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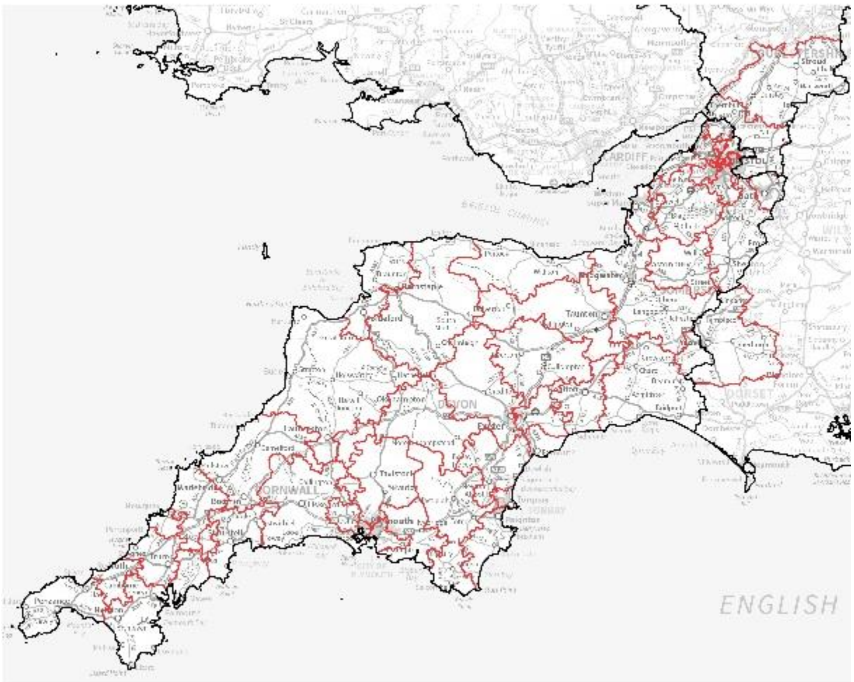
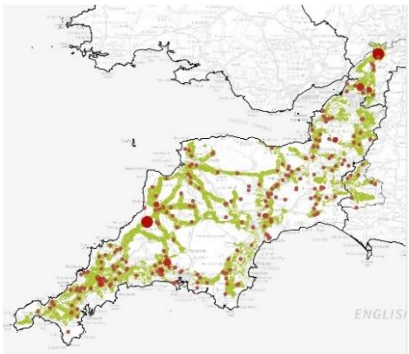
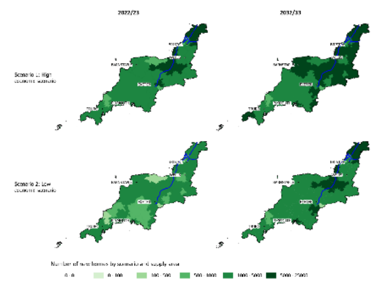
Distribution Future Energy Scenarios

A generation and demand study

Technology growth scenarios to 2032







South West licence area

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Acronym	Definition
ADBA	Anaerobic Digestion & Bioresources Association
AONB	Area of Outstanding Natural Beauty
BEV	Battery Electric Vehicle
CCGT	Combined Cycle Gas Turbines
CCC	Committee on Climate Change
CfD	Contract for Difference
CHP	Combined Heat and Power
DNO	Distribution Network Operator
DSR	Demand Side Response
Duos	Distribution Use of System
EFR	Enhanced Frequency Response
EfW	Energy from Waste
EPN	Eastern Power Networks
ERF	Energy Recovery Facility
ESA	Electricity Supply Area
EV	Electric Vehicle
FFR	Firm Frequency Response
FIT	Feed in Tariff
GIS	Geographic Information System
LCOE	Levelised cost of electricity
NO_x	Nitrogen Oxides
PHEV	Plug-in Hybrid Electric Vehicle
PPA	Power Purchase Agreement
PPP	Public–Private Partnership
R&D	Research and Development
RDF	Refuse-derived fuel
RHI	Renewable Heat Incentive
RO	Renewables Obligation
SAC	Special Area of Conservation
SRF	Solid Recovered Fuel
SSSI	Site of Special Scientific Interest
STOR	Short Term Operating Reserve
TDR	Transmission Demand Residual
ToUT	Time of Use Tariff
WMS	Written Ministerial Statement

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Table of Contents

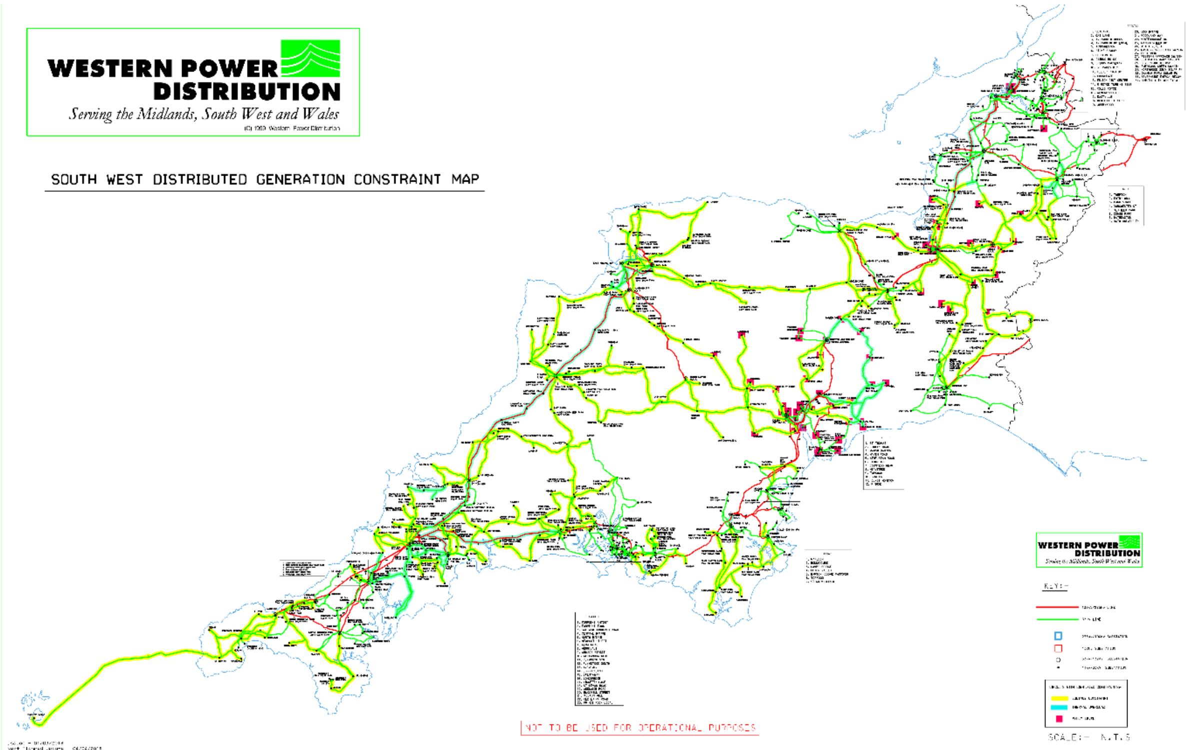
Introduction

This report is the second future technology growth scenarios report for Western Power Distribution's (WPD's) South West licence area.

The UK has experienced unprecedented growth in distributed generation in the last six years that has presented major challenges for distribution networks. Growth in new generation capacity has slowed, however Distribution Network Operators (DNOs) need to adapt to seismic shifts in technology such as battery storage, smart technologies and electric vehicles that will change how energy networks are used and how they need to be managed.

The south west has high levels of distributed generation, particularly large scale solar PV. These levels of distributed generation have caused significant constraints on the network. In some places this has stopped new generators connecting.

Figure 0-1: Constraints on WPD's South West licence area (as of March 2018)[1]



The cost of network reinforcement to remove constraints is currently borne directly by generators causing a constraint. Generators not able, or willing, to pay for the upgrade can also accept 'Active Network Management' that allows them to connect but with the condition that they stop generating when network limits require it.

[1] https://www.westernpower.co.uk/docs/connections/Generation/Generation-capacity-map/Distributed-Generation-EHV-Constraint-Maps/South-West-Thermal-Map.aspx

Regulatory developments

In response to technological change BEIS and Ofgem have set out a "Smart Systems and Flexibility Plan" that requires a fundamental shift in the role of DNOs to Distribution System Operators (DSOs) that actively managing capacity and usage on their networks. WPD published the latest version of their DSO Strategy in December 2017.[2]

Ofgem are also currently developing proposals and consulting on how both transmission and distribution networks and capacity should be funded in the future. This is to ensure that existing network capacity is used efficiently and that networks receive appropriate value signals to fund network upgrades when needed.[3]

Strategic network reinforcement

DNOs can undertake a very limited amount of strategic network reinforcement that isn't directly funded by generators or new demand customers.

Any strategic investment by WPD needs to be carefully assessed, with a strong business case to choose 'least risk of regret' investment proposals. Considerations include:

- Areas with low or no spare capacity
- High potential for growth of future distributed generation or disruptive demand
- A clear model for cost recovery

This report is part of the process to develop these investment options and responds to Ofgem request for "enhanced forecasting and planning" from DNOs.[4] It provides scenarios, at Electricity Supply Area (ESA) level, for the potential growth of distributed generation, electricity demand growth and electricity storage in the South West licence area.

WPD has set out a five step methodology to develop a business case for strategic investment outlined in Table 0-1.

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[2] https://www.westernpower.co.uk/About-us/Our-Business/Our-network/Strategic-network-investment/DSO-Strategy.aspx

[3] See Charging Futures Forum: https://www.ofgem.gov.uk/publications-and-updates/charging-futures-forum

[4] https://www.ofgem.gov.uk/system/files/docs/2017/02/unlocking-the-capacity-of-the-electricity-networks-associated-document.pdf

Table 0-1 : WPD's five step methodology for strategic investment in distribution network.

Strategic network investment business case development	
Step 1. Distributed generation, electricity growth and demand growth scenarios ***(this assessment)***	Assessing the potential growth in distributed generation, electricity storage and demand by technology type, Electricity Supply Area (ESA) location and year, by scenario
Step 2. Network 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 network reinforcement strategic investments Identify future network solutions (including required National Grid electricity transmission upgrades)
Step 4. Assess alternative options	Assess the potential for demand side response (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

Methodology

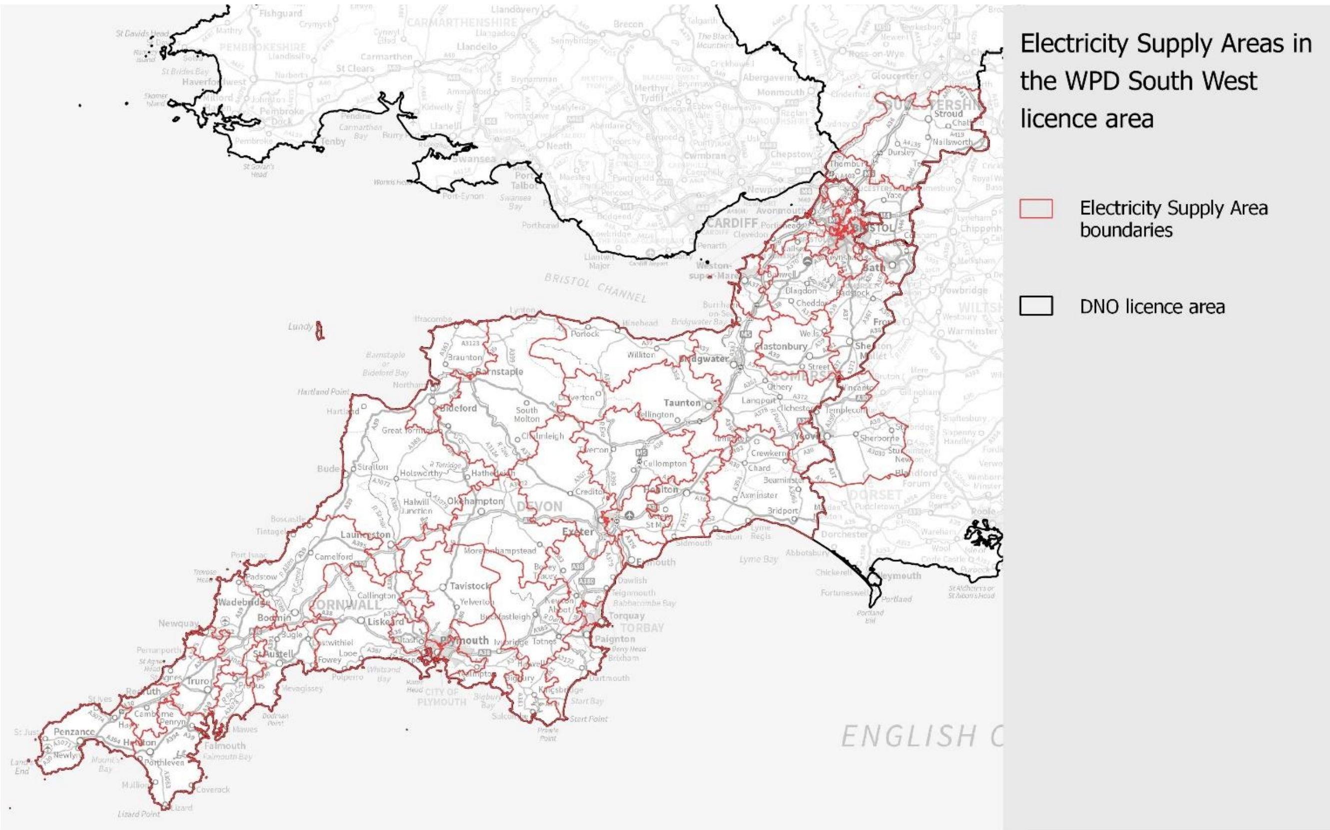
This report presents four scenarios from 2018 to 2032 for the potential growth of disruptive demand technologies (electric vehicles, heat pumps and air conditioning); demand from new housing and commercial developments; new distributed generation (renewable and small-scale fossil fuel); and storage in WPD's South West licence area.

The report accompanies a dataset and documents the key market insights, assumptions and methodologies used in the scenario process.

Electricity Supply Areas (ESAs)

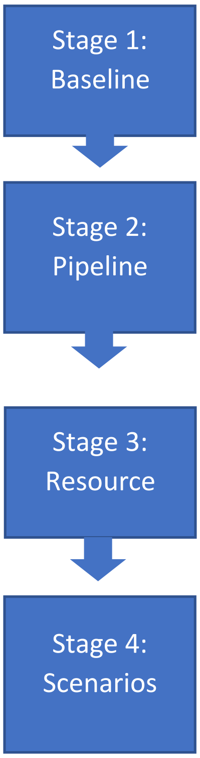
The scenarios are presented to WPD as a dataset by each of the 50 ESA in the licence area. ESAs are defined as geographic areas served by the same upstream network infrastructure. Regen and WPD have created these by mapping data on individual substations and the upstream network points using Geographic Information System (GIS) software.

Figure 0-2: Map of the 50 Electricity Supply Areas in the South West licence area



Scenario process

The analysis undertaken for each technology in the report involves the following four stages:



1. **A baseline assessment**. Technology baselines are calculated from WPD's network connection database as at the end of November 2017. This information is then reconciled with Regen's project database and further desktop research is undertaken to address inconsistencies.

2. **A pipeline assessment.** For technologies with significant lead times WPD's network connection agreement database is reconciled with the BEIS planning database and market research is undertaken. This allows an assessment of which projects in the pipeline may go ahead and in what timescale. The domestic scale and demand technologies do not have a pipeline.

3. **Resource assessment.** Locational data from a wide range of data sources and GIS analysis is used to understand the geographical distribution, local attributes, constraints and potential for technologies to develop within the licence area and each ESA.

4. **A scenario projection to 2032.** The scenarios are based on National Grid's Future Energy Scenarios 2017 (FES 2017) and interpreted for specific local resources, constraints and market conditions. Regen's existing analysis and knowledge is combined with the findings from a local consultation event along with interviews with developers, investors and analysis of current market reports.

To build the baseline and scenarios for demand from new development, we undertook a different methodology which is detailed in section 4.2.

Interpretation of FES 2017

The framework of FES 2017[5] developed by National Grid is used as a starting point for this assessment. National Grid has set out a new framework for 2018 FES, but final report was not available at the time this analysis was undertaken.

In some cases, scenarios for the south west differ from the national picture. Where this is the case the differences are explained in the relevant technology sections.

[5] http://fes.nationalgrid.com/fes-document/

Scenario descriptions

Consumer Power – a world which is relatively wealthy, and market driven.	Two Degrees – a world where environmental sustainability is top priority for government and consumers.
The Consumer Power scenario has features that lead to an emphasis on deployment of smaller scale generation and local supply through individuals, communities and other organisations, including technology development and consumers interested in green technologies. Government intervention is limited under this scenario, with policies supporting deployment mainly where there is demand from consumers and communities. The result is widespread, dispersed growth of small and medium scale renewable energy and demand technologies but some developments that run contrary to carbon reduction goals.	Under the Two Degrees scenario, it is assumed that future government policies take a strategic approach to decarbonising the energy system, consistent with the decarbonisation targets set in the Climate Change Act and reinforced by the commitments made at the Paris climate change summit. Market conditions, financial support and technology development is conducive to the strategic growth of distributed generation in this scenario. We also assume a high consumer engagement allied to the growth of electricity storage solutions and electricity demand technologies, such as electric vehicles and heat pumps. As a result, overall renewable energy and disruptive demand growth is in most cases strongest under this scenario.
Steady State – a world focused on security of supply and short-term thinking.	**Slow Progression – a world focused on long-term environmental strategy**
Under the Steady State scenario there is a poor economic environment and little green ambition in government or society as a whole. There is a continued dependence on fossil fuels into 2020's and 2030's that would not be consistent with the UK's stated decarbonisation and climate change commitments. Low-carbon trends are significantly slowed, and growth only occurs when economics become extremely favourable. Growth of all technologies are lowest for all scales and technologies under this scenario.	The Slow Progression scenario features a strategic approach to renewable energy by government, but in a poor economic environment which means there is a lower government budget for support, less investment capital available and fewer technological innovations. Government policy is focussed on the lowest cost actions, unlocking regulation and barriers where it is cost-effective to do so. Fewer larger-scale projects are likely to get support (as opposed to smaller distributed technologies). Consumers have lower and slower take-up of technologies than the Two Degrees scenario, but the trends support towards carbon reduction. The result is a medium growth scenario, with a focus on the lowest cost technologies.

I. Introduction to demand

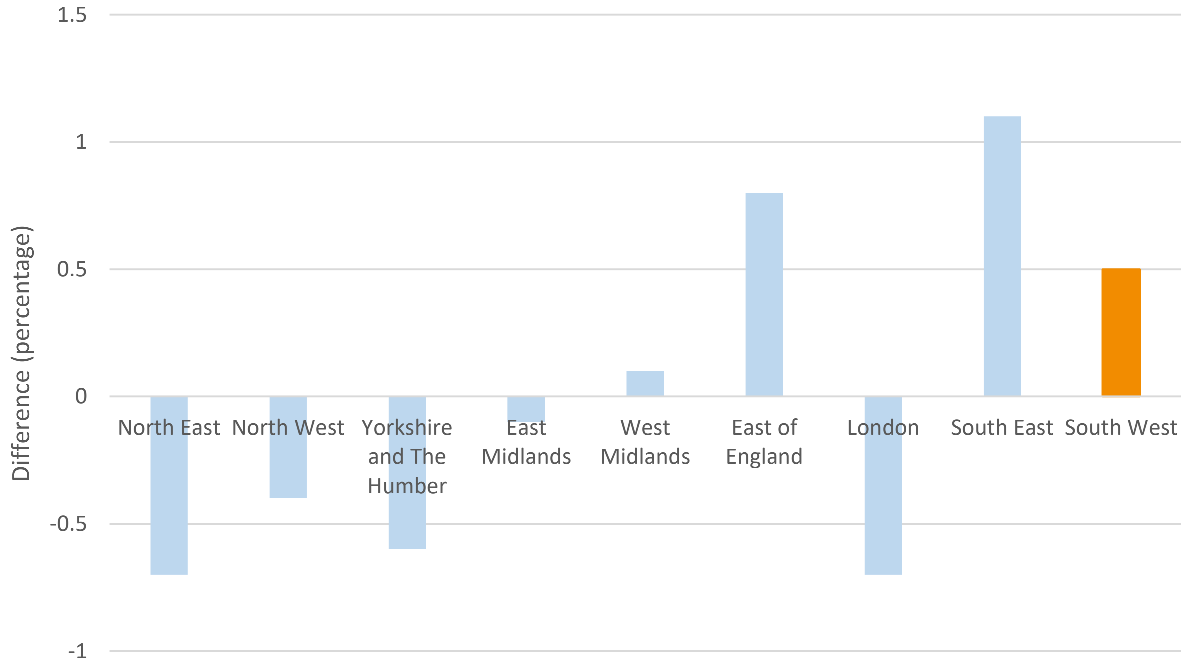
South west baseline demand

Understanding the future changes to trends in electricity usage in the licence area is important for WPD to develop a robust investment strategy.

Since 2011 household electricity demand in the south west has dropped by 2.5 per cent compared to a 4 per cent drop in England.

The south west has 10.6 per cent of the metered households in the country but accounted for 11.3 per cent of demand for electricity.[6] This suggests that, on average, the region's households use proportionally more electricity than most other regions in the UK.[7]

Figure I-1: Difference between percentage of meters and domestic electricity use per UK region.



Commercial demand has also fallen between 2011 and 2016 and the south west has the lowest average commercial consumption of all English regions, reflecting the region's smaller sized businesses.

Since 2011 the south west has experienced the second biggest fall in commercial electricity demand at 6 per cent fall. The highest was Yorkshire and Humber at 8.4 per cent. The north west is the only region where demand slightly increased.

[6] In 2016 there were around 2.5 million domestic meters in the south west region and 258,000 commercial meters
[7] https://www.gov.uk/government/statistical-data-sets/regional-and-local-authority-electricity-consumption-statistics

Demand growth factors

In recent years demand for electricity has decoupled from economic growth and reduced year-on-year. Peak demand has reduced by even more than overall demand. There is an expectation in FES 2017 and other scenarios that electricity demand will start to increase again due to increasing electrification of heat and transport. Whilst economic growth will continue to be a significant factor, the future trend for overall and peak electricity demand will also be impacted by key factors set out below. These are expanded on for specific disruptive demand technologies in the report.

Factor 1: Network charging and commercial peak demand

The electricity network is currently sized for peak demand periods that usually occur between 5:30 and 6 pm on a cold winter's day. Commercial customers on half hourly meters are incentivised to reduce their peak demand at these times by a variety of incentives and network charges. To avoid some of these charges, large commercial customers have started to generate their own electricity and, as a result, the peak usage of electricity has been falling for several years.[8] Significant changes to network charging are expected that may erode the signals to avoid peak, such as higher fixed charges.

Factor 2: Behaviour change through time of use tariffs

Domestic customers without smart metering are not currently incentivised to use electricity at different time periods in the day.[9] For households the roll out of smart meters to all electricity customers by 2020 means that they will start to have access to new tariffs and to potentially reduce their electricity costs by shifting demand to cheaper time periods. It is expected this may work to flatten domestic peak demand, current evidence suggests that up to a third of consumers would respond to tariff signals.[10]

Factor 3: Automation and smart systems

The ability for smart systems to control the impact of technologies like electric vehicles (EVs) will be a key factor in future markets. EVs, heat pumps and air conditioning units in households all have the potential to significantly increase energy demand. If there is wide-spread take-up of these technologies simultaneous usage or charging of EVs in a small area may start to overload local sub-stations. Upgrading all domestic sub-stations to cope with higher peak demand would be costly. Trials such as WPD's Electric Nation are focusing on smart systems and automation that can stagger or turn down demand when the local network or system is becoming overloaded.

Factor 4: Government action on energy efficiency and building regulations

Energy efficiency of houses is a key driver of household demand for both electricity and gas. Legislation on appliance efficiency has already cut the amount of electricity households use to run appliances in the UK. The continuation and evolution of this EU-led policy is uncertain post Brexit.[11]

The government stated an intention in the Clean Growth Strategy to bring all houses in England and Wales to an Energy Performance Certificate (EPC) 'C' rating by 2035,[12] which is a significant task.

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[8] https://www.auroraer.com/wp-content/uploads/2017/03/Ofgem-Embedded-Benefits-Reform-summary-and-Auroras-commentary.pdf

[9] The only exception to this is economy 7 and 10 tariffs where consumers are metered differently and charged less for electricity used overnight. This is usually the choice in properties that have electric heating on overnight.

[10] https://www.citizensadvice.org.uk/about-us/policy/policy-research-topics/energy-policy-research-and-consultation-responses/energy-policy-research/the-value-of-time-of-use-tariffs-in-great-britain/

[11] https://ec.europa.eu/energy/en/topics/energy-efficiency

[12] https://www.wwf.org.uk/updates/win-home-energy-efficiency-clean-growth-strategy

Disruptive technologies

The analysis in this report focuses on disruptive technologies that could significantly change demand on WPD's South West licence area and the potential growth of demand from new developments. The following chapters set out Regen's analysis, assumptions and market insights for:

- Electric vehicles
- Heat pumps
- Air conditioning
- New commercial and domestic developments

Demand scenario summary

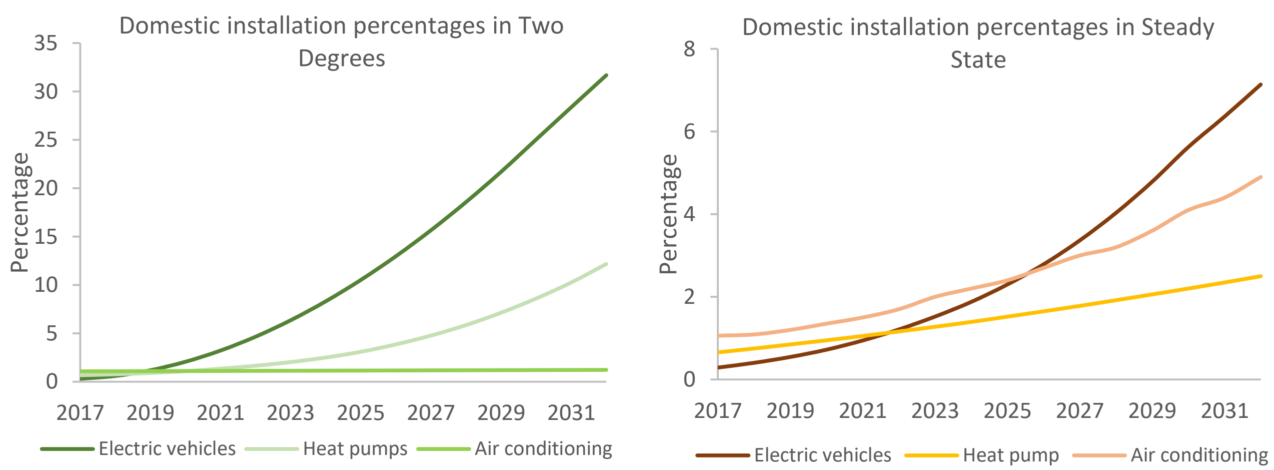
Electrification of transport and heat is a key area of uncertainty in the level of electricity demand that DNOs need to plan for. Electric vehicle demand, in particular, has a wide range of potential growth scenarios. The economy and geography of the licence area will have a significant impact on growth of technologies with potentially disruptive impacts on electricity demand. The rural nature of the south west rural has, for example, slowed the uptake of electric vehicles. However, this factor may reduce as the range of EVs increases.

