.

At a larger scale, there are now a number of container sized[7] battery solutions with a storage rating of 1-2 MWh, with the potential to be stacked that could be used to provide generation curtailment support for ground mounted PV farms.

Example: Electrovaya MWh scale storage solution

Lithium based batteries are currently dominant in the UK energy storage market, but several other battery technologies are being developed and may prove both cheaper and more environmentally friendly in the longer term. Sodium based batteries, for example, are being used extensively in other European markets.[8]

[7] http://www.pv-magazine.com/fileadmin/PDFs/pv-magazine_Storage_Special_Jul_2015.pdf

[8] Top Markets for Energy Storage in Europe Update 2015

9.2.1 Emerging business models

A key challenge and opportunity for energy storage technologies is to develop and adapt new business models that will allow storage solutions to generate revenue and/or enhance services.

The table below highlights a number of potential business models that either already exist or could potentially come to the fore over the next decade. The analysis focuses on three potential business models:

1. Consumer support – 'own use' model
2. Generation/market support
    - 'curtailment and grid compliance' model
    - 'variable price' model
3. Network support – 'services' model for transmission and distributed network

Other potential business models and functions of energy storage could emerge, for example, the use of electric vehicles to provide distributed storage or the conversion of electricity to heat within distributed heat networks.

1) Consumer support 'own use' model Providing time of use benefits for domestic and commercial generator/consumers by enabling supply 'time shift' from periods of peak generation to peak demand, both to increase the ability to use self-generated electricity and to take advantage of time based tariffs.	
Commercial drivers	**Market growth drivers**
• Increasing own use – retail/wholesale margin • Allowing peak/variable tariff savings • TRIAD avoidance for energy intensive users • Continuity of supply – island, remote, energy users • Allowing private wire projects & off-grid projects	• High numbers of PV, wind and other DG technologies • Increasing electricity prices • Falling technology storage costs • Time of use tariffs and half hourly settlement enabled by smart meters • Variable and peak tariffs • Growth of private wire applications

Generation support 'curtailment and grid compliance' model Allowing generators to mitigate grid curtailment constraints or to avoid grid reinforcement costs by 'peak shaving' – reducing peak power output. Also allowing generators to meet grid compliance by output smoothing and control of ramp rate to eliminate rapid voltage and power swings on the electrical grid.	
Commercial drivers	**Market growth drivers**
• Optimise generation capacity • Avoid grid reinforcement costs • Avoid lost revenue • Comply with curtailed connection agreements • Comply with ramp rate limits • Capacity firming	• Capacity of new DG projects • Existence and degree of grid constraints • Availability of constrained connection agreements

2) Generation support 'variable price' model Allowing generators to gain commercial value by taking advantage of price variation. Shifting supply from periods of low to higher electricity price margins.	
Commercial drivers • Arbitrage (energy time shift) • Energy price optimisation	**Market growth drivers** • Increasing wholesale price variation – peak pricing and negative pricing • Falling technology costs • New commercial models • ICT – data, control, analysis and optimisation technology • Opportunities for aggregation

Network support 'services' model for transmission and distributed network Allowing energy storage providers* to provide a range of network support services. Potentially - if costs, market conditions and regulations allow - energy storage providers could provide a wide range of balancing services associated with capacity markets and STOR providers. It is expected that the Network Support model could increasingly become relevant for larger scale storage technologies and enable new services to be provided at both the Transmission and Distributed network levels. The development towards Distribution System Operator (DSO) business models, with a commissioning or ownership function for energy storage, will also open up new opportunities. * Energy storage providers could in the future be – generators, IPPs, DSO/DNOs, utilities, technology/service providers, community or municipal providers.	
Commercial drivers/services (examples only) • Capacity support • Frequency response • Dynamic, local voltage control • Maintenance support • Intentional islanding • Capacity peak shaving • Active Network Management • Capacity/investment deferral • Reactive power compensation	**Market growth drivers** • Growth of variable (renewable) generators • New large scale energy storage solutions • Changes to the regulatory environment • New business models • DSO models • Technology innovation and falling costs • ICT – control, analysis and communications technology

9.3 Current UK energy storage projects

Pumped storage solutions have been around for some time, of which the Dinorwig power station in Wales is the largest. Newer examples of pumped storage include the Quarry Battery in Glyn Rhonwy. According to the latest CCC report, there is circa 2.7 GW of pumped storage capacity in the UK able to store around 30GWh of electricity. There are no known examples of significant pumped storage in the WPD south west licence area – partly because there no large scale hydro schemes in the region.

Domestic and small scale battery storage has begun to make an impact and a number of PV related battery solutions are now available to buy. The numbers deployed are, however, relatively small at present. This could change significantly in the coming decade.

There are currently a small number of pilot and demonstration projects in the WPD south west licence area such as the WPD SoLa Bristol project, which is a consumer based 'own use scheme'.

There are a larger number of demonstration and pilot projects across the UK. The majority of projects are aimed at renewables capacity firming applications, voltage support and energy time shift[9]. Examples include:

- Network support service schemes e.g. WPD Falcon, SSE Shetland NINES 1MW battery, SSE Orkney Energy Storage Park, Smarter Network Storage Bedfordshire,

- Consumer support 'own use' for domestic and commercial customers e.g. WPD SoLa Bristol, Moixa, SSE Zero Carbon Homes.

To date, with the exception of existing pumped storage, we have not seen many UK examples of energy storage used for variable price or arbitrage applications. This is partly because large scale energy storage solutions are still expensive, and also because the necessary market and regulatory conditions are not yet in place to support energy storage trading solutions. This may well change with increased wholesale price volatility, including the advent of negative pricing.

There are, however, a number of PV and onshore wind developers who are looking at energy storage solutions in order to overcome constrained grid connection offers and we expect that a number of energy storage projects associated with ground mounted PV and potentially onshore wind will be developed in the next 5 years. The expected increase in the number of timed and soft-intertrip constrained connection agreements will itself drive demand for energy storage solutions.

It should also be noted that there are a large number of energy storage projects currently being developed overseas, in the US especially, but also in Germany, Japan, China and Canada.