Table I-1 presents the potential level of growth of disruptive demand technologies in the scenarios. In the Two Degrees scenario EVs could account for over 30 per cent of vehicles in 2032 and with heat pumps in 10 per cent of properties. In Steady State the scenarios are 7 per cent and 2 per cent respectively.

Table I-2: Scenarios for percentage of domestic households with disruptive demand technologies in 2032.

Percentage	Electric vehicles	Heat pump	Air conditioning
Two Degrees	31.7	12.2	1.2
Consumer Power	23.8	6.5	6.7
Slow Progression	13.2	6.1	1.2
Steady State	7.1	2.5	4.9

Figure I-2: Comparison of percentage household installation rates of disruptive demand technologies in Two Degrees and Steady State.



1. Electric vehicles

EV uptake remains low in the south west but investment by government and manufacturers globally may mean the UK is nearing a tipping point of high growth in the sector.

Uncontrolled charging of vehicles on the distribution network could prove a significant strain on the electricity system. To mitigate this risk, new policies and smart charging systems are expected to be introduced in the next few years.

Table 1-1: Scenario results for EV ownership levels in WPD South West licence areas.

Percentage of all cars owned in south west that are EVs	2017	2020	2025	2032
Two Degrees	0.3	2.1	10.5	31.7
Consumer Power		1.3	7.3	23.8
Slow Progression		0.8	3.2	13.2
Steady State		0.7	2.3	7.1

Total number of EVs in south west	2017	2020	2025	2032
Two Degrees	7111	54,226	311,457	1,122,657
Consumer Power		35,376	215,619	844,188
Slow Progression		20,498	88,967	418,878
Steady State		21,495	70,986	267,631

1.1. Baseline

Electric vehicle registrations have been growing strongly but start from a very low level. Around 45,187 plug-in cars were registered from January 2017 to November 2017. This is up 45 per cent from 35,000 in 2016.[13] Around 30 per cent or 13,500 sales were of Pure Electric Vehicles (PEV) in 2017. Early figures from 2018 show a drop in numbers and proportion of PEV sales versus Plug-in hybrid electric vehicles (PHEV).[14]

Despite the growth rate and some hype, electric vehicles still accounted for a small number of new cars bought each year. Of the 2.5 million annual UK vehicle sales in 2017, between one and two per cent of all new cars were electric. At present, most electric vehicle owners are likely to still be early adopters and purchasing second cars.

Despite the hype, electric vehicle growth remains low.

In the south west, uptake has been lower than the UK average with only 5,000 plug-in electric vehicles currently registered in the licence area. Since 2016, the average electric car sales in the licence area has been 0.68 per cent, which is lower than the 1.6 per cent nationally. However, in the second quarter of 2017 the south west narrowed the gap.

13 https://www.smmt.co.uk/2018/01/december-ev-registrations/ (January 2017)
14 https://www.smmt.co.uk/category/news/registrations/evs-afvs/

Relatively low EV ownership is partly explained by the rural nature of the licence area, which can mean car users need longer ranges for which earlier models of EVs may have been unsuitable. Issues around limited range are as longer range EVs become available. For example, the 2018 Nissan Leaf has a range of 235 miles, 81 miles longer than the previous model.[15]

This gap between south west and UK growth is, therefore, likely to reduce once longer-range models become more prevalent. The south west is also relatively affluent and has more detached houses, likely enabling off-road charging, two important factors in EV uptake.

The scenarios predict that total sales of EVs in the south west catch up to near national rates by 2032 but remain five to ten per cent lower (depending on the growth scenario) due to the rural nature of the licence area.

1.2. Pipeline

There are no pipeline numbers for electric vehicles in the south west but short-term growth has the potential to accelerate.

The UK government has started to develop a multi-stranded funding and policy programme to enable the anticipated shift from fossil fuel to electricity. The Clean Growth Plan announced £1bn of funding mainly to support EV infrastructure and publicity. Government investment has meant the charging network is growing consistently. According to Zap-Map, at the beginning of 2018 there are 14,000 connectors at nearly 5,000 public charging point locations across the UK; 2,662 of these are rapid or fast chargers.[16]

High government support and subsidy means the UK could see high growth in EVs over the next few years.

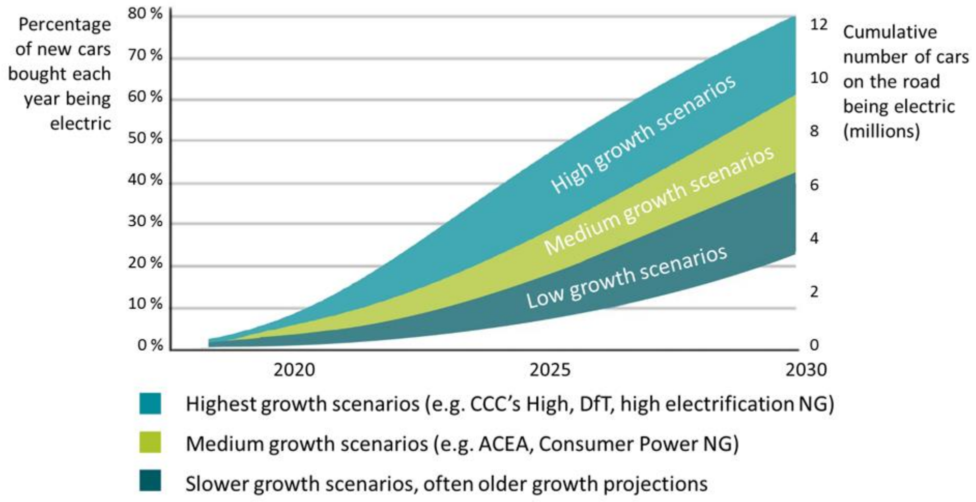
Other subsidies are also in place. The plug-in vehicle grant funded up to 35 per cent or £4,500 of a vehicle purchase until March 2018 and a further £100m was announced in the 2017 autumn budget to extend the subsidy until 2020. Electric vehicles are also currently free to tax unless they cost over £40,000. Though subsidies have been available to both PHEV and PEV, recently there have been higher sales of PHEVs. However, this is expected to reverse over the next five years as subsidies are reduced for hybrids.[17]

1.3. Technology growth prospects

Several organisations have had a go at projecting the growth of EVs producing widely different scenarios as illustrated in Figure 1-1.

[15] https://www.whatcar.com/news/2018-nissan-leaf-review/
[16] https://www.zap-map.com/ (stats as at 3 Jan 18)
[17] https://www.carwow.co.uk/best/electric-hybrid-cars-with-5000-plug-in-grant-0040

Figure 1-1: Regen's analysis on the number of EV new cars each year in different scenarios.



There is undoubtedly now strong political backing for the roll-out of alternative and electric vehicles. EVs help achieve several government targets including reducing carbon emissions, addressing urban air-quality problems and supporting the UK car industry. The UK government announced a ban on all new petrol and diesel cars by 2040. Phase outs have been announced on even tighter timescales in Scotland (by 2032), and Paris streets will be fossil-free by 2030, with diesel gone by 2024.[18]

$90 billion of industry investment is expected to drive lower costs in the medium and long term.

A key factor in projected growth is that electric vehicle costs are expected to continue to fall into 2020s.[19] This is likely to be driven both by falling battery prices and reduction in manufacturing costs due to heavy investment in electrification by nearly every significant car maker. For example, Jaguar Land Rover and Volvo are aiming for all their new cars to have some form of electrification by 2020 and 2019 respectively.

Reuters have reported that investment in electrified vehicles by the global car industry has how reached over $90 billion with at least $19 billion by automakers in the United States, $21 billion in China and $52 billion in Germany.[20]

Industry sources differ on the exact timescale, but Bloomberg predicts that the upfront costs of purchasing an EV will be lower than conventional vehicles by 2025.[21] Life-time parity of cost (including existing subsidies) with conventional vehicles is already achievable in some situations.[22]

The key to continued growth will be whether reduction in technology costs will be sufficient to compensate for inevitable reduced government subsidies for the sector. With electric vehicles expected to become increasingly mainstream, government subsidy cannot continue long term. There are also big questions

[18] http://www.telegraph.co.uk/news/2017/10/12/paris-ban-petrol-cars-city-2030-pollution-crackdown/
[19] https://www.bloomberg.com/news/articles/2017-05-26/electric-cars-seen-cheaper-than-gasoline-models-within-a-decade (January 2017)
[20] https://www.reuters.com/article/us-autoshow-detroit-electric/global-carmakers-to-invest-at-least-90-billion-in-electric-vehicles-idUSKBN1F42NW
[21] https://about.bnef.com/blog/electric-cars-reach-price-parity-2025/
[22] https://www.theguardian.com/environment/2017/dec/01/electric-cars-already-cheaper-to-own-and-run-than-petrol-or-diesel-study

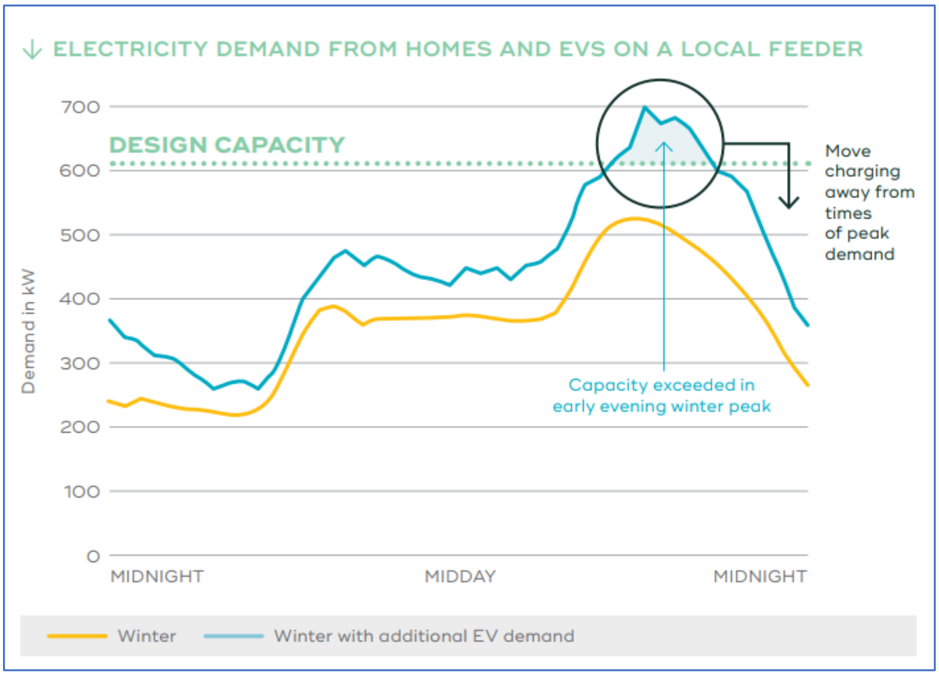
about what policies (such as road charging) government might use to recoup falling fuel and road tax income.

Smart charging is needed to mitigate significant impact on the local network

High uptake of electric vehicles will start to have a significant impact on the local electricity network. The scale of this impact, and the associated cost of upgrading the network, will depend both on the rapidity of the up-take and how well time of use tariffs and smart chargers are successful in shifting charging away from the evening peak. The Automated and Electric Vehicle Bill, currently going through Parliament, will provide powers to make smart charging compulsory.[23]

Figure 1-2 highlights the potential winter peaks created by electric vehicle use in an average house. A time of use tariff along with smart charging has the potential to significantly reduce the peak by spreading the charging period through the night.

Figure 1-2: Illustration of the high peak demand from EV chargers taken from Electric Nation study.

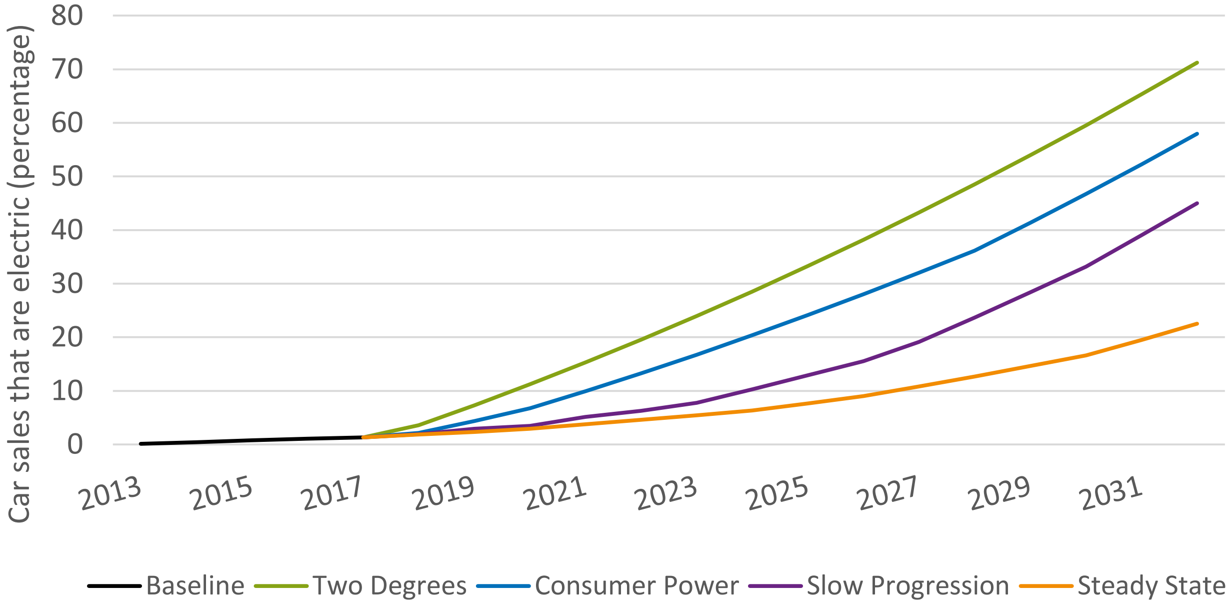


Source: Electric Nation Charging Guide - http://www.electricnation.org.uk/

[23] https://www.parliament.uk/business/news/2017/october/automated-and-electric-vehicles-bill/

1.4. Scenario results

Figure 1-3: WPD south west scenario result for proportion of all new cars sold each year that are electric (plug-in or hybrid).



Percentage of new cars sold in a year that are EV (%)	2017	2020	2025	2032
Two Degrees	1.3	11.2	33.3	71.3
Consumer Power		6.7	24.1	58.0
Slow Progression		3.5	12.9	45.0
Steady State		2.9	7.6	22.5

Table 1-2: Assumptions for factors influencing future changes in electric vehicle numbers.

Two Degrees	• Strong economic growth and investment coupled with legislation in neighbouring countries pushes UK market to meet the new fossil fuel car ban several years prior to 2040. • Government subsidy continues until cost parity is achieved. • Charging is effectively smart controlled to minimise network impact
Consumer Power	• The UK is on track to meet the ban on petrol and diesel cars by 2040. • Strong economic growth means high take-up of EVs starting early 2020s. • Smart charging is limited leading to higher peaks on the network.
Slow Progression	• UK is on track to meet the deadline by 2040 but lower economic growth means shift is happening later than in Two Degrees. • Technology cost remains higher for longer and so high growth in EV take-up starts later in 2020s than in Consumer Power.
Steady State	• UK is not on track to meet 2040 ban and is on course to miss the deadline by several years. • Insufficient subsidy and cost reduction means slow growth continues to 2032.

Relationship to FES 2017 and 2015 Scenario report

The scenarios in this report predict levels of EV ownership higher than FES 2017 and the 2015 south west scenario report. These higher growth rates are due to the new 2040 fossil car ban and other policy support announced subsequently to FES 2017.

Distribution of technology across ESAs

The 2015 south west scenarios report projected EV growth correlated with installations of domestic rooftop PV. This corresponded highly to factors which relate to EV uptake; specifically, customer affluence, and the early adopters or green engaged consumers. However as EVs become more mainstream, as projected over the study period, these factors will be superseded by different demographic factors such as population, and vehicle density.

Growth in this scenario is therefore distributed by:

- Adoption of rooftop solar PV in the near term
- A weighting towards urban and semi-urban areas, measured by housing density that indicates detached or semi-detached housing. These housing types are expected to dominate EV uptake in the near term, but to give way to more even distribution towards the end of the period.
- High income ESA areas as measured by ESA averages in the English indices of deprivation data
- The population in each ESA

2. Heat pumps

The south west is a leading region for heat pumps, but at present they remain a high-cost and niche technology, despite government interest in increasing deployment.

However, there is potential for hybrid systems, once more cost competitive, to unlock new markets in on-gas houses. High growth depends upon new and effective policies or regulations particularly in new and off-gas grid houses.

Table 2-1: Summary of percentage of houses with heat pumps in WPD South West licence area.

Percentage of homes with heat pumps	2017	2020	2025	2032
Two Degrees	0.7	1.1	3.1	12.2
Consumer Power		1.0	2.3	6.5
Slow Progression		1.0	2.0	6.1
Steady State		0.9	1.5	2.5

Number of heat pumps in licence area	2017	2020	2025	2032
Two Degrees	8,766	14,417	41,201	197,193
Consumer Power		13,697	30,338	104,538
Slow Progression		13,208	27,058	91,197
Steady State		12,715	20,302	33,400

2.1. Baseline

Current installations of heat pumps are strongly correlated to off-gas grid households of which the south west has relatively high numbers. For example, Cornwall has 44 per cent of households not connected to the gas network. The local authority unweighted average is 16 per cent.[24]

Currently cost remains a barrier to wide-scale take-up of heat pumps and public awareness remains low.

The south west is the leading area for heat pump installation, in total 8,766 have installed in the area through the Renewable Heat Incentive (RHI) by the end of 2017. Potentially, more heat pumps may have been installed in new houses but these are not recorded in government data.

Assuming 80 per cent of those installed in the licence area are in off-gas grid houses[25], this would suggest that 3.3 per cent of off-grid houses in the licence area have heat pumps.

Awareness of heat pumps also remains low. The latest attitudes tracker from BEIS found that 43 per cent of people are unaware of air source heat pumps (ASHP) and only two per cent of people would expect to install one in their houses.[26]

Heat pumps have higher upfront costs than conventional heating systems. These can be from £7,000 to £12,000 depending on the size and technology.[27] Though the technology is expensive, the key barrier is the

[24] BEIS non-gas consumption
[25] Assumption from Regen analysis of RHI data
[26] BEIS Public Attitudes tracker. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/678077/BEIS_Public_Attitudes_Tracker_-_Wave_24_Summary_Report.pdf
[27] https://www.renewableenergyhub.co.uk/heat-pumps-information/heat-pumps-cost-and-savings.html

cost of retrofitting properties to enable a ground or air source heat pump to work efficiently. This includes adding new large radiators or underfloor heating, as well as upgrading to highest insulation standards.

Deployment rates of heat pumps continue to fall short of government aspiration though numbers vary. There were 44,000 RHI registered heat pumps at the end of 2017, government numbers from physical surveys estimated around 94,000 in 2015 and industry figures suggest a maximum of 200,000 are currently installed.[28] The Committee on Climate Change's Fifth Carbon Budget report has decreased its target for the number of heat pumps in UK houses by 2030 from 4 million to 2.3 million – a figure that remains challenging.

2.2. Pipeline

There is no heat pump pipeline however in the short-term, installation rates may improve as a result of higher subsidies through the RHI.

A significantly increased tariff for air source heat pumps was introduced in September 2017 running to April 2021, see Table 2-2.

Table 2-2: Tariff increases for heat pumps made in 2017

Technology Type	Current tariff (p/kWh)	Uplifted tariff (p/kWh)
Biomass plant	3.85	6.54
Air source heat pump	7.63	10.18
Ground source heat pump	19.64	19.86

2.3. Technology growth prospects

Recent developments in hybrid heat pumps, which work with a backup technology (primarily gas) have started to reduce some of the barriers and raise potential for much higher growth in the sector. Industry claims that a well-managed hybrid system can deliver a 35 per cent reduction in energy compared to a traditional condensing boiler.[29]

Hybrid heat pumps are key to future growth as they have the potential to significantly reduce installation cost barriers

As well as starting to make it a cost-effective option for an on-gas grid customer, a hybrid system also requires less disruptive change, the higher temperature heat can use existing radiators and the heat pump operates at times it is most efficient (e.g. low electricity prices or moderate heat requirements) with back up sources taking over when it is not.

Higher deployment will need further incentives or regulations, such as those used for condensing boilers in 2005. If all new heating systems were required to be hybrid or heat pumps this could lead to 6.6 per cent of properties per year fitting these systems (based on a 15-year boiler replacement cycle).

[28] One reason for the variation may be new developer built houses are not eligible for FIT and therefore heat pumps are not recorded. http://hvpmag.co.uk/news/fullstory.php/aid/4712/The_bigger_picture_-_heat_pump_trends_for_2017.html

[29] https://www.daikin.co.uk/en_gb/product-group/hybrid-heat-pump.html

Potential for policy focus on off-gas houses during 2020s will particularly impact the south west.

Ambitious intentions to support for low-carbon heat were announced in the Clean Growth Strategy but policies are yet to be developed *"*Beyond the RHI, our ambition is to phase out the installation of high carbon fossil fuel heating in new and existing off gas grid residential buildings (which are mostly in rural areas) during the 2020s".[30]

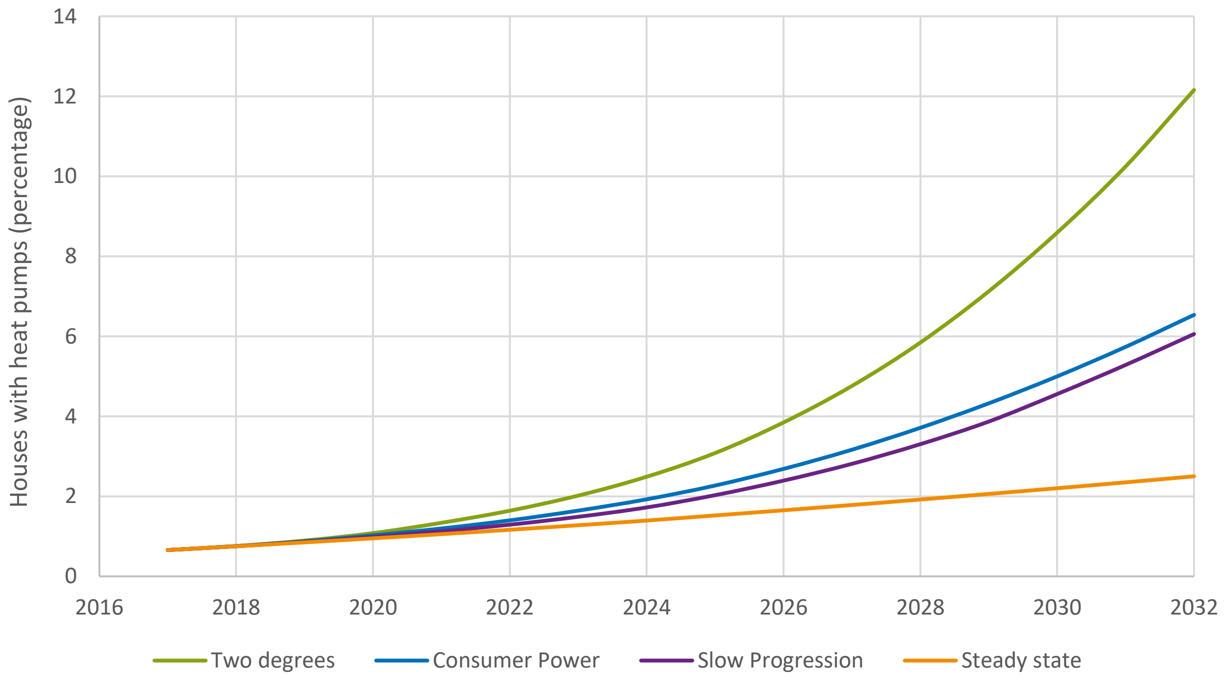
Smart controls or hybrid systems needed to mitigate potential significant impact on local networks.

The impact of high levels of heat pumps installed on a local distribution network could be significant. Demand could be more difficult to shift away from peak periods than for electric vehicles and there could be near universal use of systems during cold periods and in the evening, causing a significant increase in peak winter demand both morning and evening.

The actual impact on the network will depend on the heat pump technology installed and the effectiveness of smart controls.[31] Some systems can run solely on gas and have no electrical input and other systems with electrical back-up can work well with smart system controls to lessen network impacts. Most promising are hybrid heat pumps that could significantly lessen network impacts by using fossil fuels at peak times rather than high price electricity. This is a concept being explored by the WPD and WWU Freedom Project.[32]

2.4. Scenario results

Figure 2-1: WPD south west scenario result for growth of heat pumps in houses



[30] P.79, Clean Growth Strategy, 2017 https://www.gov.uk/government/publications/clean-growth-strategy
[31] https://www.theccc.org.uk/wp-content/uploads/2013/12/Frontier-Economics-Element-Energy-Pathways-to-high-penetration-of-heat-pumps.pdf
[32] https://www.westernpower.co.uk/Innovation/Projects/Current-Projects/FREEDOM.aspx

Table 2-3: Percentage of south west domestic properties with heat pumps 2032 by type

	On-gas	Off-gas	New properties
Heat pump type	Majority hybrid systems ASHP with gas	Single systems with higher proportion GSHP[33]	Majority single system ASHP
Growth factors	- Cost savings from hybrid heat pumps - Boiler efficiency legislation	- Clean growth strategy policies - Boiler efficiency legislation (non-gas)	- Building standards and insulation levels - Boiler efficiency standards
Scenario percentage	**2032**	**2032**	**2032**
Two Degrees	8.8	25.9	57.0
Consumer Power	5.4	11.9	12.5
Slow Progression	4.3	13.7	38.0
Steady State	1.9	5.3	4.7

Table 2-4: Assumptions for future changes in heat pumps installation rates

Two Degrees	• New government legislation on efficiency of heating systems and economic growth drives higher take up of both hybrid and single systems from early 2020s. • Legislation is focused on off-gas grid houses. • Hybrid heat pump technology is proven and competitive
Consumer Power	• Costs reduce for hybrid heating which drives higher take up than Steady State. • Limited government support is focused on off-gas grid houses which increase deployment to reach 11 per cent by 2032.
Slow Progression	• Slow growth in the short term as costs stay high • Legislation drives take up in off-gas houses later in 2020's. 13 per cent of off-gas houses have heat pumps by 2032.
Steady State	• No new legislation • Slow growth in the technology continues to 2032.

Relationship to FES 2017 and 2015 Scenario report

We have increased our expected level of installations ahead of the scenario projections in 2015 south west scenarios to reflect the government's Clean Growth Strategy plan on phasing out high carbon heating for off-gas grid properties in 2020's. As a region with high numbers of off-gas grid houses, this policy would particularly impact the south west.

The scenarios remain slightly below the FES 2017 numbers for Two Degrees as installation costs are likely to remain high in the majority of properties which are on gas. The scenarios are above the percentages for Slow Progression and Consumer Power reflecting the level of off-gas houses in the licence area. Steady State is consistent with FES 2017.

Distribution of technology across ESAs

The scenarios project heat pump growth separately for new house developments, on-gas and off-gas properties and new houses. The geographic distribution is based on the total number of houses in an ESA, as well as the number of properties not connected to the gas grid, and the baseline in the early years of the projections.

[33] Ground Source Heat Pumps

3. Air conditioning

Though domestic air conditioning has low uptake at present, mechanical cooling has potential to be a large new source of demand for local electricity networks, growing significantly towards the end of the scenario period.

Table 3-1: Summary of percentage of houses with air conditioning in WPD South West licence area

Percentage of south west houses with air conditioning	2017	2020	2025	2032
Two Degrees	1.06	1.09	1.14	1.21
Consumer Power		1.50	2.81	6.67
Slow Progression		1.09	1.14	1.21
Steady State		1.35	2.40	4.90

3.1. Baseline

The UK's mild climate means that demand for domestic cooling is currently low. FES 2017 estimates that air conditioning is currently installed in around 1 per cent of houses.[34] However, as summer peak temperatures rise due to climate change, demand for cooling is expected to increase, particularly in dense urban areas that act as heat islands.

In contrast, in commercial properties air conditioning installations have been steadily rising since the 1990s and often is included as part of upgrades to system integrated heating and cooling. The Carbon Trust expects that 40 per cent of commercial floor space will be air conditioned by 2020 compared to 10 per cent at the end of 1994.[35] BRE assume that this growth is likely to continue to 2040 but at slightly lower levels. [36]

Due to lack of alternative data on air conditioning uptake in the south west, this scenario follows FES 2017 assumptions and it is assumed that the south west has the same percentage of houses with air conditioning installed as the FES 2017 national picture.

[34] Assuming one unit per household
[35] https://www.carbontrust.com/media/17824/j7906_ctg005_air_conditioning_aw_interactive.pdf
[36]https://www.bre.co.uk/filelibrary/pdf/projects/aircon-energy-use/StudyOnEnergyUseByAirConditioningFinalReport.pdf

3.2. Technology growth prospects

FES 2017 predicts that temperatures after 2040 could rise to levels that would drive exponential increase in the installation of air conditioning systems in houses, suggesting up to 60 per cent adoption by 2050.[37] The impact of the extra demand would potentially double the summer evening electricity peak and account for around 2.5 per cent of the total UK electricity demand. Air conditioning installation growth is expected to be weighted towards both dense urban housing and affluence.

Exponential growth in domestic air conditioning will depend on the extent of climate temperature rise.

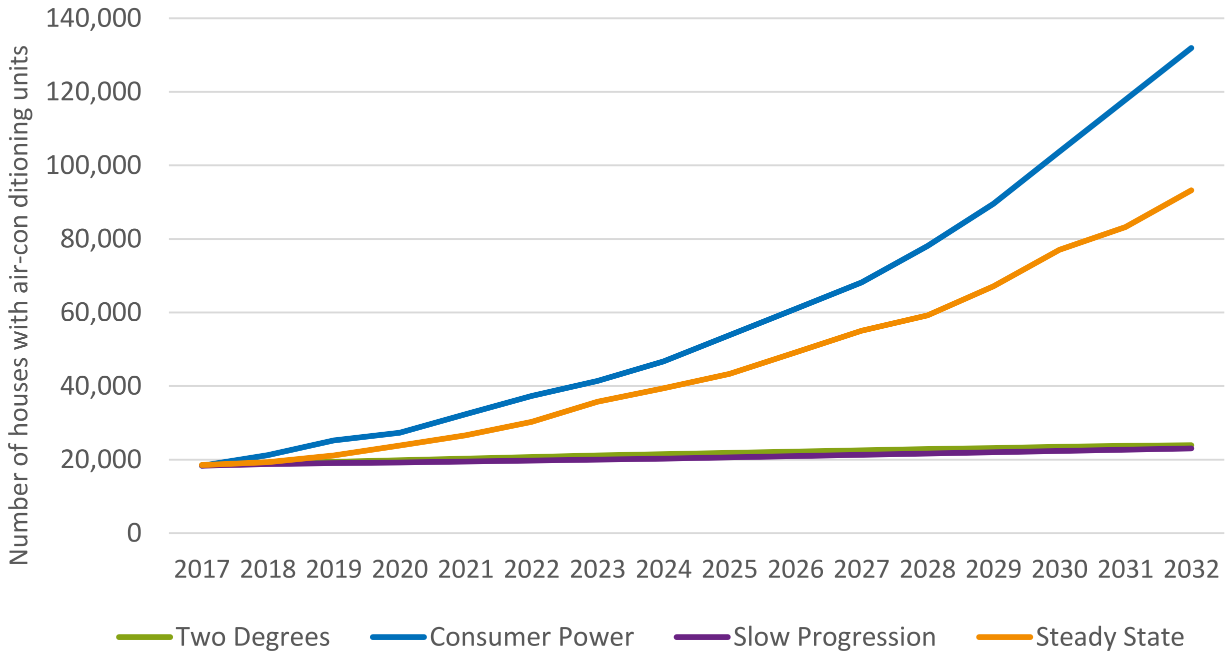
Building standards have traditionally focused on heat retention in buildings, some of which may ultimately increase the need for mechanical cooling and ventilation in the summer. If summer temperatures rise significantly in the UK, standards would need to be adjusted to encourage passive cooling.

Government policies and regulations have the potential to both drive or mitigate the need for mechanical cooling in houses.

A further driver may be the uptake of heat pumps. Many heat pumps have potential to work as cooling units. If policies are successful in driving the uptake of heat pumps, some units may be adjusted to offer cooling to domestic properties as a secondary benefit.

3.3. Scenario results

Figure 3-1: WPD south west scenario results on numbers of houses with air conditioning.



[37] http://fes.nationalgrid.com/media/1290/ac-2050-v212.pdf

Table 3-2: Assumptions for factors influencing growth in air conditioning installation rates

Two Degrees	• Temperature rise is mitigated by action reducing the need for cooling. • Building standards require any cooling is predominately provided by passive ventilation systems
Consumer Power	• Unmitigated climate change means summer temperatures would increase significantly at the end of the scenario period. • Strong economy leads to air conditioning becoming standard in urban areas.
Slow Progression	• As with Two Degrees.
Steady State	• Unmitigated climate change means summer temperatures would increase significantly at the end of the scenario period. • Growth is lower than Consumer Power due to less wealth.

Relationship to FES 2017 and 2015 Scenario report

This report is the first projection of air conditioning in the WPD licence area scenarios and trends are taken directly from the FES 2017. In future scenarios the trends for Two Degrees and Slow Progression would benefit from being updated as warming in these scenarios is not entirely mitigated and growth may be seen to some extent, particularly in Slow Progression.

Distribution of technology across ESAs

The distribution of air conditioning in the south west has been weighted by affluence on the assumption in all scenarios that air conditioning remains a luxury appliance and by housing density to reflect the urban heat island effect in high density areas leading to an increased demand for cooling.

4. Domestic and non-domestic development

New housing or commercial developments can have a significant impact on electricity demand on the distribution network at a local level. To consider the impact of development on demand at an ESA level required a different methodology than technology growth scenarios. An assessment of what future developments are planned in the South West licence area was undertaken. This process included engagement with all 25 local authorities in the area.

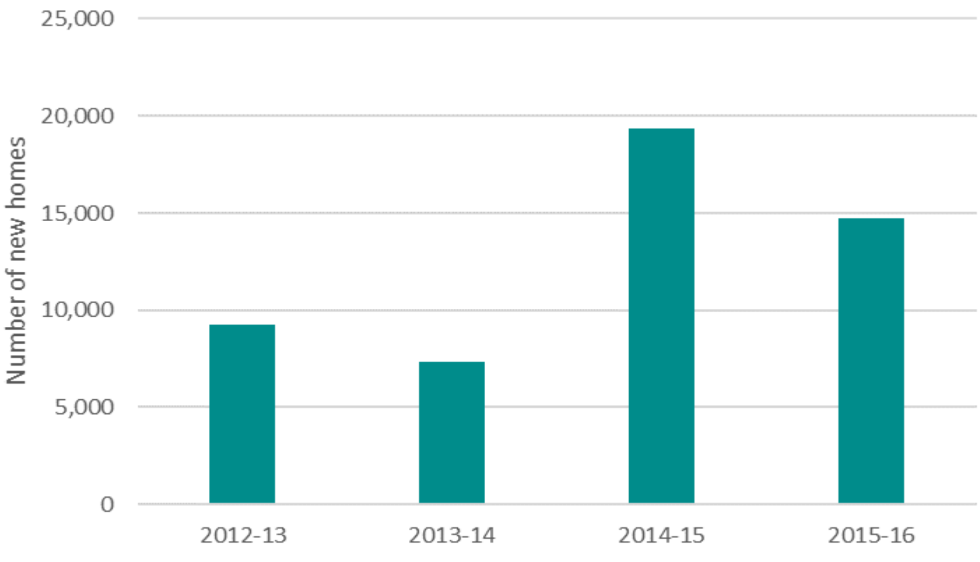
The data presented in the scenarios only considers developments currently in local plans. As a result, the scenarios tail off towards 2030 as local plans tend to be focussed on developments planned for between 2018 and the mid-2020s. Forecasts for potential additional developments are not included, as it would be difficult to place these geographically.

In September 2017 the government set out measures to encourage higher housing build out rates including a new methodology for councils to assess local housing need and to meet the annual requirement identified by the government of 266,000 new houses per year across England.[38] These scenarios should, therefore, be revisited regularly so that new developments from updated local plans can be included.

4.1. Baseline

Totals for the number of new houses in the South West licence area have seen an increase in more recent years. However, overall annual build out rates tend to fall short of the requirements set out in the local plans.

Figure 4-1: Annual totals for new houses in the South West licence area, 2012-2016[39]



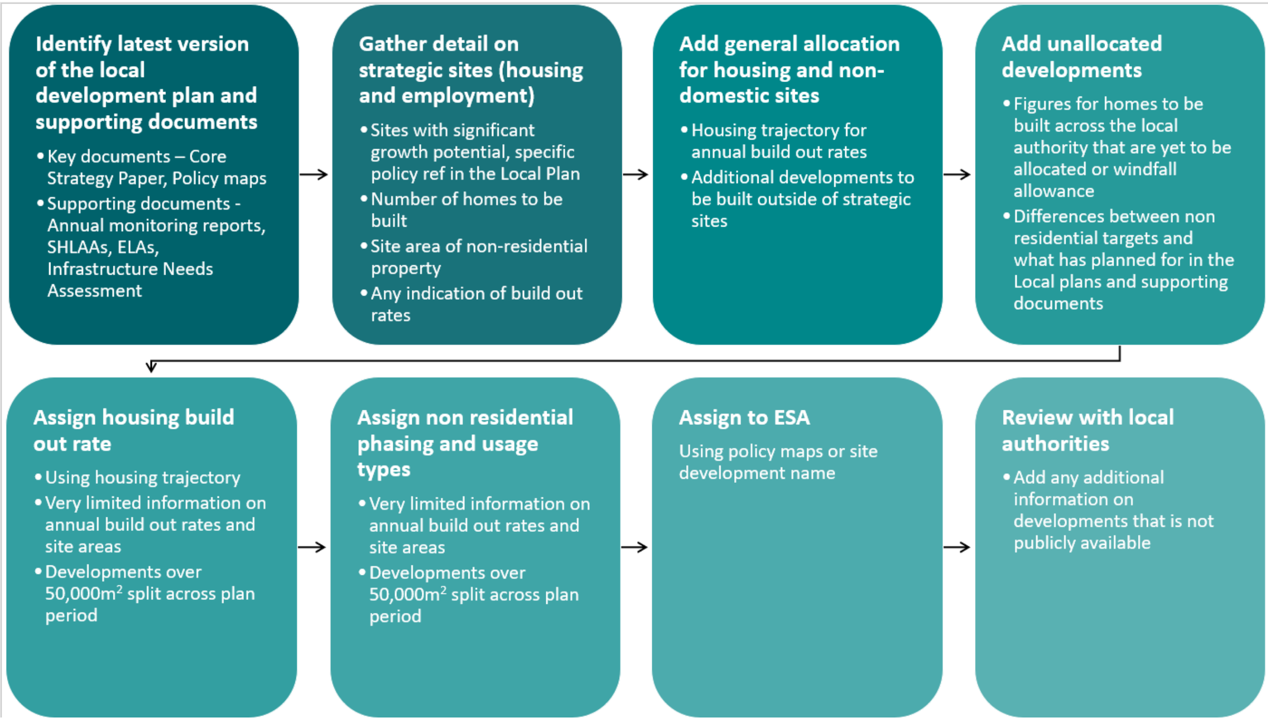
[38] https://www.gov.uk/government/speeches/local-housing-need

[39] Source: BEIS sub-national electricity consumption data, 'LSOA domestic electricity 2016', based on number of new MPANS annually.

4.2. Methodology

A detailed analysis of each of the local authorities' local plan provided the primary source of data on location, size and type of new developments. This was augmented by a review process with additional telephone interviews and a consultation workshop with local authority planning teams. The methodology is set out below.

Figure 4-2. Summary of data collection methodology for domestic and non-domestic sites



Data sources

Produced by local authorities, each local plan typically provides a core strategy paper that is the main document in the local development framework (LDF) and additional supporting documents, such as annual monitoring reports and maps identifying potential sites.

Some local authorities have produced Joint Spatial Plans (JSP), with a single local plan covering a wider area, such as the West of England which consists of Bristol, Bath and North East Somerset, South Gloucestershire and North Somerset.

These documents normally provide an outline plan of where developments are likely to take place and varying levels of detail on the building type and end use.

If the local plan was outdated or too vague, supporting documents which provide the evidence base were used, these include:

- the strategic housing land availability assessment (SHLAA)
- employment land assessment (ELA)
- annual monitoring reports.

Such documents are updated regularly for each planning authority and identify available sites that have the potential for housing and non-domestic development.

4.3. Types of development

Development sites

Development sites are categorised into two main types: strategic sites and general allocation sites.

Strategic sites are highlighted in local plans as areas of development with significant growth potential. There is no established single definition for what constitutes a strategic site; however, generally these are large developments, either housing led or mixed-use regeneration projects.

General allocation covers additional housing or non-domestic developments that will be built outside of the strategic sites. These developments tend to be smaller sites with less specific location details.

Unallocated houses

Local plans generally contain targets for new houses to be achieved during the plan period. This target is made up of planned development sites and, in some cases, also includes ‘unallocated’ houses to be built across the local authority that are not earmarked for any specific sites.

Where unallocated housing was identified, the quota was distributed across the local authority’s ESAs, based on geographic area and any additional information in the plan as to where it might be focused.

Information gathered about development sites

The available data for each development site was reviewed to obtain, where possible:

- An estimate of the number of domestic units to be built.
- The site area (m^2) of non-domestic property to be built.
- Any indication of phasing, amount of property to be built per year etc.
- The site’s location and the relevant ESA/ESAs it would connect to.
- Status of the local plan.
- The category of planned end-use for non-domestic sites/areas of sites. The non-domestic categories provided by WPD are listed in Table 4-1 and cover 15 different electricity profiles.

Table 4-1: Non-domestic profile categories

Non-domestic demand profile categories	Equivalent General-Use Classes Order
Factory and Warehouse	B8, B2
Government	D1
Hospital	C2
Hotel	C1
Hypermarket	A1
Medical	D1
Office	B1
Other	
Police	D1
Restaurant	A3
Retail	A1
School and College	D1
Shop	A1
Sport and Leisure	D2
University	C2

Review with local authorities

To ensure the most up to date information on future developments, data collected was sent to planning and economic development officers in the 25 local authorities across the South West licence area for review and comment.

Contacting the local authorities individually highlighted how in some areas the local plan core strategy can be out of date quite quickly, due to the lengthy examinations process. Although the current local plans remain useful for identifying large strategic sites, the detail of SHLAAs, five year supply documents, ELAs and annual monitoring reports is often necessary to capture the most up to date information and the full picture. These documents often include details on the smaller 'off plan' sites, which are not part of the larger allocations.

A stakeholder engagement event was also held. This allowed local authorities to feedback any further information on the process.

Although any review has the limitation of being a snap-shot, the combination of local plans and local authority engagement provided a good level of detail on which to base future development projections.

4.4. Housing growth factors

Factors affecting the scenarios: housing and non-domestic demand

The key factor affecting the growth rate of new developments is the economic environment. The level of green ambition will have little relevance to the number of developments – although it may change the energy demand of a property (the demand profile of housing and non-domestic properties is outside the scope of this report). Two Degrees and Consumer Power are, therefore, considered as one scenario that assumes high growth rates due to a better economic environment and Slow Progression and Steady State as a second scenario with a lower growth rate.

Consumer Power and Two Degrees

Under these scenarios, we assumed that build out rates for domestic and non-domestic development matched the targets given in the local plan.

Slow Progression and Steady State

These scenarios are effectively the current trajectory of much lower housing development than government has identified is needed. The following assumptions were made, setting out a slower pace of development:

- Strategic sites: we assumed that strategic sites are likely to go ahead, regardless of economic climate, but are likely to suffer delays and reductions in the total number of houses built. The following reductions were used for strategic sites:

Year	Description of reductions
2017/18 -2018/19	Current developments more likely to go ahead, 50 per cent of annual build out rate built to schedule, remaining 50 per cent delayed.
2019/20 – 2022/23	40 per cent of annual build out rate built to schedule, remaining 60per cent delayed.
2023/24 – 2027/28	40 per cent of annual build out rate built to schedule. Delayed projects from 2017/18 and 2018/19 are distributed equally across the five year period.
2028/29 – 2032/33	40 per cent of annual build out rate built to schedule. Delayed projects in 2023/24 - 2027/28 are distributed equally across the five year period.

- General allocation: for non-strategic sites, the planned target figure has been multiplied by 64 per cent, to reduce the total housing built in the slow economic growth scenario. This percentage reduction was calculated by assessing total completed build figures in the UK compared with anticipated figures for the years 2008 to 2010 (following the economic recession).
- Unallocated houses: as with general allocation, the planned target figure has been multiplied by 64 per cent.

4.5. Scenario results

Overall development

The Two Degrees and Consumer Power scenarios see 254,897 houses developed by 2032 in the licence area. An additional 2,032 ha of non-domestic development is also developed.

Steady State and Slow Progress scenarios result in 166,379 houses and a further 1,050 ha of non-domestic development by 2032.

Table 4-2: Total figures for domestic and non-domestic development up to 2032

	High economic scenario		Low economic scenario	
	Domestic (number of houses)	Non-domestic (ha)	Domestic (number of houses)	Non-domestic (ha)
2020/21	96,110	729	51,796	273
2025/26	192,758	1,730	105,800	874
2032/33	254,897	2,208	160,199	1,252

Across the 25 local authorities, 164 strategic mixed-use developments were identified. A further 85 strategic sites have been identified for office or industrial use only. General allocation sites total 86,178 for housing and 186 ha for non-domestic development. The largest strategic sites identified include the Weston Villages in North Somerset with up to 5,668 houses and the Sherford New Community in South Gloucestershire with 3,424 houses. There are 48,503 unallocated houses planned up to 2032.

Domestic developments

Table 4-3 shows total number of new houses in the South West licence area to 2032. Housing development is concentrated around areas with high population density, such as Bristol and Plymouth. Other local authorities with high future housing growth are either close to existing large conurbations or have a considerable number of strategic sites.

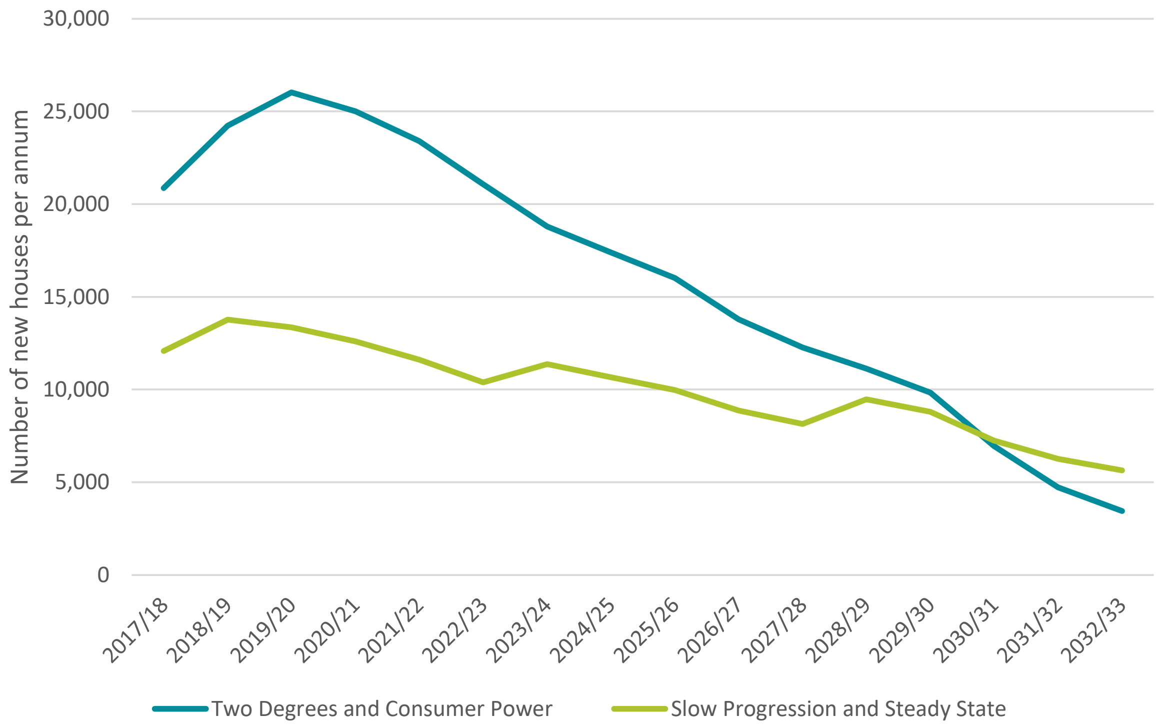
Table 4-3: 2032 totals for planned new houses by local authority in the South West licence area

Local authority	Two Degrees and Consumer Power (Total number of houses)	Slow Progression and Steady State (Total number of houses)
Bath and North East Somerset	12,489	7,933
City of Bristol	10,082	7,951
Cornwall	39,279	25,703
Cotswolds	329	181
East Devon	8,606	6,164
Exeter	3,006	2,355
Isles of Scilly	200	128
Mendip	2,926	1,866
Mid Devon	8,886	5,345
North Devon	8,933	5,741
North Dorset	653	508
North Somerset	17,061	10,083
Plymouth	17,552	10,595
Sedgemoor	10,189	5,713
South Gloucestershire	37,112	22,713
South Hams	5,519	3,045
South Somerset	17,015	10,026
Stroud	5,908	3,778
Taunton Deane	12,791	7,753
Teignbridge	12,865	7,918
Torbay	8,412	5,210
Torridge	7,850	4,994
West Devon	2,491	1,441
West Dorset	2,145	1,426
West Somerset	2,599	1,630
Total	**254,897**	**160,199**

Figure 4-3 shows a peak early on in Two Degrees and Consumer Power as strategic sites with more certainty of going ahead are often focussed in the initial stages of the plan period. In addition, the data included from SHLAA or annual monitoring reports often only covers a five year trajectory, offering more certainty of what will happen in the near term. The amount of robust data available reduces with further projection out towards the end of the scenario period, particularly for monitoring reports based on planning applications, hence the decline towards 2032. In a high growth scenario, further development sites could be expected to come forward towards 2020 – however, assumptions about development that is not yet identified have not been included.

Steady State and Slow Progression shows the decreased level of growth once we have applied the percentage reduction figures to annual build out rates in a slower economic climate. The average annual growth rate over the study period is 10,012, slightly lower than the five year average historic growth rate figures for the south west of 12,686 new houses per year.[40]

Figure 4-3: Local plan new house projections in the South West licence area



[40] Based on historic 4 year average (2012-2016) for number of new houses by LSOA in the south west licence area. Source: BEIS sub-national electricity consumption data, 'LSOA domestic electricity 2016', based on number of new MPANS annually.