9.4 Overall energy storage growth by scenario analysis 2015-2030

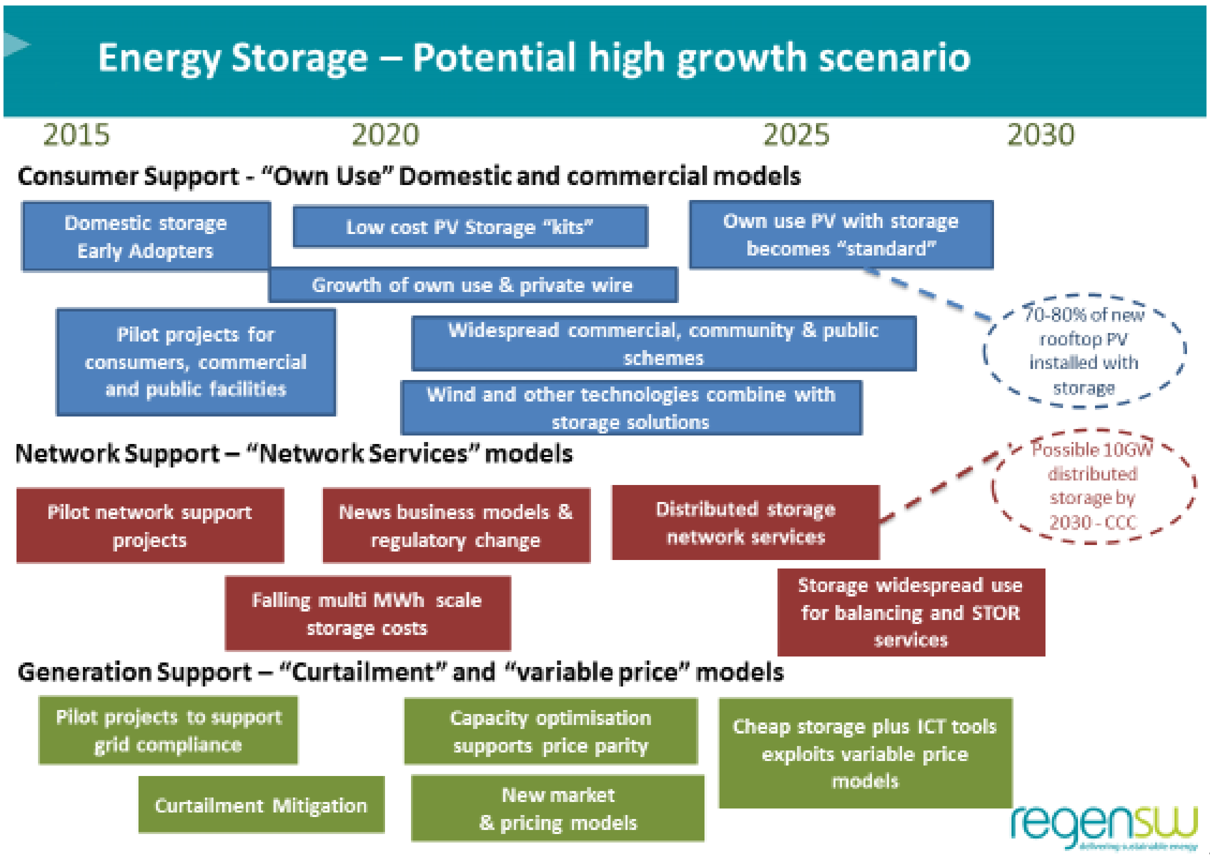
Industry analysts have identified that energy storage solutions could grow exponentially in the coming decade and several industry reports have produced high level growth estimates.

The Committee on Climate Change Power Sector Scenarios for the Fifth Carbon Budget report[10] estimates that there are around 200 MW capacity of demonstration and pilot storage projects across the UK. The report scenario assumes a growth of up to 10 GW of distributed storage across the UK by 2030, providing both

[9] Top Markets for Energy Storage in Europe 2015 Update

[10] CCC 5th Carbon Budget Report Nov 2015

reserve and frequency response, in addition to the current 2.7 GW of pumped storage. The report however highlights that such growth is contingent upon successful trials, further cost reduction and the 'regulatory and legal' clarification of energy storage technology.



Focusing specifically on the south west of England, the most likely drivers of energy storage growth in the near term will be:

- Early adoption of 'own use' energy storage for domestic and commercial generators taking advantage of energy price savings and variable time shift tariffs
- Curtailment and grid compliance storage associated with larger scale PV and onshore wind farms as generators respond to constrained network offers – although the economics of such schemes are still to be tested.
- Energy storage linked to community based energy generation schemes, either to support 'own use', private wire, or to overcome local grid constraints
- Network support energy storage particularly for island (e.g. Isles of Scilly) and isolated grid regions – which given the south west is a peninsula could be significant.

In the longer term, and especially under a Gone Green future energy scenario, we may also see larger scale energy storage solutions used to take advantage of price variance and arbitrage opportunities. Although at the moment this is not yet commercially viable, falling energy storage costs combined with the development of more sophisticated information and communication technology may open market opportunities.

The rapid growth of own use energy storage solutions is a real possibility and evidence from the US and Germany suggests that storage solutions will increasingly be offered as part of a standard PV or small scale wind package. Evidence from the German Solar Trade Association suggest that 70 percent of solar installers are now offering energy storage solutions as part of a standard PV package and that the proportion of new domestic PV storage systems will grow by 50 percent with 1 in 3 installations now taking a storage options. In part, the high growth in Germany has been driven by very high electricity prices; however, with falling costs energy storage solutions could equally grow here in the UK.

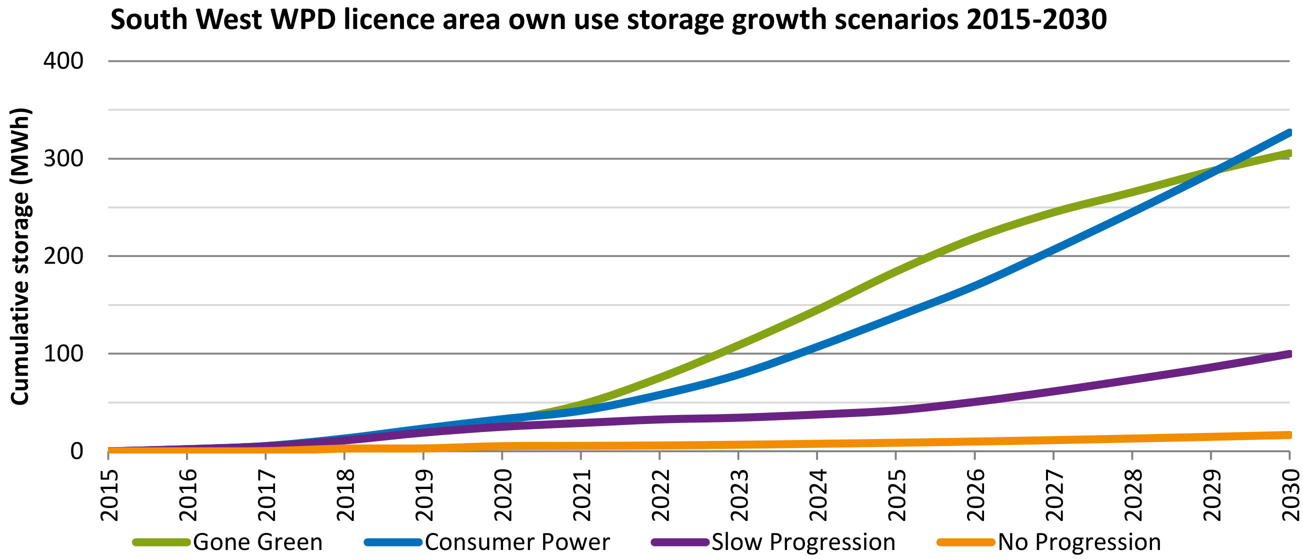
Commercial applications for 'own use' energy storage are also expected to increase as companies, large corporations and public bodies seek to reduce their energy dependency. For example, see Kingfisher group's announcement that it will invest £50 million on a range of measures to reduce grid energy consumption by 10 percent. http://www.kingfisher.com/index.asp?pageid=55&newsid=1125