Non-domestic development

Table 4-4 shows that the local authority of South Gloucestershire has the highest amount of planned non-domestic development. This local authority has 23 strategic sites over 80 ha (80,000 m²), including land at Yate, a 30 ha employment site. This site links with the Yate extension, which aims to provide an additional 2,000 houses.

A significant proportion of the non-domestic developments in Teignbridge are planned at Newton Abbot. The aim of this development is to allow further growth to the largest town in the Teignbridge region.

The remaining local authorities have a combination of multiple strategic sites and general allocation to provide the non-domestic development anticipated. Across the licence area, an additional 1,796 ha of employment land has been allocated for B1, B2 and B8 (office, factory and warehouse) uses. The development sites also provide over 49 ha of retail development.

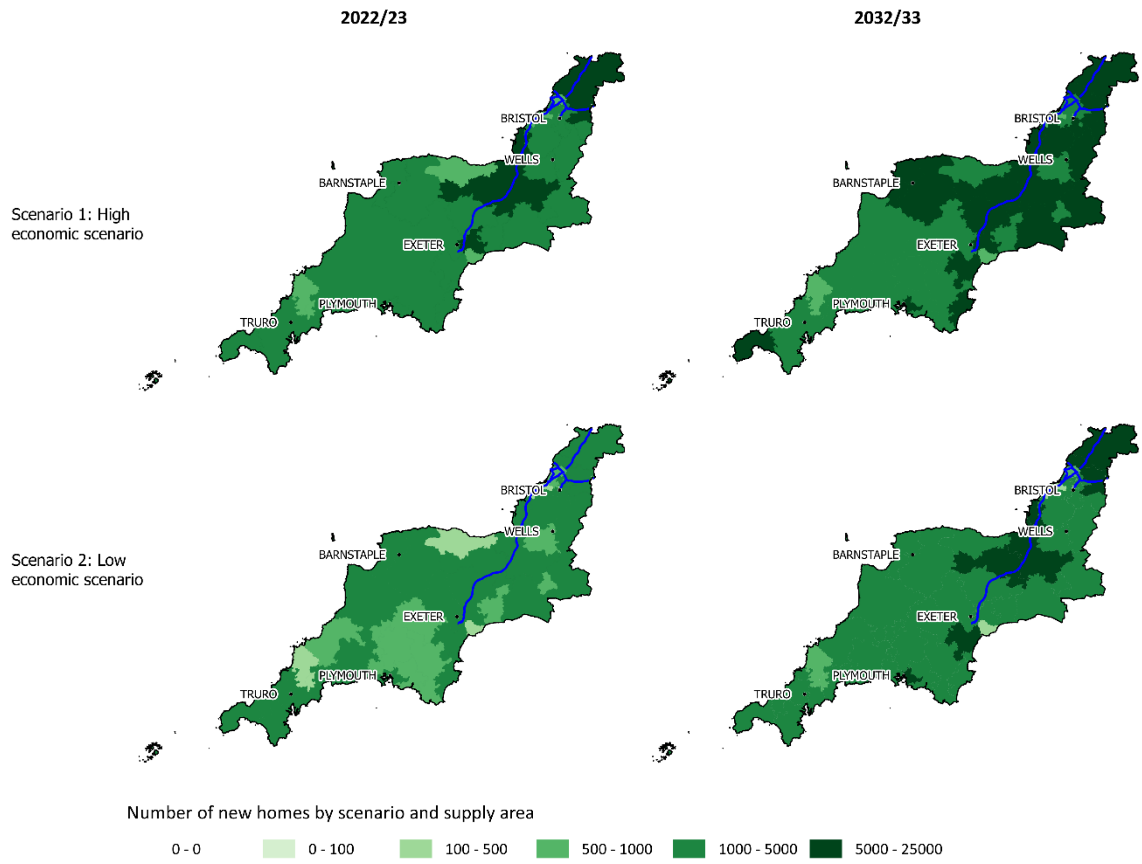
Table 4-4: 2032 totals for planned non-domestic developments by local authority

Local Authority	Two Degrees and Consumer Power total non-domestic developments (ha)	Slow Progress and Steady State total non-domestic developments (ha)
Bath and North East Somerset	71	49
City of Bristol	102	50
City of Plymouth	84	51
Cornwall	158	76
Cotswolds	2	1
East Devon	155	94
Exeter	48	36
Mendip	6	4
Mid Devon	28	17
North Devon	106	64
North Dorset	6	4
North Somerset	139	61
Sedgemoor	129	59
South Gloucestershire	337	200
South Hams	14	8
South Somerset	128	82
Stroud	156	84
Taunton Deane	157	97
Teignbridge	180	106
Torbay	47	25
Torridge	39	23
West Devon	17	10
West Dorset	89	47
West Somerset	9	4
Total	**2,209**	**1,252**

4.6. Geographic distribution by ESA

Figure 4-4 shows the distribution of total housing figures for each ESA in the licence area. As would be expected, the largest growth is focused around areas with high population density or in the local authorities surrounding the major cities.

Figure 4-4. 2022 and 2032 new housing distribution by supply area in the high and low economic scenarios



The local authorities with high domestic demand in the south west overlap with the local authorities where the highest amounts of domestic growth are planned. Cornwall, Bristol, South Gloucestershire and Plymouth are the top areas for future domestic development; this follows existing trends, as these local authorities are in the highest band for electricity sales per meter (350+ GWh).

Figure 4-5 shows the distribution of non-domestic development for each ESA in the licence area. The largest developments cluster around existing commercial sites and are often strategic economic growth areas, such as the Draycott in Stroud and Vearse Farm in West Dorset.

The assumption of delays under Steady State and Slow Progression scenarios results in a low amount of commercial development to 2022. Strategic commercial sites often have very long lead in times and are heavily dependent on the economic climate to gather substantial investment.

Figure 4-5 2022/23 and 2032/33 non-domestic development distribution by supply area in high and low economic scenarios

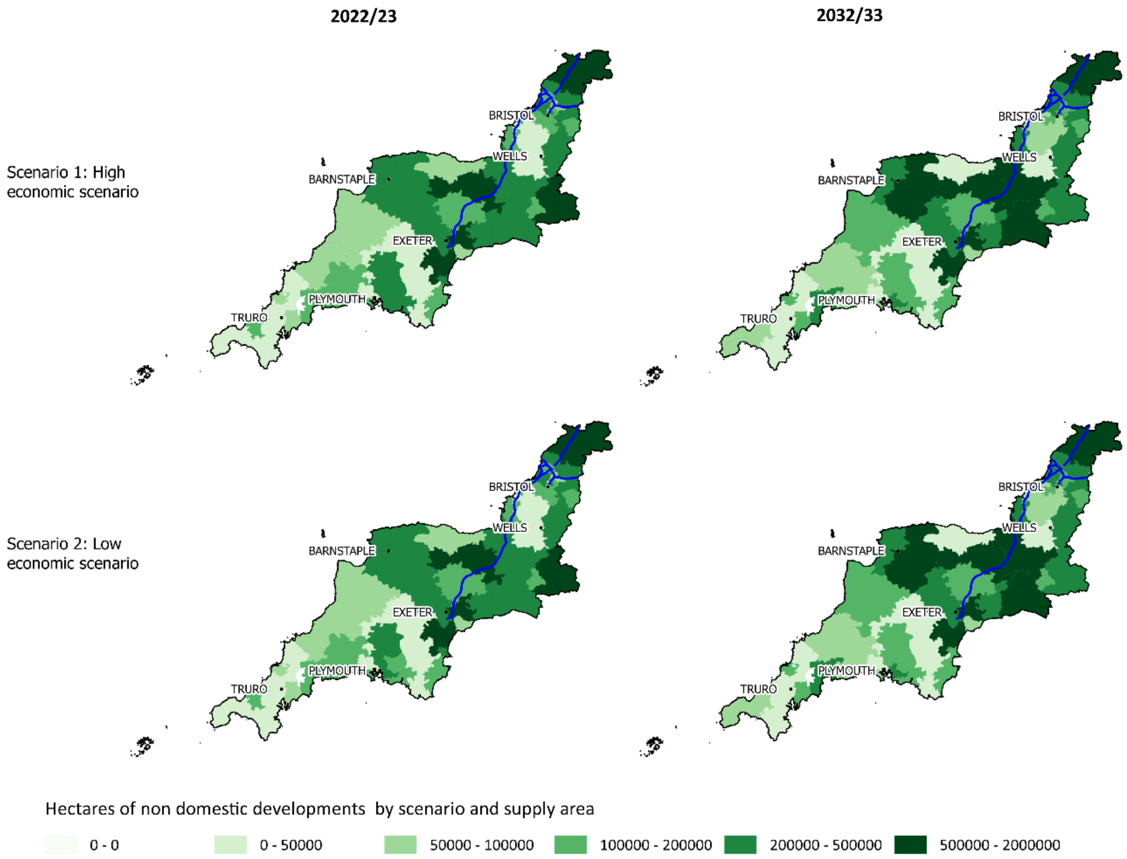
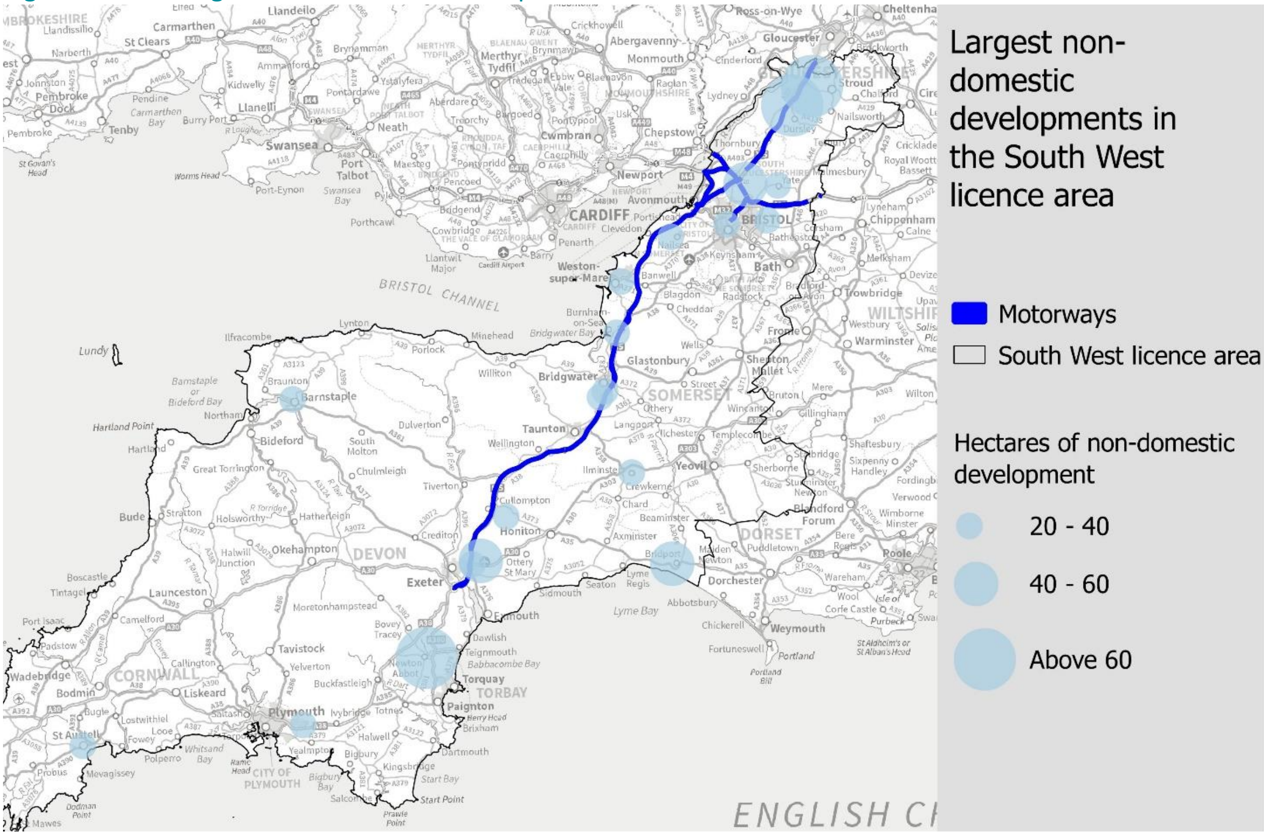


Figure 4-6 illustrates the growth in commercial and industrial developments across the South West licence area. Of the largest 20 commercial and industrial sites, 13 are focussed around the main motorway arteries of the M4, and M5, where key existing infrastructure and accessibility allow for larger developments.

Overall, total figures for commercial and industrial development in the south west are lower than totals in the West Midlands licence area. There are several major sites across the south west (for example in South Gloucestershire and Teignbridge), which make up a significant portion of the planned developments. Additional large domestic and non-domestic developments are anticipated near established commercial sites and existing transport infrastructure.

Figure 4-6. 20 Largest non-domestic development sites in the South West licence area



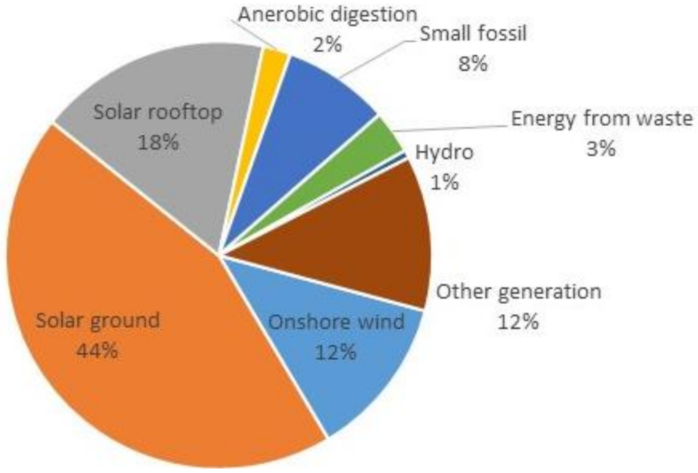
II. Introduction to generation

South west baseline generation

At the end of September 2017, the UK's renewable electricity capacity totalled 38.9 GW, an increase of 13 per cent (4.4 GW) from 2016. Solar and onshore wind provide 32 per cent of the capacity with offshore wind at 16 per cent.[41]

The south west has been a first-mover in installing renewable generation technologies. There is currently around 2.5 GW of distributed energy capacity installed on the WPD south west distribution network, 1.6 GW or 64 per cent of this capacity is ground mounted or rooftop solar PV. This is 5 per cent of the UK total renewable energy capacity and over 10 per cent of the solar capacity in the UK. Approximately 15 per cent of electricity consumption in the south west region is met by onshore renewables.[42]

Figure II-1: WPD South West licence area baseline 2017 percentage of distributed generation technologies



This section sets out Regen's analysis, assumptions and market insights behind the future growth scenarios of electricity generation technologies in WPD's South West licence area. The generation technologies analysed are:

- Anaerobic digestion
- Energy from waste
- Small scale fossil fuels
- Geothermal
- Hydropower
- Marine (wave and tidal)
- Ground mounted solar PV
- Rooftop solar PV
- Onshore wind
- Other generation (note not scenarios)

[41] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/669723/Renewables.pdf. P.58 (12 March 2018)

[42] Regen's 2016 Progress Report. https://www.regensw.co.uk/Handlers/Download.ashx?IDMF=84ec0a2f-03da-4e7a-9e22-38a30937c50a Note the south west region covers a slightly different area to Western Power Distribution's licence area.

Generation growth factors

The key factors considered in each of the FES 2017 scenarios for the growth of distribution generation are set out below and discussed further in the individual technology growth chapters. These cover government policy; market factors and the available local resource.

Factor 1: Government policy and commitment to least-cost carbon reduction and targets.

The Climate Change Act commits the government to an 80 per cent reduction in greenhouse gas emissions against 1990 levels by 2050. The UK has also agreed to an EU target of meeting 15 per cent of its 2020 total energy demand (heat, electricity and transport) from renewables. Under current predictions, the UK is set to miss this target and there is uncertainty about whether the current government will continue its commitments. Sanctions for missing the target are uncertain, particularly after Brexit.

Other considerations than cost-effectiveness often determines the energy strategy of governments and the degree to which renewable energy technologies are supported vis-à-vis other technology options, such as gas generation and nuclear. For example, despite being the lowest cost generation technology, onshore wind is effectively banned in England under planning rules.

Factor 2: Revenue or subsidy support, and for which technologies.

Subsidies like the FIT and RO have been used effectively to establish and reduce the costs of some renewable energy technologies. The closure of both for large scale renewables in 2016 and 2017 respectively has had a dramatic effect on deployment rates. The remaining FIT for domestic renewables is due to end in 2019.

As the price of power on the electricity market becomes more variable, a subsidy or price guarantee mechanism is increasingly important for new generation. Without a level of income certainty, risk and cost of capital become prohibitive. Contract for Differences (CfDs) provide price certainty at a specified price level through auctions. However, it is not available for all technology types and less developed technologies such as geothermal and marine are, in reality, unable to compete on a cost basis for the available support.

Factor 3: Levels of network capacity to enable distributed generation to export to the market.

The high level of renewables deployed onto the distribution network in the south west has meant that the licence area has greater network capacity constraints than other licence areas in the UK. As a result there are high cost of connections and capacity constraints. In some areas this has all but halted new distributed generation.

This can be addressed by strategic investment (of which this report aims to help to direct) or by avoiding upgrade costs through enabled by ‘smart’ solutions, active network management and demand response solutions etc. In all but the Steady State scenario it is projected that these network issues do not constrain the deployment of renewables in the medium and long-term.

Factor 4: Ability for distributed generation projects to achieve planning permission. Planning applications in England for energy generation installations above 50 MW, and since 2016 for all scales of onshore wind, are determined by local authorities under the Town and Country Planning Act. As a result, the planning environment in England varies considerably depending on the political leanings and opinions of the local authority. Developers have tended to focus their efforts in areas with a reputation for a more benign planning environment. In the greener scenarios it is anticipated than planning environment is relatively benign allowing the majority of new renewable sites to be built up to 2032.
Factor 5: Future technology development and efficiency There are many assumptions built into the relative Levelised Cost of Energy (LCoE) of different generating technologies. A growing global market for renewable and storage technologies has already driven down costs for some technologies remarkable rate. Continued technology development and innovation is expected in new technology areas such as energy storage, marine energy and electric vehicles. Other technologies such as Anaerobic Digestion and hydropower are more mature and therefore may not see significant cost reductions.
Factor 6: Growth potential and resource availability Resource availability is the key factor in the growth scenarios. Though there is often significant theoretical resource in an ESA there are often also practical constraints on this resource such as environmental designations of land that limit development or limitations on total available resource. There may be relatively less potential for future growth in the south west area, as an early adopter of distributed renewable generation.

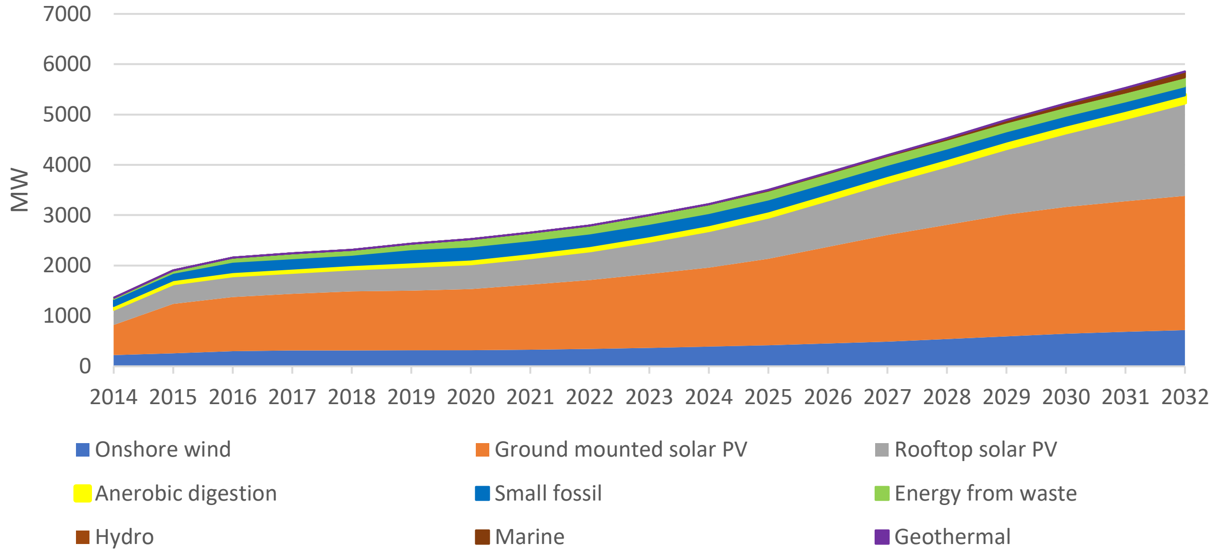
South west scenario summary

Under a Two Degrees scenario, distributed electricity capacity in the licence area could more than double from 2.2 GW to 5.9 GW in 2032. Even in Steady State there is a capacity increase of 48 per cent to 3.7 GW.

Table II-1: WPD south west scenario summary of growth for distributed generation technologies

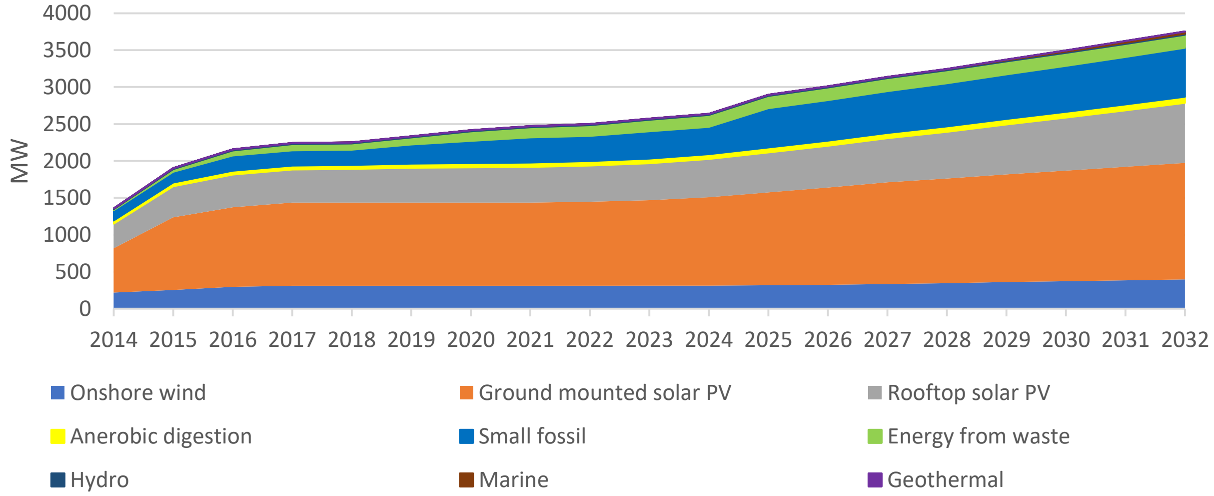
Distributed generation (MW)	2017	2025	2032	Growth 2017-2032 (%)
Two Degrees	2,541	3,505	5,858	131
Consumer Power		3,265	5,081	100
Slow Progression		2,932	4,324	70
Steady State		2,896	3,752	48

Figure II-2: Two Degrees generation growth summary for WPD South West licence area



In Two Degrees, Figure II-2, shows deployment rates steadily increasing back up, particularly in the second half of the decade, however, growth does not reach recent peaks seen in the last decade.

Figure II-3: Steady State generation growth summary for WPD South West licence area



In Steady State, growth remains slow and there is more fossil fuel generation, installed capacity of renewable generation increases towards the end of 2020s.

Figure II-4: WPD south west Steady State summary proportions of distributed generation in 2032

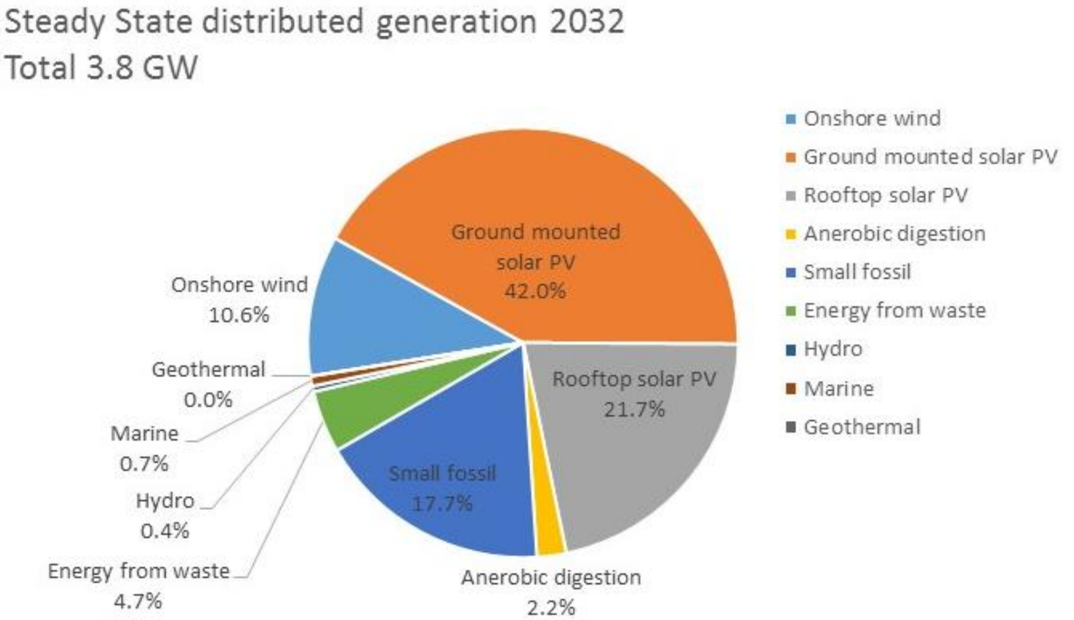
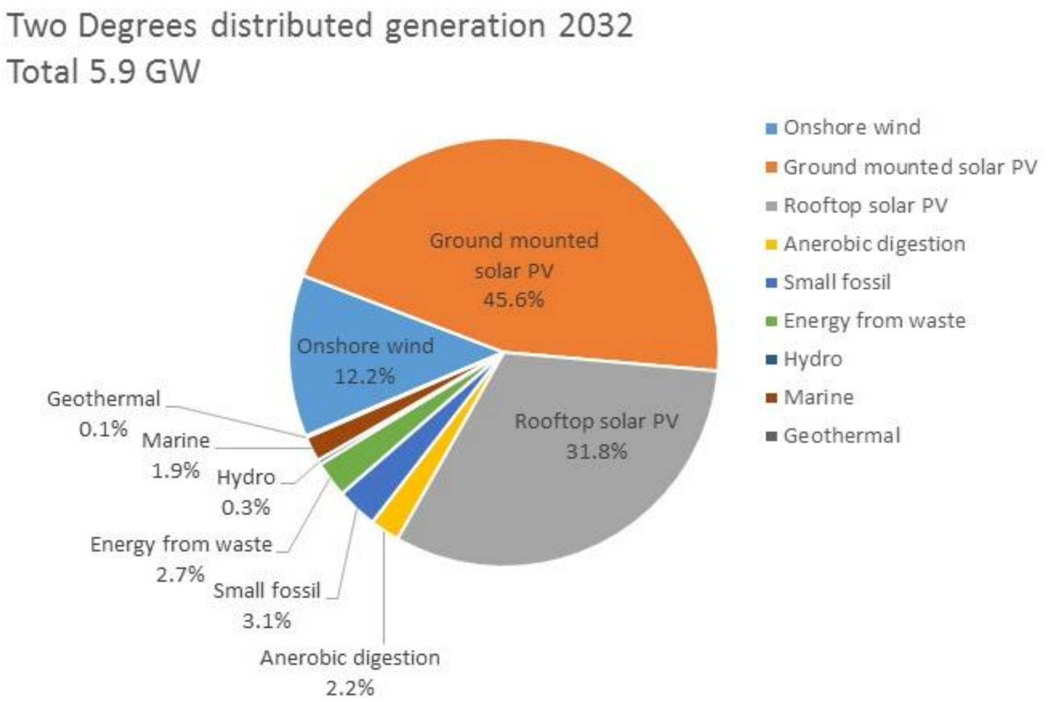


Figure II-5: WPD south west Two Degrees summary proportions of distributed generation in 2032



5. Ground mounted solar PV

After a period of very high growth, deployment of ground mounted solar has fallen dramatically following the removal of subsidies.