The roll out of smart meters will be a key enabling technology, as will the general introduction of ½ hourly bill settlement, which, although available, is currently only being offered by a small number of utilities such as Tempus.

9.4.1 Scenario factors impacting future energy storage growth in the south west

FES Scenarios - Implications for Energy Storage in the south west	
Consumer Power • Highest growth for rooftop PV • High growth Energy Storage scenario for 'own use' • Technological innovation drives down storage costs • Majority of new PV schemes include storage by 2025 • Smart meters and flexible billing is the norm • Relatively high electricity price driven by economic growth • Network support storage schemes to support community and small scale renewables in distributed network	**Gone Green** • Highest overall DG growth scenario • New business models for energy storage • Smart meters and energy billing is the norm • Higher price variance support time shift demand and generation • Relatively high electricity price driven by economic growth • New business models support price variance and arbitrage models • Energy storage replaces gas/diesel STOR to provide network support and balancing services
No Progression • Lowest growth scenario • Lowest number of new PV and onshore wind schemes • Storage costs remain relatively high • Minority of new schemes include energy storage • Some municipal and community storage schemes • Gas and diesel remain primary fuel for STOR and balancing services	**Low Progression** • Medium growth scenario for PV • 'Own use' business models help PV reach price parity by 2025 • Increasing proportion of new PV schemes include storage • Municipal, commercial and community schemes • Limited use of energy storage for network support and balancing services

9.4.2 Projection of 'own use' energy storage growth in the south west to 2030



'Own use' solar PV electricity storage growth scenarios 2015 to 2030

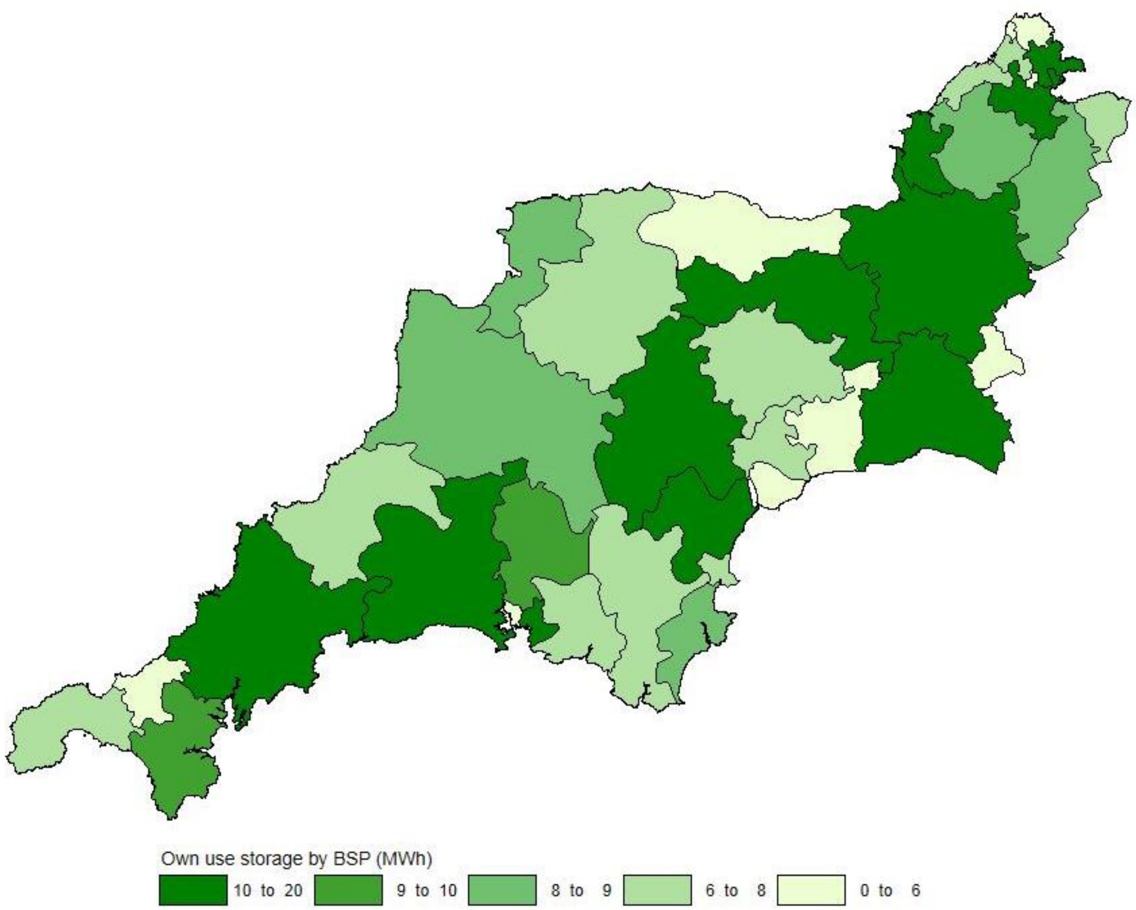
Scenario	Baseline 2015			2020 (cumulative)			2025 (cumulative)			2030 (cumulative)		
	Retrofit (MWh)	New projects (MWh)	Total 2015 baseline (MWh)	Retrofit (MWh)	New projects (MWh)	Total 2020 (MWh)	Retrofit (MWh)	New projects (MWh)	Total 2025 (MWh)	Retrofit (MWh)	New projects (MWh)	Total 2030 (MWh)
Gone green	0	0	0	22	9	31	27	157	184	27	279	306
Consumer power	0	0	0	22	10	33	27	111	138	27	300	327
Slow progression	0	0	0	22	3	25	27	15	42	27	73	100
No progression	0	0	0	4	1	5	4	4	9	4	12	17

Key points to note:

- The analysis focuses solely on the growth of domestic and commercial energy 'own use' storage solutions related to PV. A similar argument could also be made for onshore wind, however, the number of 'own use' onshore wind projects is comparatively small.
- Energy storage growth factors relate to the proportion of existing PV schemes to which energy storage is retrofitted and the proportion of new PV schemes deployed with energy storage.
- All scenarios, except No Progression, assume that smart meters and half hourly billing settlement will be readily available.

- Due to technology costs, the uptake of 'own use' energy storage solutions will be low initially, but are expected to rise from 2018 onwards.
- Retrofit energy storage schemes will increase initially – given the large installed capacity – but will decline from 2020 onwards as existing schemes are either fitted or age.
- Gone Green and Consumer Power – A high proportion of new PV schemes are expected to be deployed with energy storage reaching 70-80 percent by the end of the 2020s.
- Slow Progression – A relatively high proportion of PV schemes will include storage growth, however, the overall number of PV installations is less.
- No progression – uptake of PV is low and the proportion of energy storage adopters is lower than other scenarios, although for those that do install PV, energy storage may still be an attractive add-on.

9.4.3 Geographic distribution of 'own use' energy storage to 2030 in Gone Green



9.4.4 Projection of 'network service' energy storage growth in the south west to 2030

There are a number of factors that will affect the growth of energy storage used to provide network support and balancing services.

First, there is the underlying assumption that energy storage costs will continue to fall and the technology to develop to a scale where the provision of network support and balancing services is viable. As discussed above, a number of pilot projects are currently under way.

Secondly, there will need to be changes in the current regulatory framework and energy market to allow energy storage providers to offer network support and balancing services.

Under the Gone Green and Consumer Power scenario, it is assumed that both these conditions are met.

The rate of growth of network services will also be impacted by the underlying demand for network support and balancing services, and the degree to which energy storage can compete with other technology solutions, including currently available gas and diesel generators.

In the past few years, the National Grid has contracted for a significant increase in STOR (Short Term Operating Reserve) capacity. This growth has been partly driven by the need to support the increase in renewable energy capacity, but also to provide backup for older generating plant and a tighter reserve capacity.

Further growth in renewable energy is likely, all things being equal, to increase the requirement for network support and balancing services, which could be met by energy storage solutions. An increase in gas fired power stations under the No Progression scenario would be likely to reduce the overall demand for network services.

Changes in the way in which network support and balancing services are contracted may also have a significant impact with a movement away from centrally contracted services through the National Grid to a more distributed model, with network services commissioned through the DNOs or DSO model.

Scenario	Growth in demand for network Services	Energy storage as a network support technology	Rationale/notes
Gone Green	Highest	Highest	New technology, new business models and support for greener solutions
Consumer Power	High	High	Developments in technology and increase in distributed generation
Low Progression	Medium	Low	Costs issues and lack of technology development
No Progression	Lower	Low	Reversion to fossil fuels. Assuming Dash for Gas is achieved

Growth of network support and energy storage capacity in the south west by scenario

Scenario	Description	Category	2020	2025	2030	Units
Gone green	Total capacity growth of network support	Highest	360	400	450	MW
	Of which energy storage %		20%	35%	60%	
	Energy storage capacity installed		72	140	270	MW
Consumer power	Total capacity growth of network support	High	350	400	450	MW
	Of which energy storage %		10%	30%	55%	
	Energy storage capacity installed		35	120	248	MW
Slow progression	Total capacity growth of network support	Low	350	350	350	MW
	Of which energy storage %		5%	20%	30%	
	Energy storage capacity installed		17.5	70	105	MW
No progression	Total capacity growth of network support	Low	350	350	350	MW
	Of which energy storage %		0%	5%	10%	
	Energy storage capacity installed		0	17.5	35	MW

9.4.5 Projection of 'generation support' storage growth in the south west to 2030

The projection of 'generation support' energy storage in the south west is extremely difficult and will depend on a number of technical and market factors.

At the moment there is some interest amongst PV and onshore wind developers in looking at energy storage to mitigate grid curtailment issues and to provide grid compliant power by providing greater ramp up control and power smoothing.

The advent of curtailed connection agreements and higher grid reinforcement costs is likely to make developers look at the viability of energy storage solutions.

Projections for the growth of generation support have not been made since this technology is at such an early stage of its development. As business models and trends begin to emerge in greater detail, this could be reviewed.

9.4.6 Marine and offshore energy storage opportunities

A number of technology developers and academics are looking at options to use wave, tidal and offshore wind technologies to provide future energy storage solutions. Examples include multi cell tidal lagoons to provide pumped storage capacity and the use of wave energy to pump sea water into a head reservoir. See for example Searaser.

Future solutions could include the use of wind or wave energy options to pump compressed air into sub-sea storage facilities. See for example DNV GL video Nikashima Shelf.

Marine and offshore energy storage solutions could develop in the future; however, owing to the level of uncertainty and timing of such developments, these have not been included in the growth scenario analysis to 2030.

9.5 Short Term Operating Reserve (STOR)

Short Term Operating Reserve (STOR), is a reserve of energy for the National Grid to be called upon to increase or reduce generation on very short notice. This service is currently led by diesel generators, who are able to deliver multiple services to the National Grid, as well as backup generation to large energy consumers.

The number of such generators is currently growing, driven by an energy generation auction for backup power, and high returns for investors. These returns are as high as 23 percent (pre-tax) according to an IPPR article[11], made up of subsidies and revenues from the energy market.

The energy minister who introduced the scheme, Ed Davey, expressed that diesel generators weren't the intended beneficiaries of the scheme. Smart technologies managing electricity demand could fulfil the role, and this is reflected in our scenarios.

In the scenarios, there is no growth of STOR beyond 2020, after the current generation auction has been built out by 2019. After 2020, all scenarios see a decline in diesel STOR generators, as more efficient and cleaner solutions take-over, such as smart technologies and battery storage.