Treasury has explicitly ruled out further subsidy support until 2025.[43] The focus of the market is therefore on subsidy-free business models such as private wires or co-location with storage. The viability of the sector medium term depends on continued cost reduction.

Government support no longer available, but subsidy-free solar expected to become viable for well-sited projects.

Table 5-1: Summary of growth in capacity of ground mounted solar PV WPD South West licence area.

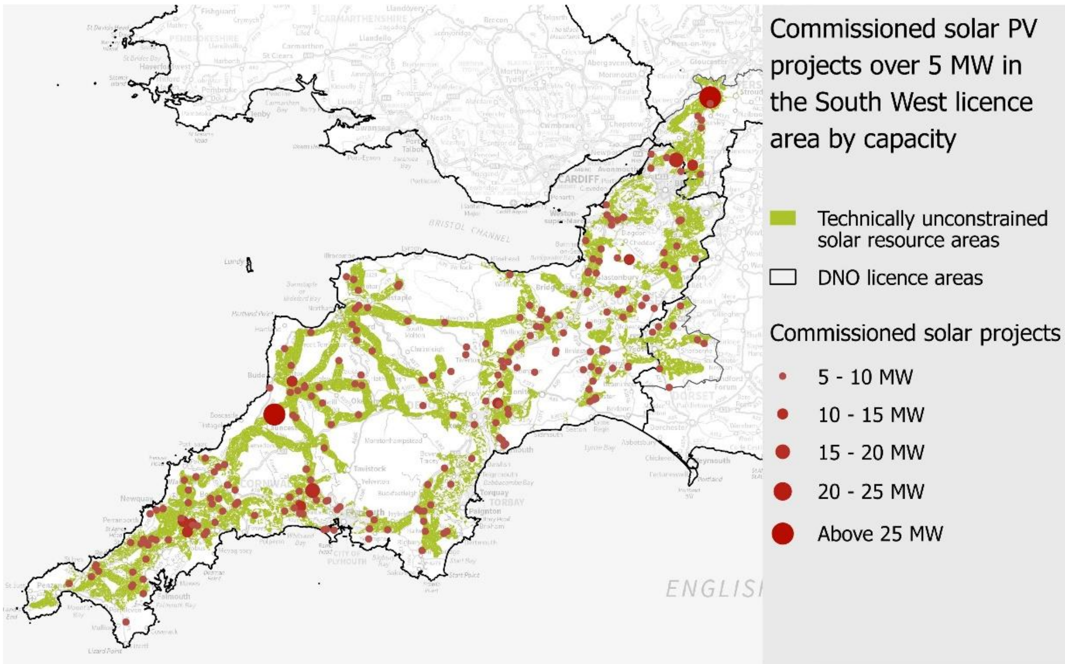
Ground mount solar (MW)	2017	2020	2025	2032
Two Degrees	1148	1238	1742	2692
Consumer Power		1159	1448	2213
Slow Progression		1159	1438	2008
Steady State		1148	1301	1621

5.1. Baseline

The south west has seen ground mounted solar PV increase from only 50 MW in 2011 to over 1.3 GW in 2017. However, only 170 MW of this was added in the last two years and new large ground mounted solar projects have largely ceased as a result of removal of subsidies and the increasing network capacity constraints in the licence area.

43 https://www.theguardian.com/environment/2017/nov/22/no-subsidies-for-green-power-projects-before-2025-says-uk-treasury

Figure 5-1: WPD South West licence area map of ground mounted solar PV projects and resource



To obtain a low cost of capital for construction, new ground mounted solar projects need to have a level guaranteed income that reduces the risk for lenders. Currently solar is not able to access price support through CfDs. With ROCs and FITs no longer available for solar projects over 5 MW, there are no subsidies for large scale solar farms. At the same time, the increasing volatility of the wholesale price of power on the electricity market has eroded the certainty of income from exporting electricity to the grid.[44]

Solar developers are now focussed on new business models that could provide a higher and more certain price for the electricity they generate such as selling to corporates directly, either with a private wire or through a power purchase agreement (PPA). However, these arrangements have proven slow and difficult to agree.

5.2. Pipeline

Despite income risks, a trickle of large, well-sited subsidy free projects is emerging. Projects currently being developed are those where developers can recoup sunk project costs, such as the costs of planning for sites with permission that were not developed in time to secure subsidies.

WPD's data shows 111 MW of accepted-not-yet-connected solar PV in the south west. This is a quarter of the pipeline for the licence area in 2015.

40 MW of the pipeline is from five larger projects, which all have planning permission in place. As these projects have already incurred the cost of gaining both planning consent and connection agreements, it is likely that these will be some of the earlier projects to come forward without subsidy. Based on engagement

[44] https://utilityweek.co.uk/market-volatility-in-oil-and-energy-prices-is-likely-to-persist/

with the developers Table 5-2 sets out the assumptions for which of these projects will be developed under each scenario.

Table 5-2: Scenario details for ground mounted solar PV pipeline projects

Project name	Size (MW)	BSP location	Two Degrees	Consumer Power	Slow Progression	Steady State
Wessex Solar Energy at West Holcombe	6	Tiverton BSP	2019	2020	2020	2021
Roborough South Hams Solar Farm	5	Ernesettle BSP	2019	2020	2020	2021
Ecotricity project at Lodge Farm	4.2	Radstock BSP 132kv	2020	2021		
Trendeal Solar Farm	12	Fraddon BSP	2020			
Hawkers Farm (Energy My Way)	1	Bridgwater Grid BSP	2020			

A further 68 MW of projects in the pipeline do not have planning permission in place. This includes a 25 MW scheme in Bowhays Cross BSP near Taunton. Large projects in the pipeline database without planning permission, and without other records identified were assumed not to go ahead in the pipeline period.

5.3. Technology growth prospects

Technology and installation costs for Solar PV have fallen, but the current deployment hiatus may slow cost reduction in installation.

Increases in global demand, supply and innovation have driven down the installed cost of solar PV by 62 per cent since 2009 according to Bloomberg.[45] The International Renewable Energy Agency[46] anticipates a further drop of 43 per cent by 2025. If achieved, that would result in an overall decrease in costs of 78 per cent from 2009 to 2025.

In the UK, installations costs for solar PV have been reducing. Industry sources indicate EPC[47] costs are £550k per MW or less for solar farm construction. This is a significant reduction from £850k in 2013. The latest tender process in France for solar PV achieved an average of 55.5 Euros/MWh, down from 63.9 Euros/MWh just a few months earlier.[48] However, as skills and installation volumes have been lost from the UK sector due to the current deployment hiatus, this cost reduction rate may be hard to maintain. Since 2015 BEIS PV cost data suggest installation costs have been relatively flat.[49]

45 https://www.bloomberg.com/news/articles/2017-01-03/for-cheapest-power-on-earth-look-skyward-as-coal-falls-to-solar
46 http://www.irena.org/newsroom/pressreleases/2016/Jun/Average-Costs-for-Solar-and-Wind-Electricity--Could-Fall-59-by-2025
47 Engineering, Procurement, and Construction
48 https://www.reuters.com/article/uk-france-solar/france-approves-bids-for-500-mw-solar-power-generation-idUSKBN1AD24G
49 https://www.gov.uk/government/statistics/solar-pv-cost-data

The first subsidy-free site at Clay Hill[50], 10 MW of solar PV co-located with energy storage, opened in September 2017. NextEnergy Solar Fund (NESF[51]) has also announced that it plans to develop four 10 MW subsidy free sites during 2019.

Other developers are looking to achieve subsidy free solar by exploiting economies of scale in locations with ample low-cost network capacity, such as the 350 MW site proposed at Cleve Hill in Kent.[52] The Cleve Hill site would use the transmission network and could be over three times the size of any existing site.

A key challenge for subsidy free solar is that at peak times of high solar generation, the excess electricity generation is likely to depress the wholesale price. Research from Aurora suggests that by the 2020s, there will be considerable falls in wholesale electricity prices at times of high solar load.[53]

Potential for co-location with storage is a key driver of future growth.

A new business model being explored is the co-location of solar PV with storage. Co-located battery storage may allow more PV sites to get grid connections by levelling peak generation. It could also help mitigate the electricity market price risk either through flexibility services or through arbitrage by storing and selling low cost solar power during higher priced evening peaks. This has the potential to transform the sector but Regen's analysis indicates that it remains a very challenging business model.[54]

A key driver for the future of the technology is the point when co-location models for solar and storage will start to improve the business case for investment in ground mounted solar.

[50] http://anesco.co.uk/clayhill-uks-first-subsidy-free-solar-farm/
[51] https://nextenergysolarfund.com/
[52] https://www.theguardian.com/environment/2017/nov/09/giant-solar-power-plant-uk-biggest-north-kent-coast-subsidy-free-power-station-faversham
[53] http://www.auroraer.com/wp-content/uploads/2017/11/Aurora-Battery-Conference-31-Oct-2017.pdf (2017)
[54] https://www.regensw.co.uk/energy-storage-the-next-wave-2

5.4. Scenario results

Figure 5-2: WPD South West licence area ground mounted solar growth scenarios.

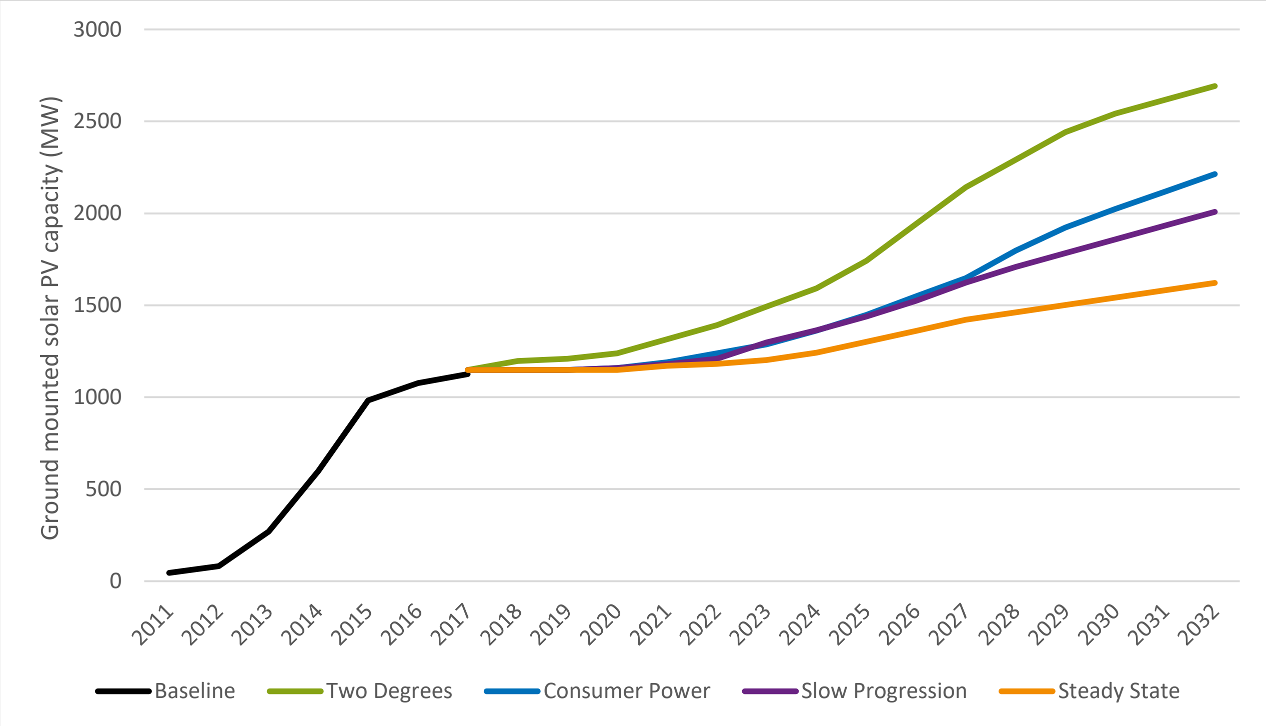


Table 5-3: Assumptions for factors influencing capacity growth for ground mounted solar PV

Two Degrees	• Pipeline projects with sunk costs such as planning are built out. • Reducing cost and co-location with storage business models leads to increased growth and investment from 2020/21. • Projects are supported by a strong corporate PPA market. • Growth does not reach the rate of previous years and reduces towards the end of the period as the best sites are already constructed.
Consumer Power	• The most attractive sites in the pipeline are built. • The co-location model starts working towards mid 2020s as technology costs reduce. • There is more of a focus on smaller sites linked to local demand.
Slow Progression	• Cost reductions occur later than in Two Degrees and government support helps larger schemes get built in mid 2020s.
Steady State	• Growth continues at slow pace as a result of continuing network constraints. • Economics improve towards the end 2020s leading to slow increase in growth rate.

Relationship to FES 2017 and 2015 Scenario report

The Two Degrees scenario is around 500 MW lower than the Gone Green scenario in 2015 south west scenarios. This reduction reflects the hiatus in deployment since the removal of the FIT and RO. The other scenarios remain broadly consistent with 2015 study.

The growth projected is lower than that in FES 2017 in the three scenarios other than Steady State, particularly in Consumer Power which expects a 176 per cent growth by 2032 compared to 75 per cent in this model. As the south west already has high deployment of PV, opportunity for growth will be lower compared to others in the UK. There are also fewer opportunities for very large sites.

Distribution of technology across ESAs

Assessment of the potential for ground mounted solar PV focussed on the available land for development and proximity to the network in the south west. Additional considerations for developers may include orientation or visibility of the site, as well as housing density and vehicular access.

The developable land area for solar has been estimated with regards to the following constraints:

- Designated land areas – Ancient Woodlands, Areas of Outstanding Natural Beauty, Country Parks, National Parks, Special areas of Conservation, Sites of Special Scientific Interest etc.
- Physical constraints – roads, woodlands, waterbodies, 50m buffers around houses etc.
- Historic assets – such as scheduled monuments
- That developable land is within 1.5 km of the 33 kV (or higher) network

The scenario generation growth projections are distributed according to both the results of the developable land resource assessment and the existing baseline distribution across the ESAs. Figure 5-1 shows the developable solar resource corridors and the existing baseline of ground mounted solar PV sites. The commissioned solar project baseline and the resource areas identified show a strong concurence across the South West licence area.

6. Rooftop solar PV

In the UK lower subsidies mean the short-term growth in rooftop solar PV is slow and uncertain. In 2017 growth in the south west slowed to 10 per cent of the 2015 rate.

However, solar PV installation is seeing acceleration across the world, and the technology is starting to undercut conventional generation globally. Global market growth and cost reduction are likely to drive stronger UK growth in medium and longer-term.

Table 6-1. Summary of capacity growth of rooftop solar PV in WPD South West licence area.

Percentage of properties with rooftop PV in 2032	New build (in 2032)	Existing houses (pre 2017)	Commercial
Two Degrees	58.2	14.5	29.8
Consumer Power	37.6	12.5	24.4
Slow Progression	28.2	9.4	21.0
Steady State	14.3	6.5	17.4

6.1. Baseline

The south west currently has the highest rooftop solar PV capacity of UK regions.[55] Over 300 MW of rooftop solar PV has been installed on domestic properties accounting for around 3.9 per cent of houses in the south west.

Over 140 MW of solar PV has also been installed on 3,000 commercial roofs, up from just 100 installations in 2010.

Government support minimal or negative in the short term.

Technology costs continuing to fall but reductions are levelling out.

Rooftop and small-scale solar PV has, for the moment, retained a small subsidy through the FIT. This reduced from 4.22 p/kWh to the current level of 0.38 p/kWh in 2016. The remaining FIT is available for installations up to 5 MW until March 2019 (unless the budget is exceeded). The 2017 autumn budget announced that all subsidies will stop after this point.

The reduction in government support means growth has stalled. In the south west installation rates of rooftop solar PV capacity in 2017 was less than a tenth of the peak deployment rate. The resulting fall in jobs, expertise and experience will have a long-term impact on the market and potentially slow the pace of cost reduction.

[55] Regen Progress Report 2016

6.2. Pipeline

Increases in global demand, supply and innovation have driven down the installed cost of solar PV by 62 per cent since 2009 according to Bloomberg.[56] The International Renewable Energy Agency[57] anticipates a further drop of 43 percent by 2025. This would bring the costs down by 84 percent since 2009.

KPMG expect that costs are likely to continue to be eroded across most solar PV components from module, inverters to installation costs. However, network and planning costs for larger schemes in the UK are expected to rise.[58]

Despite falling technology costs the payback for domestic PV is currently around 10 years and the FIT still makes a significant contribution. Once the FIT ceases in 2019, the domestic market may drop further as the payback period increases to around 18 years. However, there are plans in the market for large scale roll out. Solarplicity are aiming to provide 'free' solar to 800,000 social houses in England and Wales in the next five years.[59]

The FIT is less significant for solar on commercial roofs where the power can be used on site and offset the retail price of power. This has already reached a point where the right properties and usage profile can have payback periods of five to six years.[60]

However, barriers remain. The decision to include solar PV in business rates means there is now a potential penalty for commercial properties installing solar PV.[61] Furthermore, only a limited number of companies have the capacity and ability to make a strategic long-term investment in energy management that PV requires.

6.3. Technology growth prospects

New business models that match rooftop Solar PV with storage could fuel medium and longer-term growth

The south west has good potential for further increases in rooftop capacity. The region has high solar irradiance and high existing levels of rooftop PV as well as relatively large amount of lower density (rural and semi urban) housing with usable roof areas.

Once payback periods improve through a combination of reduced technology costs, renewed government subsidy support or rising energy prices, the licence area will experience relatively high growth.

Co-location of rooftop solar PV with storage from batteries also has the potential to provide an additional income stream bringing down payback periods for domestic and commercial installations. Aggregation of small solar with storage (batteries or an electric vehicle in households) along with smart technology could enable offering flexibility services to the grid.

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56 https://www.bloomberg.com/news/articles/2017-01-03/for-cheapest-power-on-earth-look-skyward-as-coal-falls-to-solar
57 http://www.irena.org/newsroom/pressreleases/2016/Jun/Average-Costs-for-Solar-and-Wind-Electricity--Could-Fall-59-by-2025
58 KPMG research 2015 - /UK_Solar_Beyond_Subsidy_-_The_Transition%20(1).pdf
59 http://www.bbc.co.uk/news/business-41122433
60 Industry sources February 2018
61 https://www.solar-trade.org.uk/business-rates-self-owned-rooftop/

The extra income commercial or domestic systems could receive from an integrated system of generation and storage is expected in our higher growth scenarios to start to provide attractive returns and result in an uptake in domestic and commercial roof-top PV installations during 2020s albeit at lower levels than the previous peak.

Technology costs of the combined system coupled with the energy price will be key factor determining growth towards the mid-2020s.

6.4. Scenario results

Figure 6-1: WPD South West licence area scenario of growth in rooftop solar PV

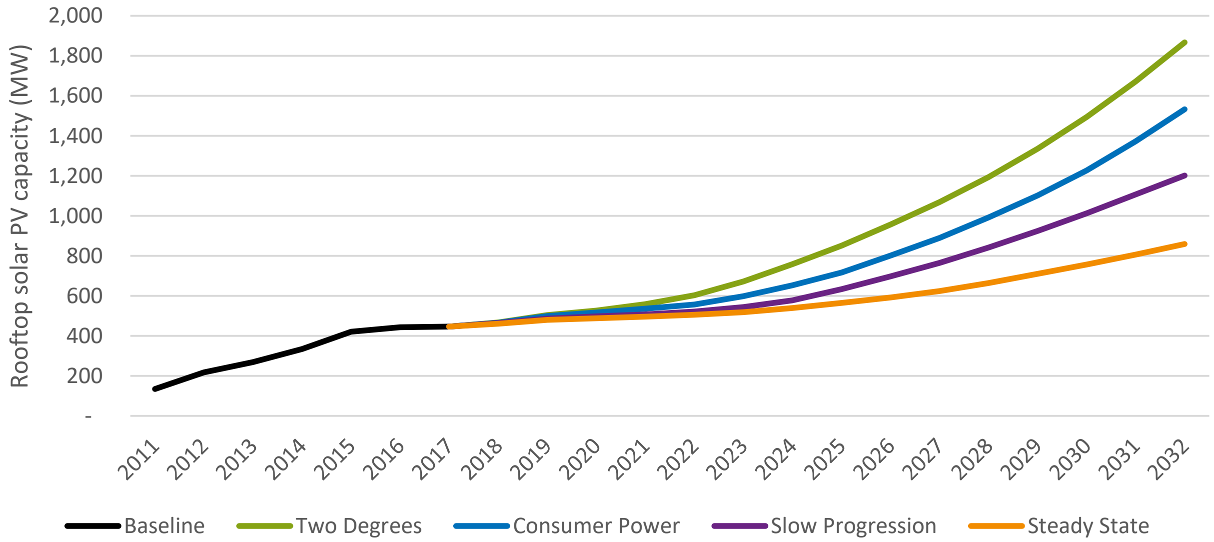


Table 6-2: Assumptions for factors influencing capacity growth in rooftop solar PV

Two Degrees	• Growth starts to improve in the very short term towards the FIT close date in 2019 • New government subsidy introduced focusing on social housing and community. • Technology costs continue to decrease and combined storage PV battery systems accelerate growth past early 2020s. • Growth of EVs makes domestic systems attractive.
Consumer Power	• Growth picks up to 2019 to meet FIT deadline. • No further government support means growth staying low to mid-2020s. • Technology cost reductions by mid 2020s start to make new business models viable for homeowners and businesses.
Slow Progression	• Growth remains slow in short and medium term as government support removed and technology costs do not fall significantly. • From mid 2020s some government support focused on social housing. • Growth picks up towards the end of the scenario period as technology costs allow for co-located solutions with electric vehicles.
Steady State	• No further government support for technology means low growth continues until mid-2020s. • Technology costs in second half of next decade reduce to levels that are competitive with electricity prices leading to growth pick up.

Relationship to FES 2017 and 2015 Scenario report

We have raised slightly the expectations of percentage of houses with solar PV ahead of the 2015 south west scenarios due to faster EV and storage growth that may make co-location models attractive.

The scenario growth rates are slightly higher overall than the FES 2017 to reflect the solar resource in the south west. Two Degrees is the highest deployment level which differs from the FES 2017 that has Consumer Power as its highest scenario. FES 2017 assumes that resources in Two Degrees will be concentrated on strategic investment elsewhere reflecting that rooftop solar PV is a relatively small contribution to achieving carbon targets. Our analysis is that in a green scenario with high economic growth and lower technology costs, consumers will invest in rooftop solar PV and we will see subsidised support for solar PV in priority areas such as social housing.

Distribution of technology across ESAs

Distribution of domestic rooftop solar PV is dependent upon the affluence of an area, the total number of houses, and the existing baseline. Analysis reveals that PV tends to spread within communities so that installations are concentrated. The commercial sector is driven by similar factors but we have given more weight to existing trends.

7. Onshore wind

The removal of subsidy and planning support for onshore wind in England has almost completely stopped development of new projects, there is only one 3.5 MW turbine in the current pipeline that is expected to be built. By comparison, there was 95 MW of onshore wind in the pipeline in the 2015 south west scenarios report.

In Wales and Scotland, where planning remains favourable, development has continued, albeit at a lower level. Growth in the sector in the south west will depend on technology costs, government support and most significantly, a change to the planning rules in England.