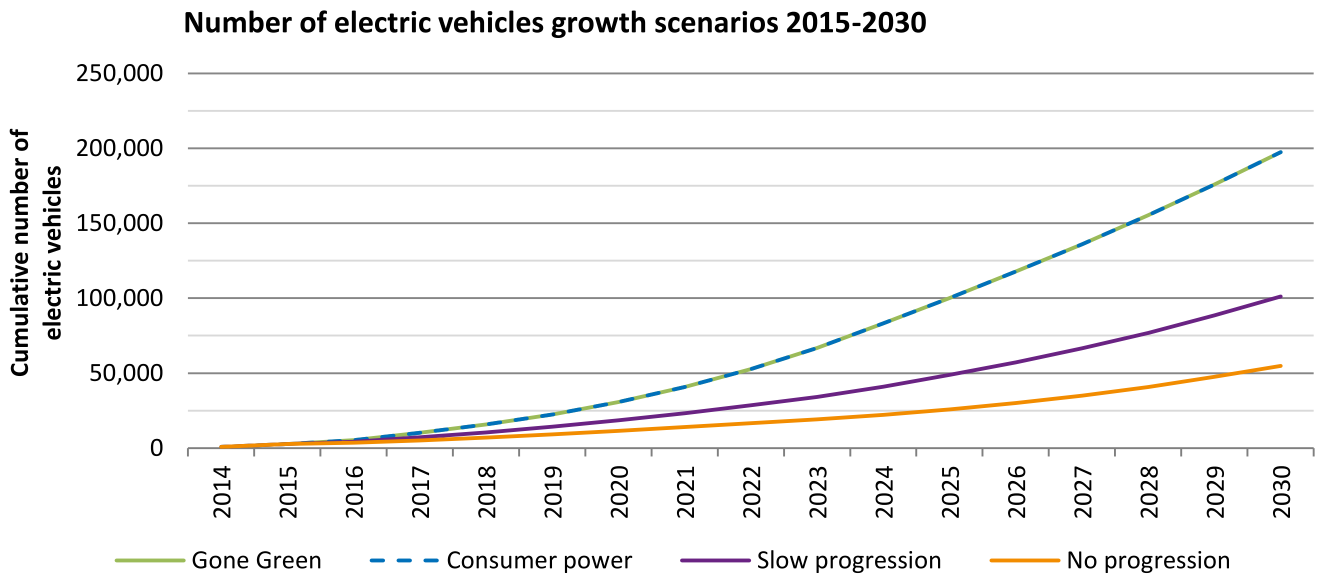
BSP distribution projections have not been made since all scenarios see diesel and gas STOR capacity decreasing beyond the current generation auction. This is due to the anticipated shift to smarter solutions in all scenarios, due to the heavily polluting and inefficient nature of diesel generators.

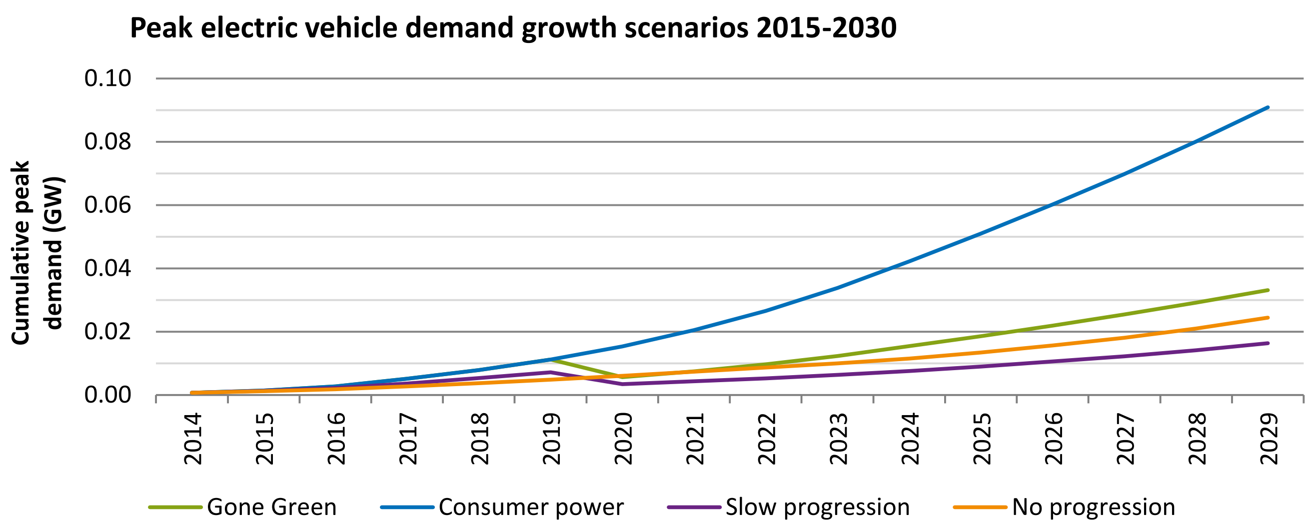
Changing STOR capacity in the south west by scenario

Scenario	Description	Category	2020	2025	2030	Units
Gone green	Total capacity growth of network support	Highest	360	400	450	MW
	Of which STOR %		80 %	65 %	40 %	
	STOR - gas and diesel		288	260	180	MW
Consumer power	Total capacity growth of network support	High	350	400	450	MW
	Of which STOR %		90 %	70 %	45 %	
	STOR - gas and diesel		315	280	202.5	MW
Slow progression	Total capacity growth of network support	Low	350	350	350	MW
	Of which STOR %		95 %	80 %	70 %	
	STOR - gas and diesel		332.5	280	245	MW
No progression	Total capacity growth of network support	Low	350	350	350	MW
	Of which STOR %		100 %	95 %	90 %	
	STOR - gas and diesel		350	332.5	315	MW

[11] http://www.ippr.org/publications/mad-maths-how-new-diesel-generators-are-securing-excessive-returns-at-billpayers-expense

10 Electric vehicles – growth scenarios





Scenario electric vehicle summary for the south west licence area

Scenario	Baseline number of vehicles	Scenario number of vehicles	Total number of vehicles
Gone green	2,658	194,999	197,656
Consumer power	2,658	194,999	197,656
Slow progression	2,658	98,706	101,364
No progression	2,658	52,319	54,976

10.1 Electric vehicles – growth potential

The number of electric vehicles on Great Britain's roads tripled over the last year, fuelled by falling costs and government grants. There are now nearly 50,000 electric vehicles on the roads in the UK, which is a milestone that may see government grants dropped. However, even if the grants end, continuing falling costs will see the number of vehicles continue to grow.

The growth potential for electric vehicles has been calculated by modelling 2015 Future Energy Scenarios (FES) data to the WPD south west license area. The FES predict the number of electric vehicles in Great Britain will grow to between approximately 900,000 and 3,300,000 in 2030.

In order to have this many electric vehicles on the road, between 7 to 25 percent of all vehicles sold will be electric by 2030, up from 1.2 percent today. The table below summarises the numbers of cars and the percentage of total car sales the EVs represents for each scenario, for the south west licence area

Summary of electric vehicle number and peak demand by scenario for the south west licence area

	2015 Baseline		2015-2030 scenarios		Total 2030		Does the scenario predict time of use tariffs being implemented
Scenario	Peak demand (MW)	Number of electric vehicles	Peak demand (MW)	Number of electric vehicles	Peak demand (MW)	Number of electric vehicles	
Gone green	0.6	2658	36.3	194,999	36.9	197,656	Yes
Consumer power	0.6	2658	100.7	194,999	101.3	197,656	No
Slow progression	0.6	2658	17.9	98,706	18.5	101,364	Yes
No progression	0.6	2658	27.3	52,319	27.9	54,976	No

There is significant growth potential for electric vehicles, which will result in increasing demand on the electrical grid. Therefore, as well as numbers of vehicles, we have modelled the peak energy demand for the south west license area based on FES peak energy demand data.

10.2 Modelling Great Britain FES data to BSP

First, modelling the FES data to the south west was achieved by using DECC and DfT regional data on vehicles. The DECC data details the number of vehicles in each region and so was used to proportion 6 percent of Great Britain electric vehicles to the south west, based on the fact the south west license area currently has 6 percent of all vehicles. The DfT data provides statistics on annual vehicle miles travelled by region, so was used to proportion 5.5 percent of the peak demand to the south west licence area.

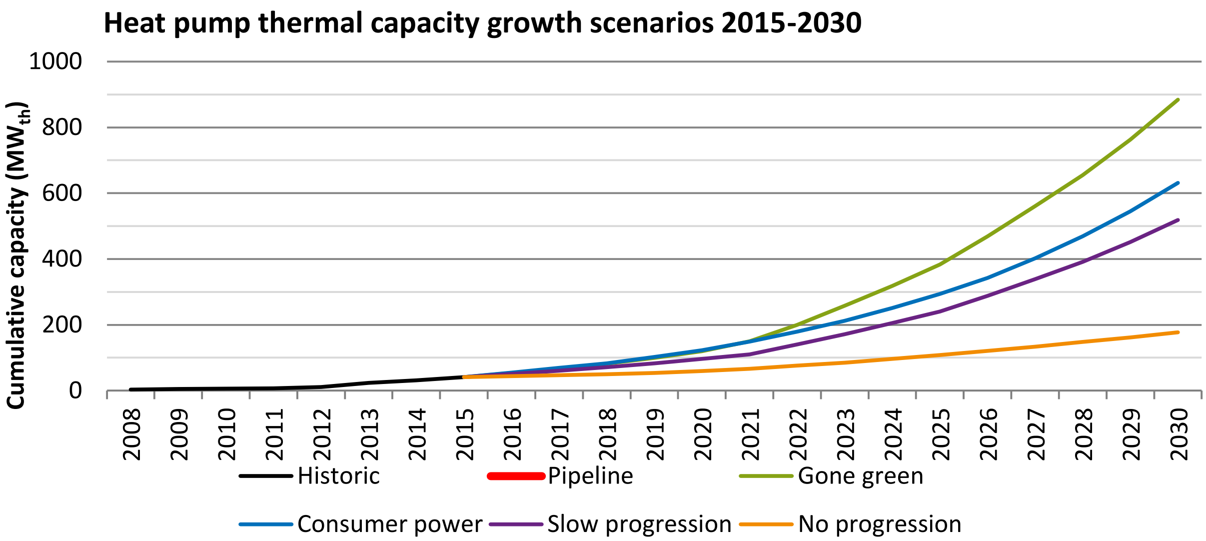
Once the total number of vehicles was known for the south west area, that total was proportioned to BSP based on two factors:

- Primary - Total number of households within the BSP
- Secondary - Historic trends of domestic rooftop solar PV uptake within the BSP.

Historic trends of rooftop solar PV was included as a proxy factor for level of affluence and early adoption. There is also the potential that, as a broad demographic, those with solar panels are more likely to be early adopters of electric vehicles, due to both their willingness to invest and interest in green technologies.

11 Heat pumps – technology growth scenarios

11.1 Summary distributed generation growth scenarios 2015-2030



Baseline and scenario thermal capacity summary

Scenario	2015 baseline (MW_{th})	2030 Retrofit scenarios (MW_{th})	2030 New Build scenarios (MW_{th})	2030 total scenarios capacity (MW_{th})
Gone green	41	308	534	884
Consumer power	41	308	282	632
Slow progression	41	213	264	518
No progression	41	97	39	177

11.2 Heat pumps – future energy potential

Heat pumps (ground source and air source) are at present a small but growing part of the UK energy market. If deployed in significant numbers heat pumps could potentially place a significant additional demand on the grid – especially at peak times – when electricity is used to augment the heat energy extracted from ground and air sources.

A number of studies commissioned by Government and other bodies have predicted that heat pumps could become a key technology to enable the decarbonisation of heat energy generation in the UK. For example; in the 'The Future of Heating: Meeting the Challenge' (2013), the Department of Energy and Climate Change (DECC) predict that heat pumps will be the main heat source for off-gas rural and suburban areas in the future.

In addition, government policy has combined with improving technology so that we now have heat pumps directly competing for the on-gas market through the development of hybrid air source heat pumps. Hybrid systems enable customers to use the ASHP at times when electricity is cheaper than gas. Heat pumps may also be used to supply heat networks, with a pilot in construction at EON's Cranbrook network, near Exeter.

From 14,000 units in 2012, BSRIA[12] expect 26,000 ASHP systems to be sold in 2015, reaching 50,000 by 2017 – all largely driven by the owner/occupier market[13]. The Committee on Climate Change's Fifth Carbon Budget has decreased its target for the number of heat pumps in homes by 2030 from 4 million to 2.3 million. This is the 'minimum that could keep deep decarbonisation of heat in buildings in play for 2050'[14].

Despite this potential the number of heat pump installations to date has fallen well below these estimates reflecting that there are still a number of significant challenges to growth. In summary these challenges include:

- A natural inertia against domestic and commercial customers replacing heating systems
- Higher upfront capital costs – which has not been overcome by grant and Renewable Heat Incentive schemes
- Practical constraints – land space and bore holes – especially for ground source heat pumps
- Need for well insulated homes and ideally underfloor heating solutions - heat pumps work best providing low-grade heating that requires relatively air-tight, well insulated properties to achieve cost effectiveness.
- Public awareness of heat pumps remains low. DECC's Public Attitudes Tracker found in 2015 that 33 percent of those surveyed were aware of air source heat pumps and 40 percent were aware of ground source heat pumps, with less than 5 percent feeling that they knew a lot about the technologies[15].
- Doubts and concerns about heat pump performance – partly driven by some poor installations but also some critical studies – and their reliance of electricity as the main backup and augmentation energy source

11.3 South West historic growth and baseline capacity to 2015

From a low base, the rate of heat pumps installation has remained steady in recent years. Since 2012, approximately 10 MW_{th} of heat pumps has been installed annually, approximately 1,100 units each year. Heat pumps showed the greatest number of projects added for any renewable heat technology in 2014/15, with off gas properties driving demand for domestic renewable heating technologies.