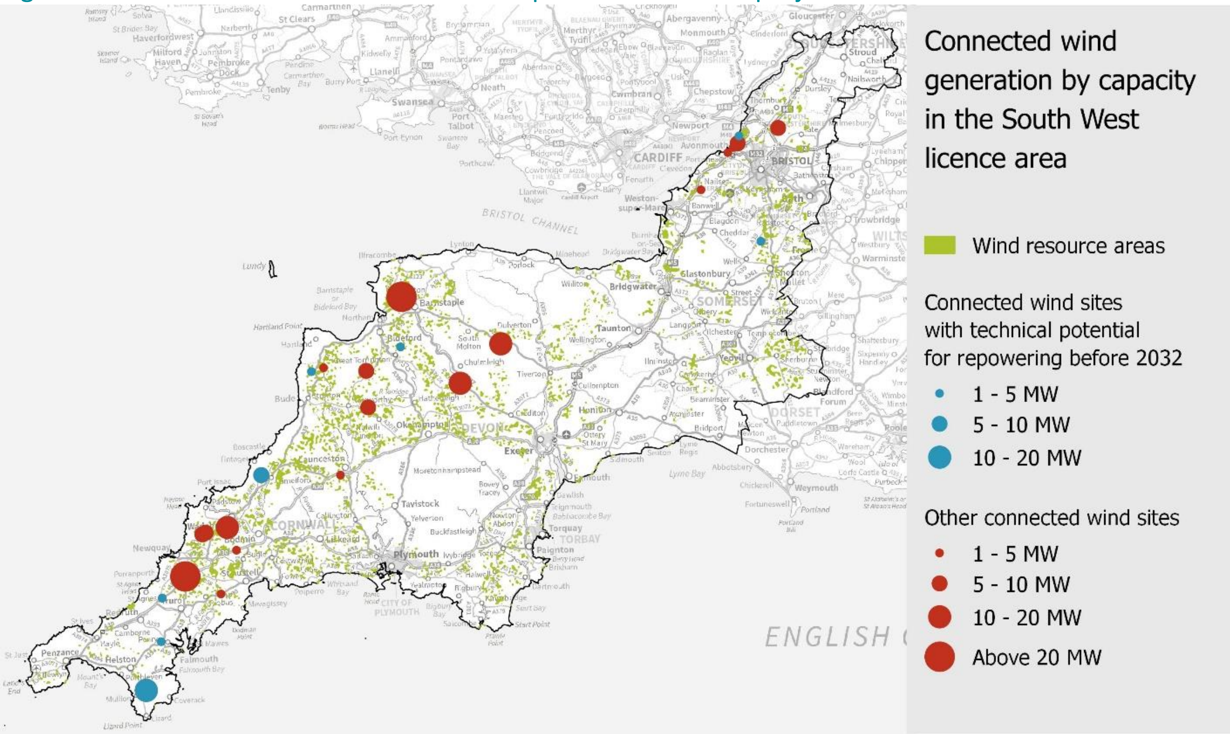
Table 7-1: Summary of onshore wind capacity growth in WPD South West licence area.

South west onshore wind capacity (MW)	2017	2020	2025	2032
Two Degrees	323	328	427	728
Consumer Power		328	361	496
Slow Progression		327	370	575
Steady State		323	330	408

7.1. Baseline

The south west currently has 323 MW of wind capacity from 740 projects, of which 25 are over 1 MW. The largest is the 66 MW Fullabrook Windfarm in Devon commissioned in 2012, the next biggest is the 20 MW Carland Cross Wind Farm in Cornwall commissioned in 2013. As with the national picture, government policy has slowed growth. There was 15 MW of onshore wind installed in 2017 and no new sites are expected to be built in 2018.

Figure 7-1: WPD South West licence area map of onshore wind projects and resource



Onshore wind currently has no financial support from the UK government and, since March 2016, subsidies have been removed from all but the smallest onshore wind projects. The CfD process, which provides price certainty for new generation, is not currently available to onshore wind. The 2017 Clean Growth Strategy announced that the scheme will be opened up to limited Scottish 'Island projects' for the next CfD round in 2019[62] but this clearly has no impact in England.

Lack of price support and changes to planning rules has meant that growth in onshore wind deployment has stopped in the south west.

However, onshore wind costs have fallen dramatically in recent years and are expected to continue to fall due to savings from larger turbines and lower maintenance costs.

BEIS's 2016 Electricity Generation Cost Report, for example, gave a central estimate of the cost of onshore wind as £64/MWh in 2016, a substantial decrease from the DECC report issued in 2013, which predicted 2016 costs would be £88/MWh.[63] The report identified onshore wind as the cheapest form of renewable power in the UK.

Falling costs have increased the potential for subsidy free projects and for viability of sites with lower average wind speeds.[64] Planning permission was recently provided to a seven turbine project in Wales that is not eligible for any subsidy.[65]

Sector 'on ice' waiting for change in government stance to unlock growth in the cheapest form of renewable energy.

In England, including the south west, planning rather than finance presents the biggest barrier to further development of onshore wind. Government planning policy effectively bans onshore wind development.[66]

Developers are building out any remaining projects that have planning permission and subsidies and consolidating their portfolios. Wind sites remain 'on ice' waiting for a change in policy.

7.2. Pipeline

WPD's accepted-but-not-yet-connected database for onshore wind consists of only three projects. Two of these projects are in Avonmouth for a 2.5 MW and a 3.5 MW project. Planning permission was agreed in 2017 for one 130 m turbine in Avonmouth.[67] It is assumed in all scenarios that this one 3.5 MW turbine with planning will go ahead before the end of the FIT in 2019.

The other project is Good Energy's Big Field Wind Farm which aimed to be subsidy-free and majority community-owned, but despite this was rejected by the Secretary of State in 2017. This decision is currently under a legal challenge but this project is not included in the pipeline.

The final RO grace period ends in January 2019. No further projects are expected in the south west before this deadline.

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[62] https://www.orcadian.co.uk/islands-wind-projects-included-uk-government-support-scheme/
[63] https://www.gov.uk/government/publications/beis-electricity-generation-costs-november-2016
[64] https://www.agora-energiewende.de/fileadmin/Projekte/2017/Future_Cost_of_Wind/Agora_Future-Cost-of-Wind_WEB.pdf

[65] https://www.naturalpower.com/consent-pant-y-maen/
[66] https://www.parliament.uk/documents/commons-vote-office/June%202015/18%20June/1-DCLG-Planning.pdf
[67] http://www.bristolpost.co.uk/news/bristol-news/council-approves-plans-130m-wind-409251

7.3. Technology growth prospects

There is pressure on the Government to relax their opposition to onshore wind. An increase in overall generation capacity will be required as coal fired power stations shut down. As the cheapest form of generation, onshore wind is an attractive option as part of the overall generation mix.[68]

Public support is high and growing, but vocal minority opposition remains a significant barrier.

The current anti onshore wind policies result from strong opposition to onshore wind from a vocal minority. The government energy and climate change public attitudes tracker[69] shows clear evidence that support for onshore wind is consistently high across all age ranges (74 per cent support with 8 per cent opposed).

Pressure for government support is currently focused on a 'subsidy free' CfD which provides a guaranteed 'strike' price at the wholesale price of electricity. This would enable projects in Scotland and Wales to progress. However, for projects to progress in the south west a change of planning policy in England would also be required. This is challenging in this parliament as the current policy is a Conservative party manifesto commitment.

The early introduction of a subsidy free CfD and a more benign planning environment are key factors in the Two Degrees scenario.

If support improves for onshore wind, deployment will pick up relatively swiftly, though there will be a lead time to develop new projects.

Any new market growth will likely continue the trend towards larger sites and turbine sizes. This is because planning and installation costs do not increase in proportion to size, whilst electricity output and, therefore, income increases disproportionately as the turbine's height and swept area increases.

The poor economics of smaller turbines (under 500 kW) along with significant planning obstacles that are irrespective of size, means this part of the sector has almost entirely disappeared. We expect growth in all scenarios to be very low.

The small scale wind sector has almost entirely disappeared, growth is expected to focus on larger turbines.

In the south west, repowering existing sites will be an important future trend due to relatively high numbers of smaller sites and turbines in the baseline. There are two sites reaching 20 years of operation in 2018 and in 2020 respectively, both have 16 small turbines. There are also several sites reaching 20 years of operation towards the end of the scenario period.

Previous repowering projects have reduced the number of turbines at the same time as doubling or even tripling capacity. Two further 12-14 MW sites may look to repower at the end of 2020s.

[68] https://www.regensw.co.uk/news/response-to-committee-on-climate-change-review
[69] https://www.gov.uk/government/statistics/energy-and-climate-change-public-attitudes-tracker-wave-23

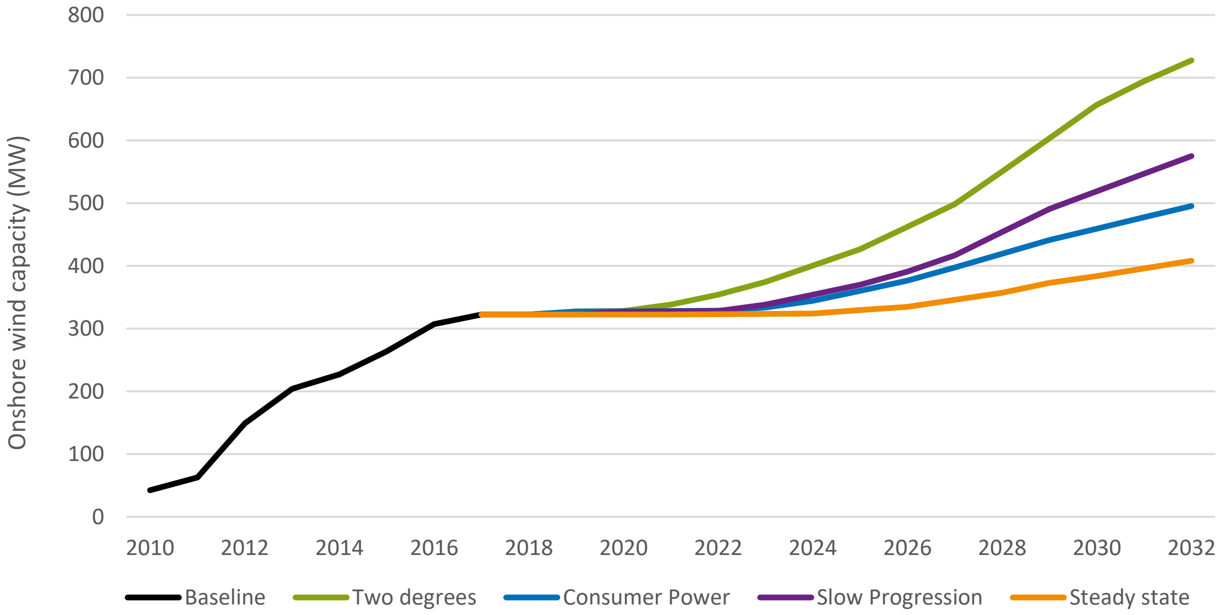
7.4. Scenario results

Relationship to FES 2017 and 2015 Scenario report

Due to south west's wind resource, land capacity and relatively high support for the technology, these scenarios suggest growth will be stronger than the FES 2017 predictions by 2032 in all but the Steady State.

However, as onshore wind development has almost ceased and there is no short term prospect of and improvement in the climate for onshore wind this report has less overall capacity in 2032 in all scenarios than the 2015 south west scenarios report commented.

Figure 7-2: WPD South West licence area onshore wind scenario growth in capacity



Distribution of technology across ESAs

Assessment of the potential deployment of onshore wind focussed on the available land area, specified proximity to the network, and wind speed at 45 metres height.

The developable land area has been estimated with regards to the following constraints:

- Designated land areas – Ancient Woodlands, Areas of Outstanding Natural Beauty, Country Parks, National Parks, Special areas of Conservation, Sites of Special Scientific Interest etc.
- Physical constraints – roads, woodlands, waterbodies, 500m buffers around houses etc.
- Historic assets – such as scheduled monuments
- That developable land considered only within 2.5 km of the 33 kV (or higher) network.

A series of resources areas were then produced, initially constrained to sites above 6 ms^{-1} with further distributions based upon higher wind speeds. The distributions of the projected onshore wind capacity by ESA considered the wind speed and available resource area, as well as the baseline.

Table 7-2: Assumptions for factors influencing onshore wind capacity growth

Two Degrees	• Renewed access to government support through CfDs. • Relaxation of planning restrictions occurs by 2020. • Repowering projects happens first and new projects with a lead time of 3-4 years means growth reaches a peak in mid 2020s. • Growth reduces again once the best sites are constructed.
Consumer Power	• No government subsidy support • Planning restrictions are relaxed from early 2020s. • Falling turbines costs makes subsidy free projects viable in the south west. Growth improves 3-4 years after planning is relaxed due to project lead times. • Higher level of lower capacity sites sized for industrial and commercial demand than Two Degrees. • Some repowering of smaller sites.
Slow Progression	• Relaxation of planning occurs later in 2020s. • Government price support introduced with a focus on the most cost-effective and larger sites in the licence area. • Largest sites may have the option to connect to the transmission network.
Steady State	• Continuing hiatus in development with little growth until late 2020s • As technology costs continue to fall a small amount of repowered turbines come online during the period.

8. Anaerobic digestion

With a large agricultural land area, the south west has good potential to grow anaerobic digestion (AD). However, new projects have struggled as lower subsidies, along with a more challenging sustainability and planning processes, have impacted deployment.

Renewed support from government in 2017 through the RHI and for 'green' gas in the Renewable Transport Fuel Obligation (RTFO) could help the industry resume growth.

Table 8-1: Summary of capacity growth in anaerobic digestion in WPD South West licence area.

South west AD capacity (MW)	2017	2020	2025	2032	Increase
Two Degrees	53.2	62.8	92.3	130.9	78
Consumer Power		60.5	84.0	121.6	68
Slow Progression		59.7	76.1	100.2	47
Steady State		57.7	67.0	82.5	29

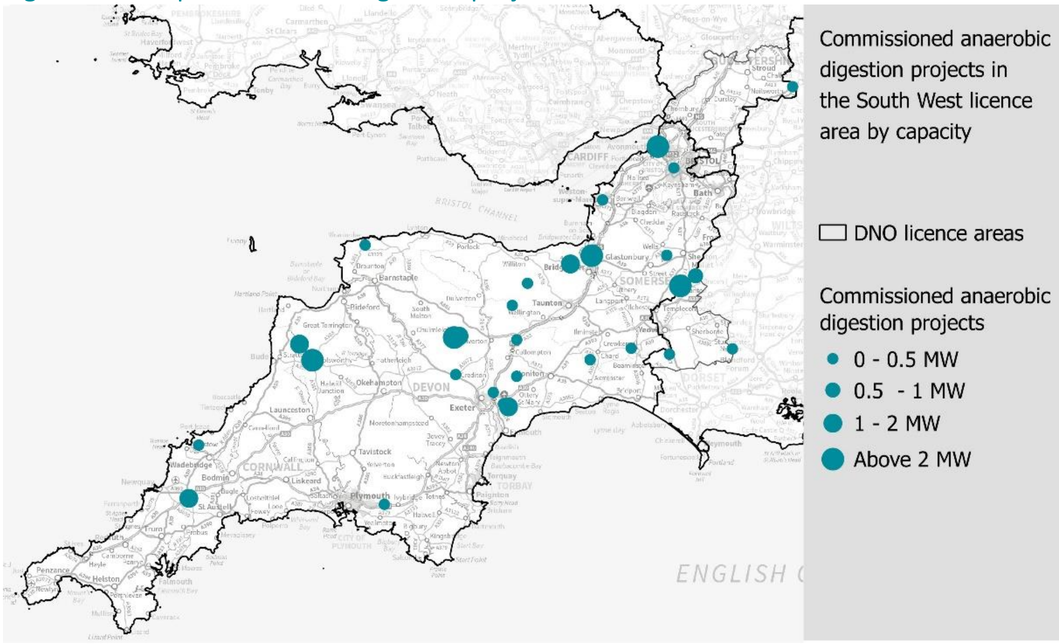
8.1. Baseline

There are 55 anaerobic digestion and biogas projects in the licence area. These plants produce 53.2 MW of electricity with an average size of around 1 MW. There are a small number of larger AD plants with the largest being a 4.9 MW project in Torridge and a 4.25 MW project in Bristol.

Current revenues for anaerobic digestion are not sufficient to fund new projects

The reduction in subsidies from the FIT means that AD capacity has not grown significantly in the last few years. The cost of planning has also started to increase as new plants come under more pressure on environmental issues, such as increased local traffic.

Figure 8-1: Map of anaerobic digestion projects in the WPD South West licence area.



AD has access to different revenue streams as the technology can produce a combination of gas or electricity. Other revenues can be accessed through processing food waste. There is potential for increasing income from exporting to grid when it is most profitable and electricity network balancing services.

These revenues are, however, currently either difficult to access or too small, and with electricity subsidies largely removed, new small-scale AD plants are difficult to finance. As a mature technology there are unlikely to be reductions in costs that would make AD currently viable without subsidy.[70]

8.2. Pipeline

There are no AD projects currently in WPD's accepted-but- not-yet-connected database.

However new RHI tariffs and income guarantees coming into force in 2018 are expected to provide a boost for the industry.[71] In September 2017 the DfT announced a doubling of the supplier obligation on renewable fuels to 9.75 per cent by 2020, along with increased RTFO rates.[72] They also declared that biomethane and AD are 'perfectly positioned' to meet the targets.[73]

Subsidies and incentives focused on heat and transport fuels may drive sector towards gas production.

To access these revenues, it is likely that new AD plants will skew towards biomethane injection to the gas network rather than biogas for electricity production. This means new plants may have less impact on the electricity network and as a result face fewer network constraints.

70 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/566718/Arup_Renewable_Generation_Cost_Report.pdf

71 http://adbioresources.org/news/press-release-anaerobic-digestion-industry-welcomes-laying-of-rhi-legislati

72 https://www.gov.uk/government/consultations/renewable-transport-fuel-obligation-proposed-changes-for-2017

73 http://adbioresources.org/news/press-release-biomethane-perfectly-positioned-to-meet-new-renewable-fuel-ta

8.3. Technology growth prospects

The south west has good potential for further growth of AD due to its large agricultural sector and land availability, key factors for the growth of the technology.

Continuation of government subsidy will be a key factor in the rate of growth of AD. As a relatively mature technology opportunity for cost reduction is low.

Availability of fuel sources will limit future size of market. Key legislation for growth will be requiring local authorities in England to collect food waste.

A key barrier for AD is feedstock availability. The government has introduced a requirement for at least 50 per cent of AD feedstock to be from waste (or residues) to receive RHI support, limiting the potential for using energy crops. Getting access to long-term high-quality waste streams is challenging.

Food waste collections are important for improving fuel supply and improving gate fees for AD. There is currently no requirement in England for local authorities to collect food waste separately. This could change in the medium term as the government has committed to working towards no food waste entering landfill by 2030, and to developing a new resources and waste strategy in the recent Clean Growth Strategy.[74] For example, Cornwall does not currently collect food waste but are considering separate food waste collection from 2020.[75]

74 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/651916/BEIS_The_Clean_Growth_online_12.10.17.pdf

75 https://www.cornwall.gov.uk/council-and-democracy/council-news-room/media-releases/news-from-2017/news-from-october-2017/cabinet-asked-to-consider-adding-food-waste-to-weekly-recycling-collections/

8.4. Scenario results

Figure 8-2: WPD south west scenarios growth of anaerobic digestion capacity.

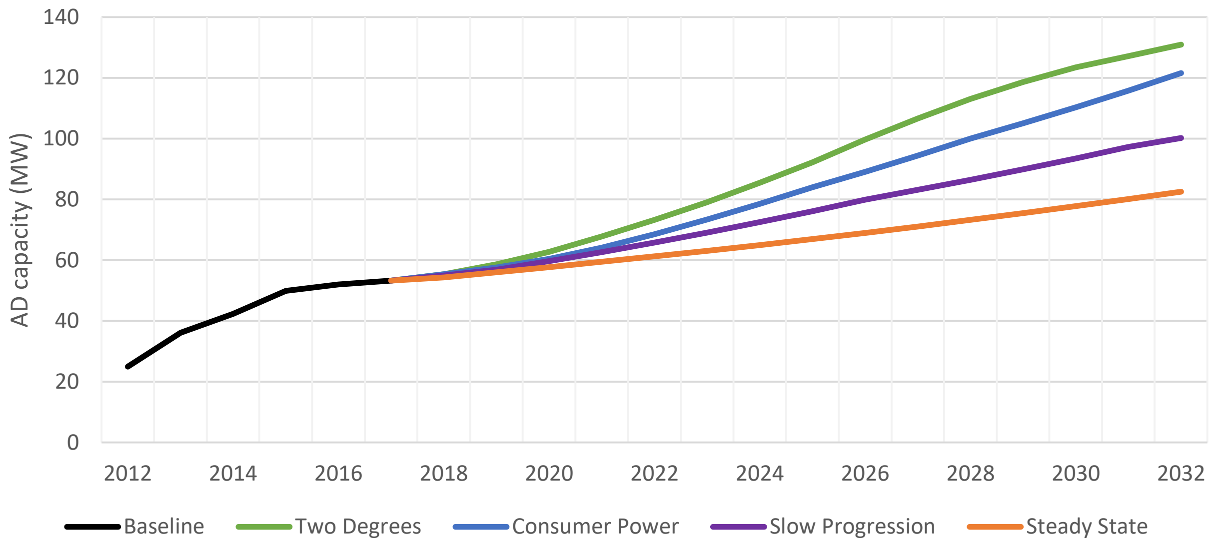


Table 8-2: Assumptions for factors influencing capacity growth in anaerobic digestion

Two Degrees	• AD deployment recovers quickly following the new RHI and RTFO • A new food waste separation requirement is introduced by the government in 2019. • Good economic growth means businesses and farms have ability to invest and growth is distributed mainly across smaller farm scale projects. • Feedstock limitations limit growth rates. • Growth reduces towards the end of the period as the sector size matches feed stock availability.
Consumer Power	• New RHI and RTFO rates slowly improve growth rates • No early change to food waste policy means there is less feedstock and therefore less growth than Two Degrees. • This scenario is still relatively high growth as businesses and farms take the opportunity to diversify to access new revenues.
Slow Progression	• RHI and RTFO only slightly improve growth as there is less money for small businesses to invest in new projects and diversification. • Food waste collection by all local authorities is required by mid-2020s which increases growth • Low economic growth holds back investment in new projects.
Steady State	• Food waste collection remains optional • Subsidy support reduces making new projects less viable. • Less economic growth means businesses and farms cannot invest in developing other revenue streams from AD except in a few cases processing on-site waste.

Relationship to FES 2017 and 2015 Scenario report

Since 2015 the south west has seen little growth in the AD sector. Growth expectations for the sector are, therefore reduced from the 2015 south west scenarios report.

In comparison to FES 2017, Two Degrees is the highest scenario as opposed to Consumer Power. This is because the AD sector needs significant policy support to grow. Slow Progression is lower than FES 2017 in terms of growth and Steady State grows at a similar level.

Distribution of technology across ESAs

New projects are distributed based partially on the availability of agricultural land class one, two and three within the ESA, as well as by the existing baseline. To reflect the potential for larger projects for food waste in urban areas, new capacity is also weighted towards semi-urban areas but excludes areas where large food waste plants already exist.

9. Energy from waste

Energy from waste (EfW) capacity is expected to continue to increase in the short term in all scenarios as landfill tax continues to divert waste streams. The South West licence area has a hub of EfW plants in Avonmouth where one of the projects processes food waste from London.

In the medium and long term, growth depends on Advanced Conversion Technology (ACT) plants which aim to produce synthetic gas from waste. However, despite significant investment, the technology remains largely unproven.

Table 9-1: Summary of capacity growth of EfW facilities in WPD South West licence area.

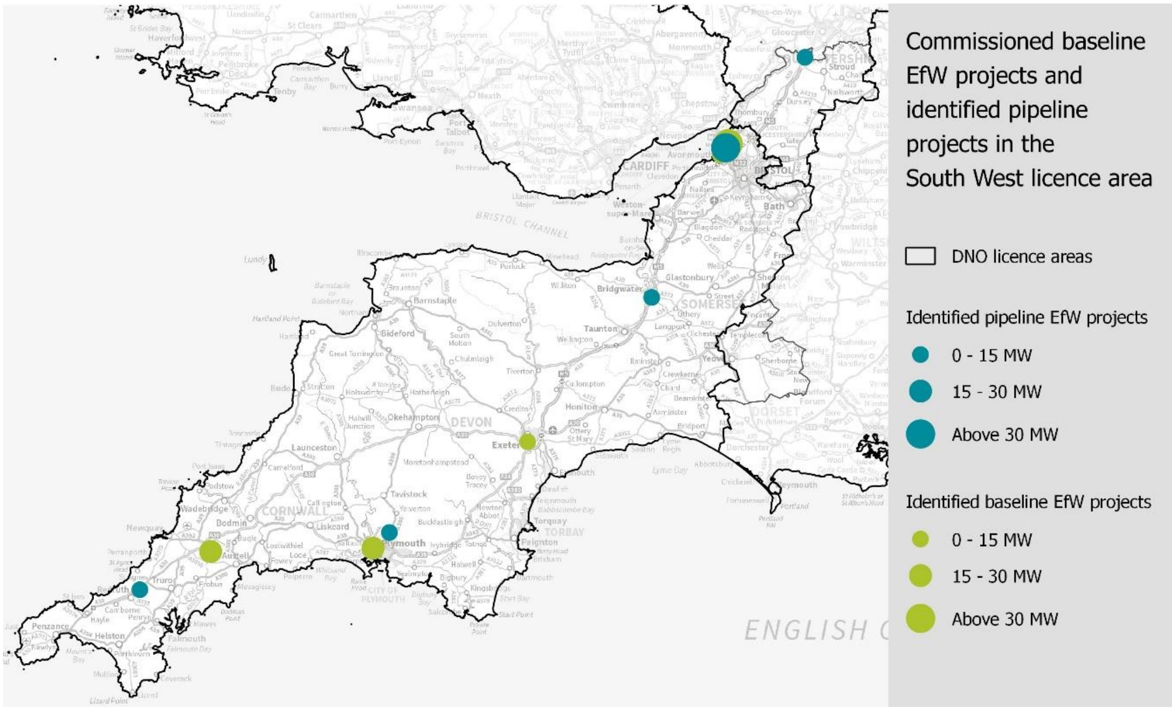
South west EfW capacity (MW)	2017	2020	2025	2032
Two Degrees	93.7	138.9	167.9	167.9
Consumer Power		145.4	205.0	217.5
Slow Progression		145.4	194.0	194.0
Steady State		138.9	175.5	185.5

9.1. Baseline

There are currently four mass burn EfW plants operating in the south west area totalling 77 MW of electrical capacity. There is a further 11 MW from an ACT site not currently operating. Three of the operating sites are large sites between 20 and 32 MW.

Though most EfW facilities deal with waste produced locally, Avonmouth's Severnside 32 MW site was completed in 2016 and imports waste from west London via rail.