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[12] Building Services Research and Information Association

[13] http://www.phamnews.co.uk/the-right-conditions-for-market-growth/

[14] https://d2kjx2p8nxa8ft.cloudfront.net/wp-content/uploads/2015/11/Sectoral-scenarios-for-the-fifth-carbon-budget-Committee-on-Climate-Change.pdf

[15] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/474170/Wave_15_Summary_of_Key_Findings.pdf

Reflecting national trends, 77 per cent of all heat pumps in the south west are air-source heat pumps and the majority of the remaining projects are ground-source heat pumps. Our data calculates that there is 41 MW_{th} of heat pump capacity in the south west licence area, comprised of 3,600 ASHPs totalling 31.2 MW_{th}, and 1,100 GSHPs totalling 9.8 MW_{th}.

The geographic spread is heavily influenced by the number of off-gas grid properties and it is estimated that as many as 80 percent of all heat pump installations are associated with off gas properties. There is therefore a strong correlation between the number of heat pumps within a BSP, and the number of off gas properties. This general trend is expected to continue, where off gas properties lead the heat pump market until costs fall further to make it more economically viable for on gas properties to install heat pumps.

11.4 Scenario growth analysis 2015-2030

Based on the growth scenarios, it is forecast the total thermal capacity for heat pumps in the south west licence area could reach approximately 884 MW_{th} by 2030 in the Gone Green scenario. This is based on an anticipated uplift in public awareness of heat pumps, falling costs, and policy driven installations on new build houses.

Against this positive trend public policy to increase building standards that could have driven heat pump demand has been weakened. The EU Nearly Zero-Energy Homes Directive[16] could encourage the adoption of new building regulations, but is now based on UK government analysis of the most cost-optimal solutions[17].

Public perception of heat pumps may improve from 2017 with the publishing of a government report into the performance of heat pumps funded through the Renewable Heat Premium Payment Scheme. This will build on trials conducted by the Energy Saving Trust, which had mixed results and was not wholly welcomed by industry but did show high customer satisfaction with systems[18].

Based on the anticipated scenario factors described below, the overall growth for heat pumps by scenario is shown in the table below.

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[16] http://www.epbd-ca.eu/themes/nearly-zero-energy
[17] http://www.eib.org/epec/ee/documents/comparative-methodology-epbd.pdf
[18] http://www.energysavingtrust.org.uk/sites/default/files/reports/TheHeatisOnweb(1).pdf

Heat pump scenario heat thermal capacity growth

Scenario	Baseline 2015 Total baseline capacity (MW_{th})	2015 percentage of houses with heat pumps Off gas houses (%)	On gas houses (%)	2030 retrofit installations as percentage of total houses Off gas houses (%)	On gas houses (%)	Scenario 2016 to 2030 Total scenario forecast (MW_{th})	Retrofit scenario forecast (MW_{th})	New build scenario forecast (MW_{th})
Gone green	41	1.2	0.1	6.5	2.0	884	308	534
Consumer power	41	1.2	0.1	6.5	2.0	632	308	282
Slow progression	41	1.2	0.1	4.5	1.5	518	213	264
No progression	41	1.2	0.1	2.5	0.8	177	97	39

The table below summarises the scenario assumptions.

FES Scenarios - Implications for heat pumps in the south west

Consumer Power

- Medium growth scenario
- Deployment reaches a tipping point and market awareness increases rapidly
- Rate of new build increases dramatically and consumers increasingly want efficient, low carbon buildings
- Demand for cooling requires reversible systems
- Demand for grid stabilisation technologies enables development of consumer market
- Rapidly decreasing prices for PV systems resulting in more integrated systems
- Some take up in on-gas areas due to investment
- Self-build market grows strongly

Gone Green

- Highest overall growth scenario
- Positive planning environment with increased regulations and enforced renovation of old buildings
- Government incentives to install heat pumps
- Dynamic grid developed with payment systems for those able to take energy off the grid and store
- Cost of energy increases resulting in increasing viability of applications (heat networks, waste heat capture)
- Substantial take up in on-gas areas due to investment
- Heat network market develops

No Progression

- Lowest growth scenario
- Poor planning and economic environment
- Cost of key components increases, stifling technology development
- Heat network development focusses on gas and biomass combined heat and power systems only

Slow Progression

- Medium growth scenario
- Positive planning environment
- But poor economic and finance outlook
- Social housing cuts result in reduced demand from this sector
- Energy prices stay low
- Retrofit growth keeps in the ‘able to pay’ sector