Figure 9-1: Map of EfW projects baseline and pipeline in WPD South West licence area



9.2. Pipeline

The pipeline for this technology from WPD's accepted-not-yet-connected database is large and contains a further seven sites totalling around 84 MW.

Three of these projects, totalling 50 MW including a 34 MW site in Avonmouth, are proven technology mass burn EfW plants and are included in the pipeline. The increasing tax on landfill continues to drive growth in the short term of mass burn EfW for domestic residual waste.

A further 34 MW and more than half of the projects in the pipeline are Advanced Conversation Technology[76] (ACT) gasification or pyrolysis plants which, if proven, could provide a cleaner and more flexible way of dealing with residual waste.

Despite potential for the technology, new and existing ACT plants continue to have operational issues and a high failure rate. As a result, there is significant uncertainty about the future of the technology and the sector as a whole. The south west's only ACT plant, the 11 MW Avonmouth Biopower plant, was built in 2013 but is now reportedly not operating.[77]

An 8 MW ACT plant that has a CfD contract has started construction and is included in the pipeline. However, there is significant uncertainty about 30 MW of ACT projects who don't yet have CfD support and these are not assumed to go ahead but are considered as part of the scenarios.

[76] http://www.eti.co.uk/insights/targeting-new-and-cleaner-uses-for-wastes-and-biomass-using-gasification

[77] https://resource.co/article/troubled-gasification-plant-stay-closed-until-2018-11585

Table 9-2: EfW pipeline projects assumptions used in scenarios

Expected pipeline	Year commissioned	Size (MW)
EfW projects completing	2019	11.3
EfW projects completing	2020	34.0
ACT plant with CfD contract	2021	8.0
ACT projects in/with planning	Post 2021 by scenario	30.6

9.3. Technology growth prospects

The government provides no support for new mass burn EfW facilities and most can operate profitably from a combination of gate fees and energy generation. However, government is continuing to support ACT technology through Contracts for Difference. Six contracts were awarded to projects in Round 2 of CfDs in 2017 totalling 64 MW.[78]

EfW incineration growing slowly but the future of the sector depends on ACT. Concerns over the viability and desirability of the technology remain.

There is an active network of opposition to proposed EfW facilities, including ACT plants despite their lower local impacts. Opposition focuses on not reclaiming the valuable resources in residual waste as well as local pollution concerns.[79] Based on the UKWIN[80] interactive map of sites, around 50 per cent of proposed EfW and ACT sites have been effectively opposed.

The EfW sector is ultimately limited in growth by the availability of waste resource

The key variable for EfW is the future availability of the waste resource. Industry sources differ on when they believe EfW capacity will exceed supply as it will depend on variables such as the level of export or import of waste to the EU post Brexit, the setting and achievement of recycling targets and the availability of untapped resources such as commercial and industrial waste.

78 https://www.mrw.co.uk/latest/act-and-biomass-schemes-backed-in-cfd-auction/10023285.article
79 http://ukwin.org.uk/
80 UK Without Incineration Network

9.4. Scenario results

Figure 9-2: WPD south west scenarios growth of EfW capacity.

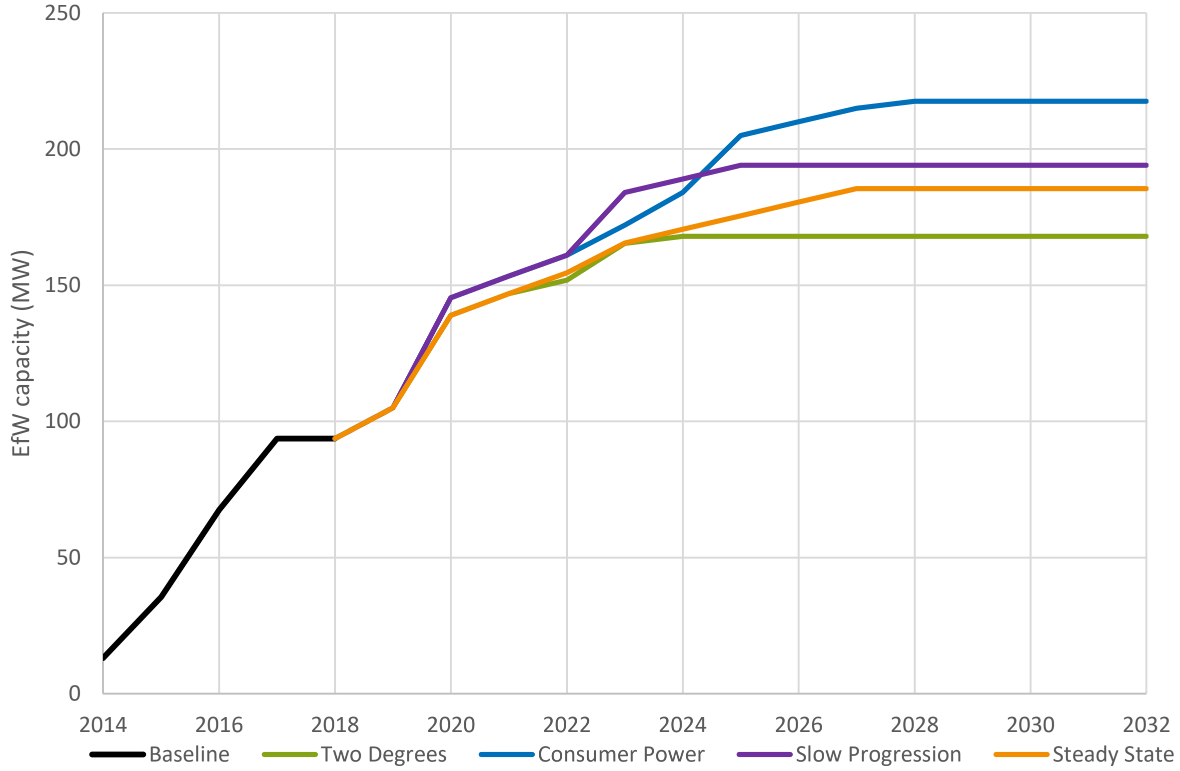


Table 9-3: Assumptions for factors influencing capacity growth in EfW

Two Degrees	• Environmental concerns mean no further mass burn EfW is developed past the current pipeline. • Waste resources are limited by stronger recycling policies and only a proportion of the proposed ACT projects go ahead. • As subsidies for green gas increase, post 2024 ACT plants produce gas for the grid and transport rather than electricity.
Consumer Power	• The highest scenario with residual waste continuing to increase the need for new projects. • All the pipeline is constructed, and further ACT plans and mass burn EfW are built to cover population gaps in the licence area. • Better revenue opportunities for green gas means that by 2030 any new plants are exporting gas rather than electricity.
Slow Progression	• The pipeline all goes ahead but further growth in incineration is limited by waste resources. • Two further population centres have EfW projects and some small ACT plants are developed towards mid-2020s. By late 2020's all new plants are ACT exporting gas as a result of higher support and revenues from green gas.
Steady State	• Only half of the uncertain ACT pipeline goes ahead reflecting the lack of investment in this new technology under this scenario. • Further mass burn EfW is built in the 2020's covering areas where there is no plant but significant population.

Relationship to FES 2017 and 2015 Scenario report

Based on proportion of population in the South West licence area, FES 2017 implies around 170 MW of EfW capacity in the south west by 2032, with significant increases in ACT technologies and lower growth in mass burn EfW. Our scenarios are broadly in-line with this figure.

These south west scenarios are slightly higher than our earlier 2015 scenario totals. This reflects the significant pipeline of projects in the area being assumed to go ahead and the importing of waste to Avonmouth from London means that the ceiling waste capacity for the south west calculated in 2015 no longer fully applies.

Distribution of technology across ESAs

The availability of the waste resource is considered the key factor in distributing projected growth outside the pipeline scenarios.

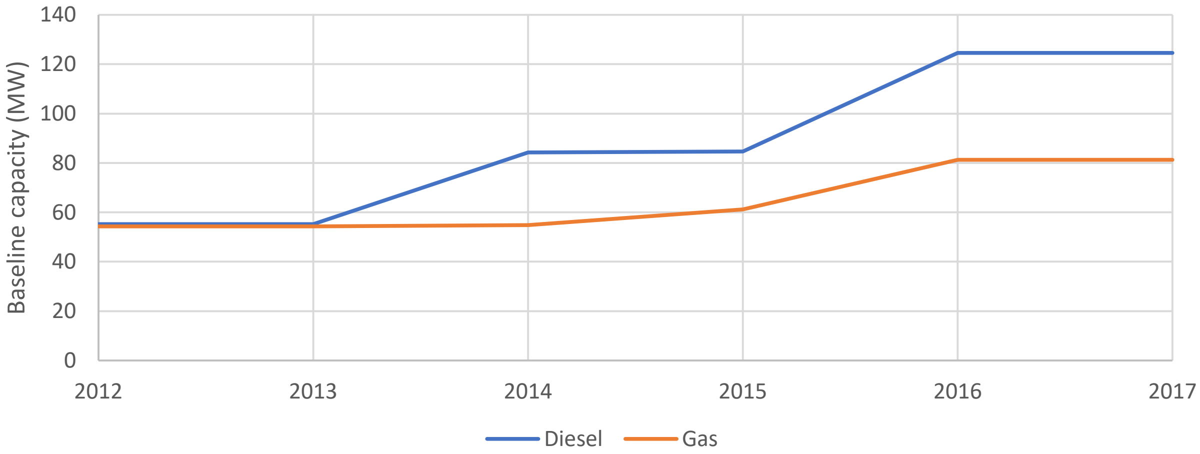
Once the pipeline is built out there are only a few population centres lacking an EfW plant in the south west. Depending on the scenario, the report identifies potential further 5 MW capacity in the Newton Abbot BSP that covers Exeter, Newton Abbot and parts of Torquay, Milehouse BSP which covers Plymouth, and Barnstaple BSP which would fill a gap of provision in north Devon.

10. Small fossil generation

There has been sharp growth in small scale fossil generation in the south west. Growth is expected to shift away from diesel and towards gas as legislation continues to curb the use of diesel for electricity generation.

Gas is expected to continue to grow as businesses continue to use generators to provide peak or backup power as well as provide services to the transmission and distribution networks.

Table 10-1: Baseline growth in small fossil generation in WPD South West licence area



10.1. Baseline

To identify the existing baseline capacities and potential pipelines for small scale fossil fuels, Regen followed the methodology established in the WPD West Midlands licence area report in 2017. Projects classified as 'other generation' in WPD connected, and accepted-not-yet-connected data were researched to identify what fuel they used. Projects have been identified through planning applications, online research and cross-referencing with CM registers.

The south west has 206 MW of small scale diesel and gas generation.[81] The distributed diesel capacity has more than doubled on the south west network since 2012 with gas experiencing slower growth.

There are five projects of between 10 MW and 30 MW, two gas and three diesel. The 42 smaller plants have an average size of around 3 MW. There are two additional gas plants over 50 MW in the distribution network in the south west at Marsh Barton and Filton. These large sites have a combined capacity of 122 MW and are not considered in this chapter.

[81] The 'other generation' category for connected generation sites totals around 330 MW. Of the 73 sites over 1 MW the fuel type of 62 sites were identified with reasonable confidence as fuelled by either diesel or gas.

Recent small fossil growth has been driven by lower cost of technology, peak avoidance and network support revenues.

Though gas reciprocating engines cost more to buy, they are cheaper to run and more efficient than diesel. A typical diesel generator may only run for a minimal number of days to secure Triad revenues and meet any CM or STOR obligations. A gas reciprocating engine may be expected to run more regularly during peak price and network cost periods (5-7pm during winter months) and to be on standby to target exceptional peak wholesale and Balancing Market price periods.

Recent growth has been driven partly by a big fall in the cost of diesel generators and gas reciprocating engines. The primary business case for both technologies has been businesses avoiding Triad periods and reducing their use of electricity at peak cost.

It is likely that at least some of the falling peak demand over the last decade is due to high energy users switching to on-site generation rather than an actual demand reduction. National Grid estimates that around 7.5 GW of embedded generation[82] currently runs at peak.

Government policy changes are reducing the business case particularly for small scale diesel.

The reduction of embedded benefits and red-band DUoS[83] payments received by generators running at peak times have already started to reduce the business case for new projects. Further changes as a result of the Targeted Charging Review and the Charging Futures process are likely to increase the fixed charges paid by network users and also remove or significantly amend the Triad methodology, further impacting revenues.

Table 10-2: South west gas and diesel projects in the CMs in 2018

	CM results for the South West licence area					
Auction	Delivery Year	Gas Projects Prequalified		Gas Projects - Winners		
		No. Projects	Capacity (MW)	No. Projects	Capacity (MW)	South west proportion of all gas winners (%)
T1 2017/18	2018/19	6	61	2	23	1.4
T4 2017/18	2021/22	9	177	8	140	2.4

	CM results for the South West licence area					
Auction	Delivery Year	Diesel Projects Prequalified		Diesel Projects - Winners		
		No. Projects	Capacity (MW)	No. Projects	Capacity (MW)	South west proportion of all diesel winners (%)
T1 2017/18	2018/19	4	25	0	0	0
T4 2017/18	2021/22	0	0	0	0	0

[82] https://www.auroraer.com/wp-content/uploads/2017/03/Ofgem-Embedded-Benefits-Reform-summary-and-Auroras-commentary.pdf
[83] Distribution Use of System Charges (DUOS)

A further source of income has been the ability to capture revenues via the CM or providing Short Term Operating Reserve (STOR) balancing services. However, CM revenues are reducing. In 2016 the T-4 capacity auction paid £22.50/kW/year for capacity provision. In 2017 the T-4 auction cleared at only £6/kW/year (T1) and £8.40/kW/year.

Table 10-2 sets out Capacity Market (CM) results for gas and diesel in the south west. There were no successful CM bids identified for diesel generators in the south west and consequently it can be concluded there is low appetite for diesel generators to bid into the CM following the air quality requirements.

The low rate of CM contracts for gas generation awarded to projects in the south west indicates the area is not a favoured location for developers. This may be due to the challenge of securing electricity grid connections. It also suggests that many gas generators with connection agreements have not secured CM agreements, whether bid in or not.

10.2. Pipeline

There are 19 projects that have been identified from 'other generation' that make up the pipeline for smaller scale diesel and gas. 56 per cent of the capacity could be identified with confidence as either diesel or gas. The rest has been classified as 'not identified'. Of these there are four relatively large projects of around 40 MW. Only one 10 MW project has been identified as diesel.

Table 10-3: Pipeline analysis of gas and diesel in WPDs South West licence area accepted-not-yet-connected database with CM outcomes.

Pipeline analysis (MW)	Diesel	Gas	Not identified	Total
Successful CM	-	52.7	-	52.7
Unsuccessful CM	-	22.0	20.0	42.0
No CM bid	9.5	143.8	159.8	313.1
Total	**9.5**	**218.5**	**179.8**	**407.8**

The pipeline has been distributed to each scenario following a methodology developed for the East Midlands scenarios produced in 2016. This is set out in Table 10-4.

Table 10-4: Methodology used for assigning pipeline projects that go ahead in which scenario.

	Successful bids in CM		No CM bid identified		Unsuccessful CM bid	
	Proportion (%)	Year	Proportion (%)	Year	Proportion (%)	Year
Two Degrees	100	2019/2020	10	2019/2020	0	
Consumer Power	100	2019/2020	50	2021	50	2023
Slow Progression	100	2019/2020	35	2019/2020	0	
Steady State	100	2019/2020	70	2023	70	2025

10.3. Technology growth prospects - diesel

Air pollution controls through the Medium Combustion Plant Directive likely to start reducing distributed diesel capacity and use.

A key factor in the scenarios for diesel is the tightening of emission controls. The government is committed to ambitious air pollution reduction targets.[84] Defra enacted the Medium Combustion Plant Directive[85] (MCPD) in 2017 by amending the Environmental Permitting (England and Wales) Regulations, to impose tighter permitting and emission controls on generation with a capacity of 1-50 MWth.

This directive requires new and existing diesel generators to secure a permit that ensures:

- A NO_X Emission Level Value (ELV) of 190mg/Nm^3 (the reduction other emissions such as Particulate Matter(PM) and Sulphur Dioxide will also be targeted through the MCPD)
- Secondary abatement required to meet the this ELV must be met within 5 minutes of the generator commencing operation
- There must be no persistent visible emission
- Where the generator relies on secondary abatement to meet the 190mg/Nm^3 NOx ELV, emissions must be monitored every 3 years

Defra subsequently announced in February 2018 that the emissions exemption for back-up generators will also not apply if the plant is used for Triad avoidance.[86]

The upshot is that the deployment of diesel generators targeting revenue from balancing services and Triad avoidance will fall off from 2018 onwards, potentially in favour of other technologies such as natural gas generators.

The deployment of diesel may still be a viable option for those industries looking to provide back-up or Uninterrupted Power Supply (UPS) services to their premises, though these will be of smaller capacity on an individual site basis.

10.4. Technology growth prospects – small gas

Larger scale gas generators have been significant contributors to the 2017 CM auctions. However, the role and volume of smaller, decentralised gas generation remains unclear in the long term.

The key factor in growth in small scale gas will be the size and attractiveness of the market for gas in providing flexibility or acting as peaking plant. This will be driven by the price of gas peaking plant relative to the competing technologies.

In greener scenarios this role will be played more by batteries and demand side response, but in less green scenarios more of the function will be provided by smaller scale gas plants.

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[84] See Defra National Air Quality Objectives (2017 update) - https://uk-air.defra.gov.uk/assets/documents/Air_Quality_Objectives_Update.pdf
[85] See Defra MCPD consultation website - https://consult.defra.gov.uk/airquality/medium-combustion-plant-and-controls-on-generators/
[86] See Energyst article - https://theenergyst.com/back-diesel-can-no-longer-TRIAD-avoidance-without-cleaning/

The evidence from the CM auctions is that the south west is not a favoured location for developers of gas peaking plant. The projects need access to both the gas and electricity network and this is likely to be a critical factor in their location.

10.5. Scenario results – diesel

Figure 10-1: WPD south west scenarios diesel growth/reduction in capacity.

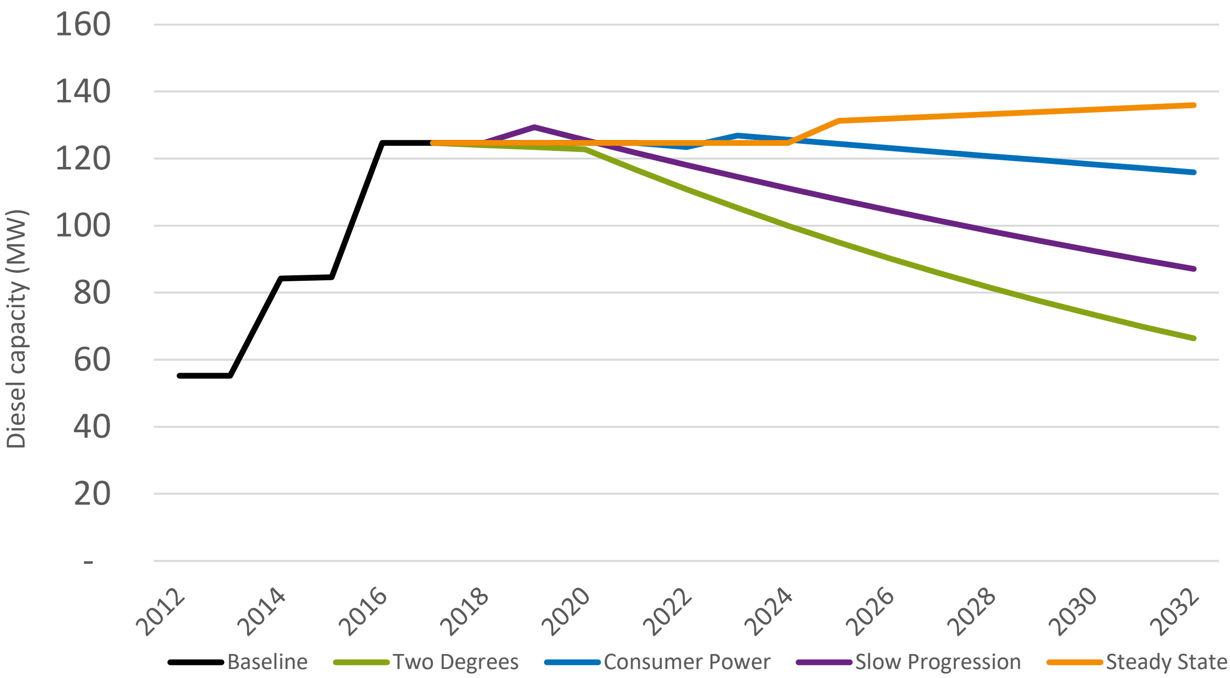


Table 10-5: Assumptions for factors influencing growth or reduction in diesel capacity

Two Degrees	• Diesel starts to decline slowly in the short term as a result of the new emissions legislation. • This decline accelerates as further emission constraints are added by government to remove air pollution impacts.
Consumer Power	• Short term increase in diesel use as pipeline of projects is built. • Capacity slowly declines as emissions controls increase costs and other technologies such as batteries prove more competitive for businesses to manage energy use.
Slow Progression	• Decline in diesel is slower than Two Degrees as policies on air quality are slower to be enacted.
Steady State	• Diesel growth slows reflecting recent emission controls but continues as flexibility market revenues continue to provide value for abated diesel.

10.6. Scenario results – small gas

Figure 10-2: WPD south west scenarios gas growth and reduction in capacity.

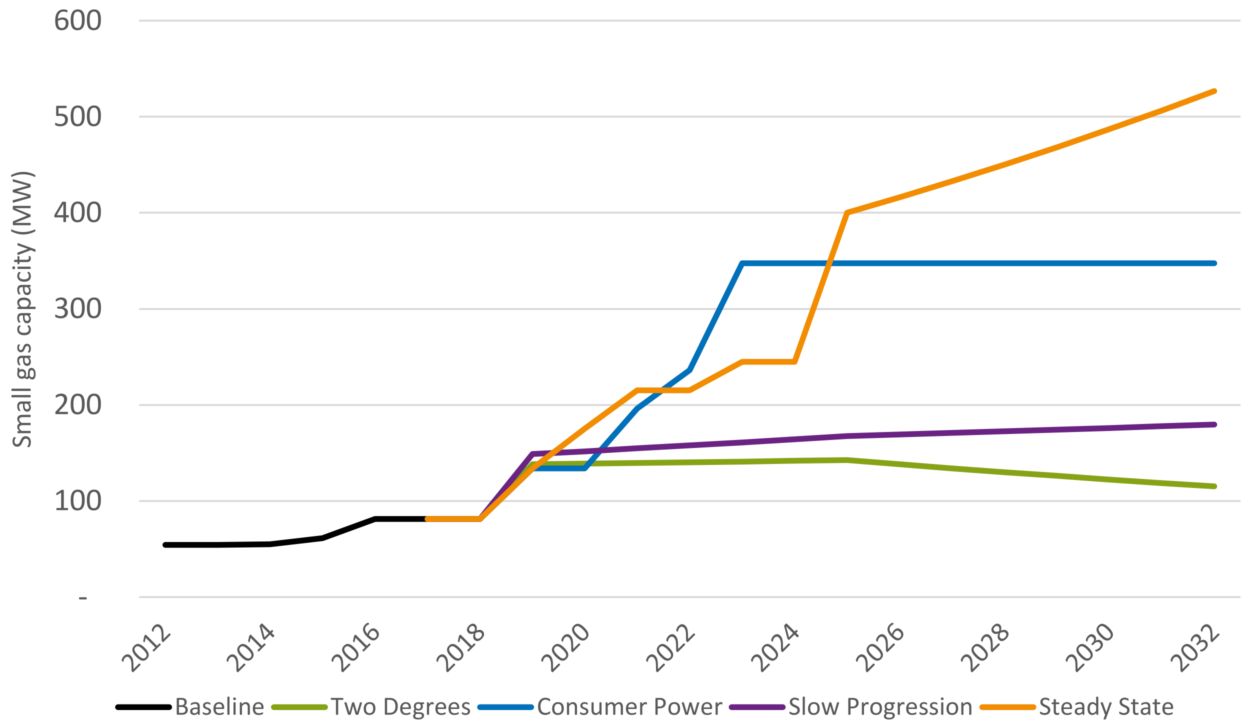


Table 10-6: Assumptions for factors influencing growth or reduction in gas capacity

Two Degrees	• Gas continues to grow in the short term as the market for flexibility increases. • More cost-effective flexibility is provided by demand side response and storage which means growth rates are slow. • Growth further declines post 2025 as policy favour lower-carbon technologies.
Consumer Power	• Gas continues to increase during the period but growth significantly reduces in mid-2020s where storage and renewable co-location, and new long-duration storage, are more competitive at providing flexibility services removing the business case.
Slow Progression	• Gas continues slow increase to the end of the period as it continues to capture some revenue from flexibility and grid services.
Steady State	• Growth continues in gas at an accelerating pace as gas prices remain low • Good revenue available in flexibility contracts as demand side response is not developed.

Relationship to FES 2017 and 2015 Scenario report

The FES 2017 increased expectations of distributed thermal capacity relative to the FES 2016, as build rates are faster than expected according to CM results. However, the announcement of charging review and emissions controls for diesel since the FES 2017 have considerably impacted the growth of these technologies at a small scale, particularly diesel as evidenced in recent CM auctions. The evidence of the CM is the south west is not a favoured location for gas peaking plant.

These scenarios have lower growth in small scale fossil fuels than projected in FES 2017 using the predictions at the 1 MW scale of gas and diesel reciprocating engines.[87]

Distribution of technology across ESAs

Factors that affect the distribution of gas and diesel engine sites include proximity to the gas and high voltage electricity network, as well as the availability of industrial, and brownfield sites. The number of market bids in each ESA is representative of the resource and network connection potential in that area and is therefore used as one of the factors effecting distribution for gas sites. For diesel engines the ability to export power is less likely to be important given emissions regulations and the number of commercial and industrial sites has been used as a distribution factor.

[87] (http://fes.nationalgrid.com/fes-document/ - Charts Workbook ES12)

11. Deep geothermal

Some areas of the south west have significant deep geothermal resource which has potential to provide electricity and heat, however the technology remains unproven and growth depends on the success of the first projects in development.