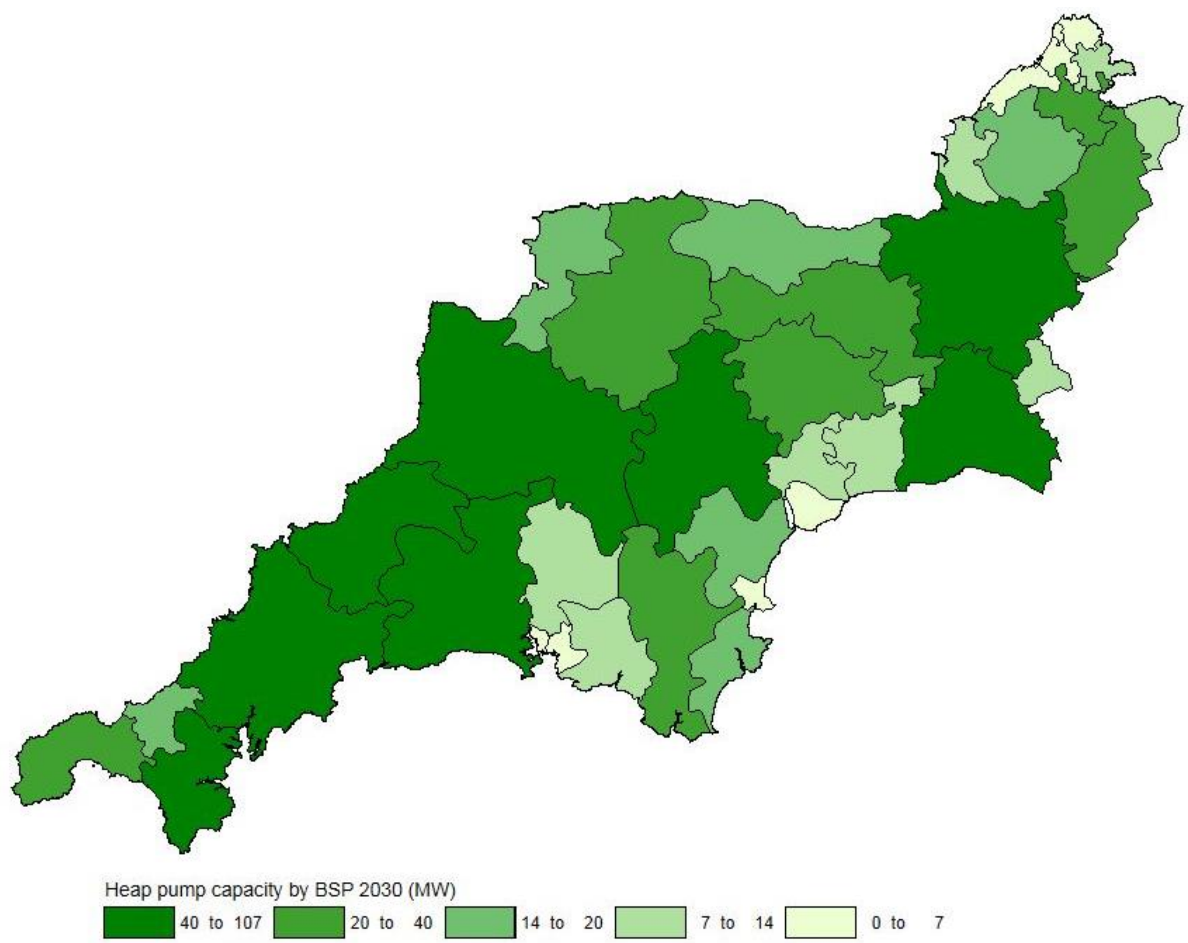
11.5 **Distribution by BSP**

Distribution by BSP of the projected heat pump numbers was calculated by a combination of these factors:

- The distribution of off gas houses
- Distribution of on gas households
- Past trends

New build houses were distributed based on the availability of land space. Environmentally protected land was taken into consideration, as well as environmental and technical factors such as flood plains and agricultural land designations.

Geographical distribution of thermal heat pump capacity in the Gone Green scenario



11.6 Heat pump capacity impact on electricity demand

Heat pump installations are rated by thermal capacity, as they provide heat to buildings. Baseline data on installed thermal capacity was collated using MCS data from the Regen SW progress report and used to develop the pipeline and the scenarios.

Equivalent data for electrical demand is not available through the MCS database. However, this study needed to estimate the impact of heat pumps on electricity demand in the region and so a conversion from installed thermal capacity to electrical demand was needed.

In order to calculate the electricity demand, a suitable Coefficient of Performance (COP) was researched. It was determined that an appropriate average for all heat pumps was a COP of 2.9. Ground source heat pumps can regularly be found to have a COP of 4; however, the majority of heat pumps are air source heat pumps, for which a COP of over 3 is unusual.

The COP of 2.9 is used for the Baseline of all scenarios; however, different COP values are used up to 2030 in the different scenarios. In the Gone Green and Slow Progression scenarios, the COP is projected to rise to 3.6 by 2030. This is because more new, well-insulated homes are projected to install heat pumps, resulting in a higher COP. In addition, technology developments will lead to an increase in the average COP in these scenarios.

In the Consumer Power scenario, there are fewer new homes with heat pumps installed, but still high numbers of retrofit off-gas properties installing heat pumps. Retrofit off-gas properties are usually older, poorly insulated houses, which will reduce the average COP. There is still investment and technology development in the Consumer Power scenario and so an average COP of 3.4 is projected to be reached by 2030.

In the No Progression scenario, heat pump improvements are hindered by poorly insulated homes and little technology development. Therefore the COP is expected to increase to just 3.1.

The projected number of heat pumps was estimated based on the total projected installed thermal capacity, using the assumption that the average heat pump thermal capacity is 8.7 kW_{th}. This value is based on historical trends, which show that the average thermal capacity of all heat pumps in the region has remained at 8.7 kW_{th} in recent years.

12 Conclusion

As with any scenario based forecast, the analysis is based on a large number of assumptions and uncertain factors, which could impact on the future growth of both distributed generation and new electricity demand. This is especially true when the analysis is taken down to detailed level of individual technology types and to specific geographic BSP areas within the south west licence area.

At a summary level, however, the growth scenario forecasts do show that, after a period of high growth over the last five years, the rate of distributed generation growth will decline post 2017 as changes to government policy and subsidy regime take effect.

Despite this downturn there is an underlying presumption that, provided that future UK Governments are committed to decarbonise energy and make good the climate change commitments made in COP Paris, then the growth of decentralised generation will recover in the next decade. Therefore even under a Slow Progression or Consumer Power scenario decentralised generation growth is significant.

Assuming an eventual decarbonisation, only if a future energy strategy was based almost exclusively on very cheap nuclear reactors, would the growth of decentralised generation be curtailed. This would imply a reversion to big generation technologies, nuclear, large scale offshore wind and large gas generation coupled with carbon capture and storage. This could potentially be a decarbonisation scenario outcome but is less likely in the period to 2030.

A key uncertainty is the speed with which the growth of decentralised generation can recover from the expected downturn. That will depend partly on government policy, but increasingly on the market and the ability of technologies to reach price parity. This in turn will depend on the rate of cost reduction and technology innovation as well as the adoption of new business models.

As the section on energy storage shows the introduction of new business models will be critical. Sometimes these will be market driven – price variability for example allowing generators and consumers to capture additional market value by avoiding peak price period or selling energy into them. In other areas new business models based on grid optimisation and network support will in part be driven by the requirement to manage more variable generation and a more decentralised generation network.

The adoption of new technologies – smart technologies, energy storage, electrification of heat and electric vehicles – could radically change the demand/supply balance and the operation of the network. This paper has touched on those but clearly there is uncertainty about how quickly new technology will be deployed.

Whatever the outcome the role of the grid and of DNOs will be critical. The analysis above will therefore provide an input for the next phase of the WPD Strategic Grid Investment Options Study.

As that broader study progresses it is clearly not a straight forward decision to commit to invest in new capacity. The alternatives of better network management, energy storage, demand side response need to be considered. Timing of investment and the impact of demand changes will also have to be modelled. A further consideration to build a business case for strategic investment is the support of local regional stakeholders, and whether strategic grid investment can be aligned with local economic plans and strategies, for example the desire to support technology development and innovation to create new job and commercial opportunities.