Two experimental projects currently with planning are hoping to prove the potential of the technology which could unlock financing and support for future projects.

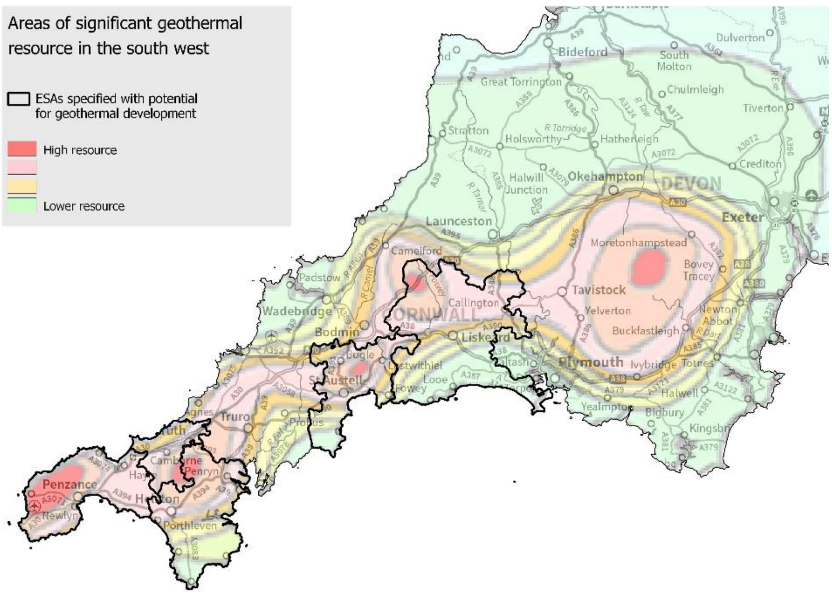
Table 11-1: Summary of scenario growth of geothermal capacity in WPD South West licence area.

Geothermal capacity (MW)	2020	2025	2032
Two Degrees	1	13	28
Consumer Power		7	7
Slow Progression		8	13
Steady State		1	1

11.1. Baseline

There are currently no geothermal projects in the licence area, although WPD's South West licence area contains some of the UK's best deep geothermal resource. Cornwall's geology has high heat flow in the granite bedrock. The ESAs with the highest heat flows and most viable for deep geothermal are Hayle, Rame, Camborne, St Austell, and St Germans.

Figure 11-1: Map of ESAs with geothermal resource in the WPD South West licence area.



Geothermal uses high temperature rocks (> 150 ^{o}C) 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. Geothermal projects can provide energy for up to 50 years.

The UK resource is at a depth of approximately four to five kilometres. The depth of drilling required for the projects is expensive and this means the resource remains unexploited in the UK.

Geothermal technologies can compete for a CfD as a 'Less established technology' at a level of £140/MWh. Geothermal is however competing against more established and cheaper technologies such as offshore wind. This means geothermal is at a significant disadvantage. No geothermal projects were allocated a CfD in round two announced in September 2017.

Government support available for deep geothermal in theory, but not in practice.

Therefore raising finance is a significant barrier for the projects as no government support is currently accessible and the early stage of the technology development means it remains too high cost and uncertain for private finance.

11.2. Pipeline

There are two projects currently with planning permission in the licence area.

Cornwall had a previous deep geothermal project in 1970s at Rosemanowes Quarry, situated in Rame BSP. The relatively shallow drilling failed to reach a sufficient temperature for electricity generation. As a result, the two new 'hot rocks' projects in the south west are seen as relatively high risk and have proven difficult to finance.

ESA with best resource	Projects in ESA
Truro BSP	United Downs
St Austell BSP	Eden Project
Rame BSP	Rosemanowes (ceased)
Camborne BSP	
Hayle BSP	
St Germans BSP	

The two projects include the 1 MWe United Downs (GEL) in Truro BSP. United Downs is an experimental project expected to be online by 2020. Since our report in 2015, the project has significantly reduced its projected size from 10 MW to a trial size 1 -3 MW. The project has also now received £10.6m of European regional development grant coupled with £2.4 of funding from Cornwall Council. A further £5m has been raised from private investors.

With the funding raised, preliminary drilling started in February 2018 and the first 1 MW is hoped to become operational by 2020. If successful it is planned to expand to meet its grid connection limit of 3MW.[88]

The second project is at the Eden project in St Austell BSP. This is a 3-4 MW site and has planning permission but remains on hold as it seeks to raise finance.

11.3. Technology growth prospects

The technology will rely on government support to help early projects get developed. Geothermal projects in the UK have been unable to raise sufficient private investment to cover high upfront costs without having a working example of the technology. Therefore, a key factor will be the success of the two pilot projects. The experimental United Downs project should also allow proof of concept and provide better understanding of technology cost that could unlock further potential.

[88] www.uniteddownsgeothermal.co.uk

11.4. Scenario results

Figure 11-2: WPD south west scenarios geothermal capacity growth.

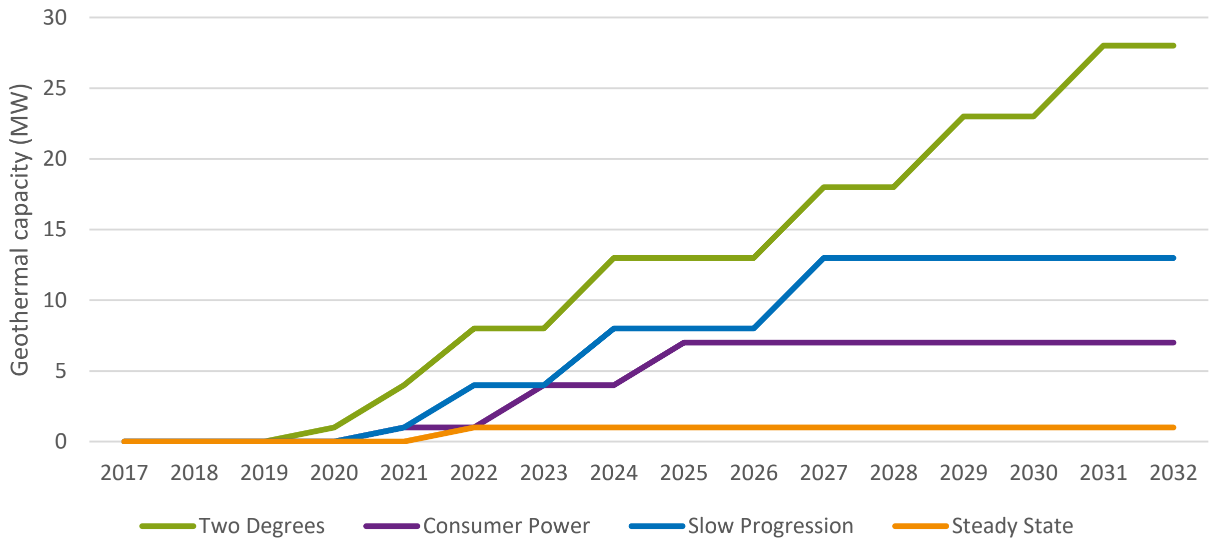


Table 11-2: Assumptions for factors influencing growth in deep geothermal capacity.

Two Degrees	• Both pilots are built to full capacity by 2022 • Pilot success leads to an expansion of deep geothermal in the UK. • Each ESA with good resource and network potential has a project of around 5 MW by 2032.
Consumer Power	• Both pilots are built but to lower capacities and later than Two Degrees. • No subsidy or financing options are available for new projects within the scenario period and there is no further growth.
Slow Progression	• The two pilots are built to full capacity but later than Two Degrees as financing is harder to achieve. • There is limited government support in 2020s and further expansion is constrained to one new site of 5 MW.
Steady State	• Only 1 MW is built in the pilot at United Downs • The pilot finds the technology is costly/inefficient and there is no further government support or private sector investment to develop further projects.

Relationship to FES 2017 and 2015 Scenario report

This scenario report has projected lower potential capacities for geothermal than in the 2015 south west scenarios report due to the pipeline projects being significantly smaller than in 2015. The United Downs project has reduced from 10 MW to 3 MW and the Eden project size is now around half of the earlier prediction.

Distribution of technology across ESAs

The projects have been identified using geothermal resource by ESA and grid connection potential. Areas around Dartmoor with high resource have been excluded due to the difficulty of connecting to the electricity network.

12. Hydropower

Hydropower has been impacted particularly by the reduction in the FIT and there have been no new projects in the south west in the last two years.

As a high upfront cost technology, the level of subsidy remains key for the growth of the small scale sector with few projects currently feasible under the existing FIT levels.

Table 12-1: Summary of growth of hydropower capacity in WPD South West licence area.

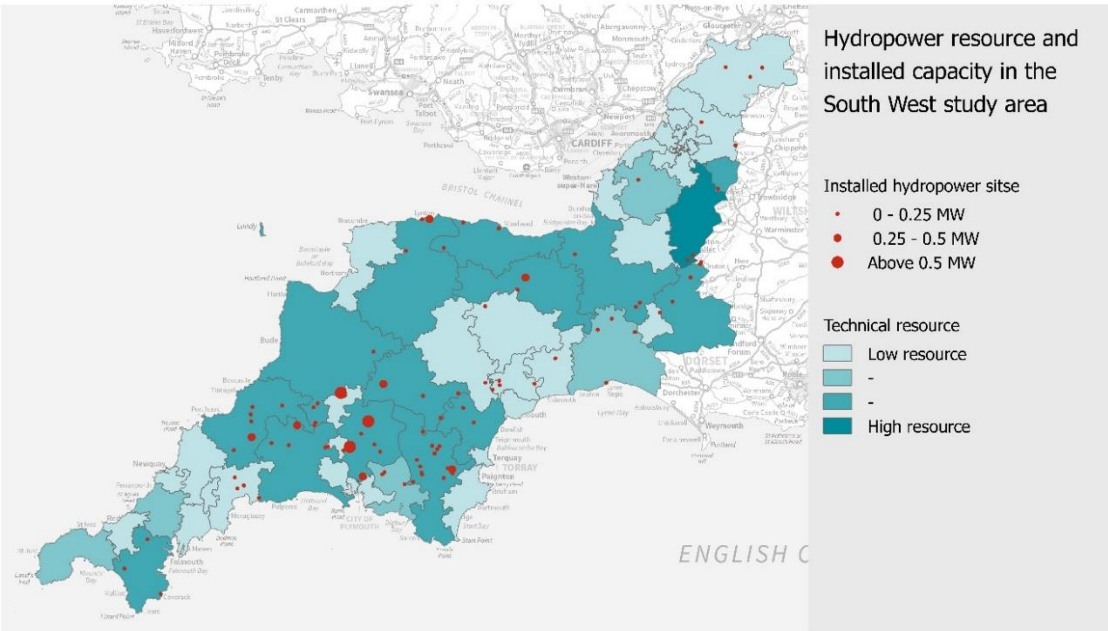
Hydropower capacity (MW)	2017	2020	2025	2032
Two Degrees	14.87	15.13	17.54	20.44
Consumer Power		14.87	17.01	19.61
Slow Progression		14.87	15.40	17.25
Steady State		14.87	15.00	15.93

12.1. Baseline

There is nearly 15.5 MW of hydro capacity in the south west from 147 projects. The largest project in the licence area is the Mary Tavy hydropower scheme. The 2.6 MW scheme was developed in the 1930s and is owned by South West Water. Excluding Mary Tavy, the average size of a hydropower project in the licence area is 100 kW.

The sector has grown slowly by around 100 to 300 kW per year to 2016. The exception was the 3.7 MW of capacity added through several larger scale projects before the FIT was reduced in 2015.

Figure 12-1: Map of hydropower projects and ESAs with resource in WPD South West licence area



12.2. Pipeline

There are no hydro projects currently in WPDs accepted-but-not-yet connected database.

The closure of the RO and significant cuts to the FIT, most recently in February 2016, mean that the remaining government subsidy for hydro is not sufficient to make most schemes financially viable. Remaining sites with potential tend to be where low cost capital is available, for example where provided by a community or landowner keen to develop a site.

Developers are focusing on higher head sites which have the most generation and therefore economic potential, particularly in North Wales and Scotland; sites with onsite electricity usage or private wire potential; and the refurbishment or improvement of existing sites.

12.3. Technology growth prospects

Hydropower is a predictable and reliable renewable energy resource. However, it is relatively expensive to deploy, limiting its growth potential. Each project requires detailed technical feasibility studies and permitting, as well as being subject to high upfront capital costs. Civil engineering costs make up a large proportion of installation costs.

Hydro technology installation costs remain high and much lower subsidies means few projects are economically viable.

The technology is relatively mature, with limited market scale, and so unlikely to see the type of cost reductions that other renewable technologies are expected to achieve.

In England there are a limited number of viable hydro sites. Those with optimal conditions and larger sites tend to have already been developed. Although there are potentially numerous feasible smaller sites, these tend to have relatively higher costs.[89]

Growth will depend on improving the level of government subsidy as well as support from local communities. Small-scale hydropower traditionally has high public approval and is appealing to community energy groups and landowners who are attracted to generating energy from this very visible resource in their area.

Hydropower tends to have local support, but environmental protection requirements are increasing.

However, environmental requirements are increasing and will increase the cost of installing even the smallest scale hydro projects. Eel regulations were introduced in 2009 and can cause major difficulties for some low head schemes. In March 2016, the UK government proposed new legislation requiring the removal of river obstructions or the building of fish passes to provide a route around or through these hurdles.[90]

[89] http://www.renewablesfirst.co.uk/hydropower/hydropower-learning-centre/how-much-do-hydropower-systems-cost-to-build/
[90] http://www.renewablesfirst.co.uk/hydropower/hydropower-consenting/hydropower-environmental-consenting/

12.4. Scenario results

Figure 12-2: WPD south west scenarios hydropower capacity.

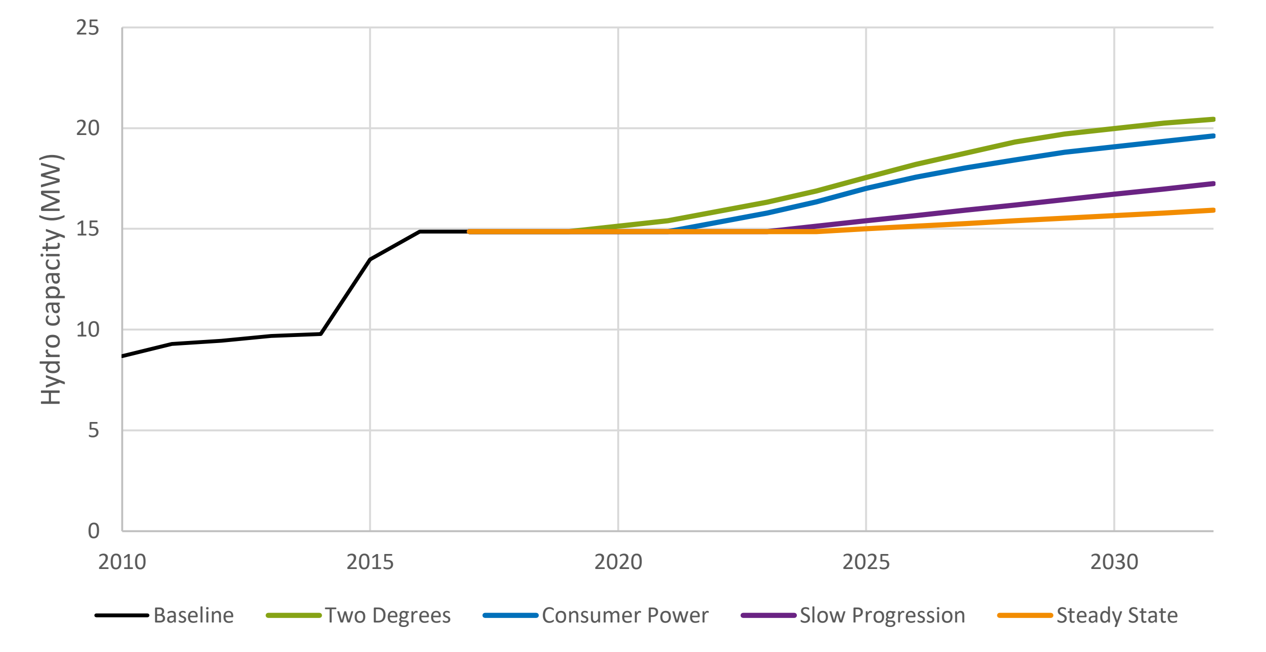


Table 12-2: Deployments assumptions for factors influencing growth in hydropower capacity.

Two Degrees	• Higher subsidies are reintroduced leading to growth of around 500kW a year during 2020s. • As the best sites are built out growth declines towards the end of the period.
Consumer Power	• A strong economy and higher electricity prices means that landowners and communities can raise finance for small scale hydro schemes • A low level of government subsidy remains for the sector. • Growth starts again slowly around 2021.
Slow Progression	• Without subsidy there is no growth in the sector until mid-2020s • From mid-2020s improved subsidies are introduced to encourage growth in non-variable small-scale generation. • Growth remains low with one medium project a year built as finance is difficult to raise.
Steady State	• No further subsidies are available post the FIT. • The sector grows at a rate similar to its low historic rate.

Relationship to FES 2017 and 2015 Scenario report

These scenarios are higher than the FES 2017 for all except the Steady State. This reflects the south west's relative affluence and potential for small scale hydro resource.

The scenarios are consistent with the 2015 south west scenarios report although Steady State has increased to reflect the increase in baseline during that year.

Distribution of technology across ESAs

Data compiled by the Environment Agency details barriers to water flow in rivers and other waterbodies, which allows for the technical unconstrained resource in each area to be assessed. The projections have been forecast both on this technical power potential, and the existing baseline of hydropower sites.

13. Marine and offshore

Offshore and marine energy is a strategic priority for the south west, with high potential capacity in tidal, wave and offshore wind. The south west is also home to Wave Hub, a fully consented and grid connected test site.

However, the lack of supportive government policies for the less developed marine sectors such as wave and tidal means growth is unlikely to start in the near term.

Table 13-1: WPD south west scenarios marine and offshore capacity growth.

Marine capacity (MW)	2025	2032
Two Degrees	10	110
Consumer Power	-	50
Slow Progression	-	75
Steady State	-	28

13.1. Baseline

Government support focused on offshore wind with other marine sectors unable to compete in the current system.

Though having significant potential marine resource, the south west currently has no marine technologies generating. Previous plans for large offshore wind projects such as the Atlantic Array windfarm have been withdrawn.

The UK currently has a leadership position in the sector and the opportunity to export technology and capability to the global market.

Government support is heavily weighted to offshore wind following the success of the technology in reducing costs. Support in the form of CfDs has helped move the sector to the point of cost competitive large scale deployment.

The less developed marine technologies such as tidal stream and wave energy have not been able to replicate this success, without proven remaining high cost and unable to compete for government support.

13.2. Pipeline

There are no marine projects currently in WPDs accepted but not yet connected database. Given the timescales for project development there are no projections for large scale offshore wind or tidal projects in the south west before the end of this analysis in 2032. Large scale projects would potentially connect to the transmission network.

13.3. Technology growth prospects

The key growth factor for scenarios is access to public finance and supportive policies to bring the less developed marine technologies to commercialisation. In order to develop successfully the marine technologies need to achieve the following stages.

1. Technology development – proving the reliability and performance of new technology
2. Success of a series of pilot and demonstration projects
3. Access to resources including the planning and consenting process
4. Access to finance – which will initially require collaboration between public and private sector investment
5. Policy and political support for the sector – both regionally and UK

Floating wind is expected to be the next technology to commercialise successfully. Wave and tidal remain in technology development phases for the medium-term.

Tidal stream and wave energy technologies are still in stage one, a period of technology development and demonstration. There have been projects at demonstration sites such as Wave Hub, and FaBTest though these deployments are currently trials and small scale pilot projects.

Of the less developed marine sectors, floating wind is the next technology likely to achieve competitiveness following several successful demonstration projects deployed in 2017 outside of the region.

13.4. Scenario results

Figure 13-1: WPD south west scenarios marine and offshore capacity growth.

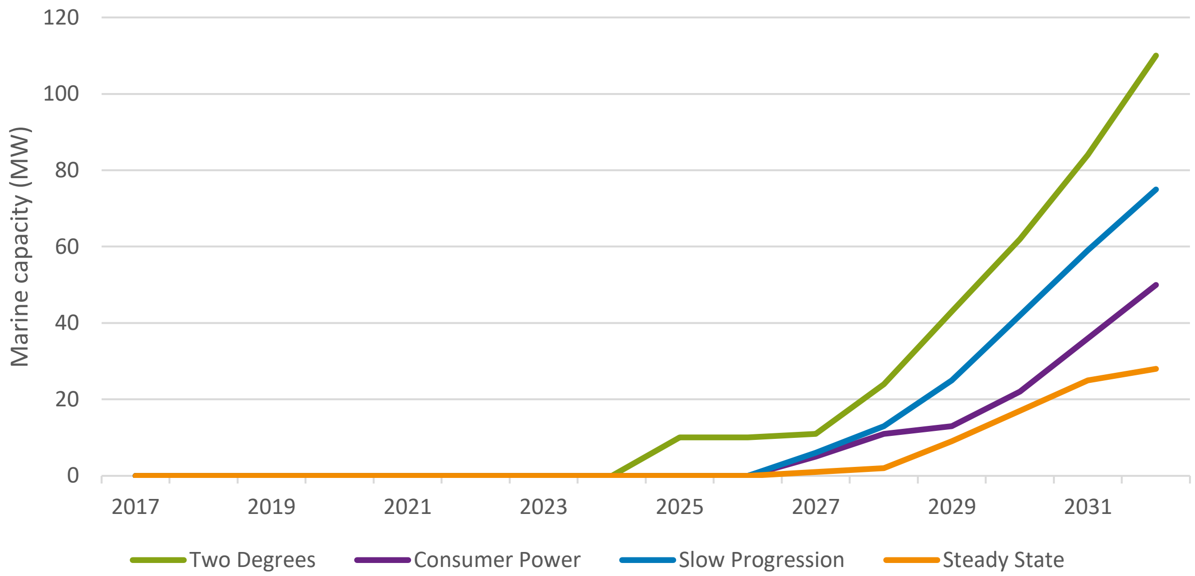


Table 13-2: Assumptions for factors influencing growth in marine and offshore technology capacity

Two Degrees	• Government subsidy and development support for the less developed marine sector is improved in early 2020s. • Floating wind technology pilots prove successful and early commercial projects are deployed in the licence area starting from mid-2020s. • Small scale tidal and wave projects at a commercial scale start to be deployed towards the end of the scenario period.
Consumer Power	• Little government support available leads to slow technology deployment • Small-scale projects installed towards 2032, mainly floating wind.
Slow Progression	• Government support improved but later than Two Degrees • Support focused on most developed/least cost technology and wave and tidal remain largely unsupported by government. Capacity in these remains mainly demonstration projects. • Deployment of the first commercial floating wind projects in the licence area will be further towards the end of the period.
Steady State	• No government support leads to lowest growth scenario. • Global investment in floating wind means a few floating turbines are projected to come online towards the end of the period. • Both wave and tidal remain small scale pilot and demonstration projects only.

Relationship to FES 2017 and 2015 Scenario report

The growth predictions for the marine energy sector, particularly for the highest growth scenarios have been reduced significantly since the 2015 south west scenarios. The absence of any meaningful government support or access to finance mean that tidal and wave sectors have not developed as expected.

Distribution of technology across ESAs

Projects have been distributed by ESAs located closest to the best offshore resource sites as well as expected project development areas.

14. Other generation

14.1. Baseline

The other generation category covers large gas generation and those projects on WPD's connection register that have not been identified as a particular energy source. This will include CHP and landfill gas.

There is 285 MW of distributed generation capacity in WPD's connected data base in the South West licence area. Of that generation, there are two large gas generation plants at Rolls Royce plants in Filton and Marsh Barton making up 125 MW of the total.

Several sites in this category have export capacities below their installed capacity and overall export is around 10 per cent lower than installed. This is likely to be because a proportion of the generation is used for behind the meter operations.

14.2. Pipeline

There are a further 29 'other generation' projects in WPD's accepted-not-yet-connected database. These have a total generation capacity of 253 MW. The majority of this is from nine projects between 10 – 50 MW which are likely to be medium-sized gas plants. The largest is a 49 MW plant connecting to Willand STOR ESA 132kV.

III. Introduction to storage

The UK energy system is undergoing significant change, large coal generation is closing being replaced by distributed and more variable forms of low carbon generation. Storage, particularly battery storage of electricity, is seen as one of the key enablers for the future energy system, providing much needed flexibility for both the national electricity system[91] and for local/regional network management.[92] There has been a significant amount of industry and government interest in the potential of the technology.

Government policy

BEIS and Ofgem's publication of the Smart Systems and Flexibility Plan identifies a programme of actions to support the development of energy storage. Changes included defining storage as a subset of generation to remove 'double network charging'[93] and guidance on co-locating energy storage with FIT or RO accredited generation.

However, though the long-term need for flexibility remains, other current policy changes have been less positive. The loss of embedded benefits[94], flattening of peak distribution network charges and the derating of storage in the CM are dampening the market for battery storage in the short-term. A summary of key policy changes is summarised in Table III-1.

Table III-1 - Policy and regulatory developments around energy storage

Policy and regulatory development	Timeframe	Impact on Energy Storage
'Minded to decision' of removal of embedded benefits/Triad credits for embedded generators	March 2017	**Negative** – the removal of Triad 'credits' to distributed generation removes a significant incentive. Storage could have enabled intermittent generation to focus the supply of their energy to the network during Triad times, thus securing firm financial benefit.
Removal of 'double charging' for storage, treating storage, for the purposes of network charges, as purely generation asset class	March 2017	**Positive** – treating energy as a generation asset only for network means storage assets won't be charged to both 'fill' and 'empty'. However, the charges proposed to be removed are during times when storage is much more likely to be discharging, so the benefit is limited.
Ofgem Targeted Charging Review and Charging Futures Forum	May / Aug 2017	**Positive** – a holistic charging review is a positive outlook for the industry, with the potential to introduce a more up to date charging arrangement, that reflects the nature of a distributed generation dominated network.

[91] See National Grid's *Product Roadmap for Frequency Response and Reserve* (Dec 2017)
[92] See ENA Open Networks 2017 Achievements and Future Direction document (Dec 2017)
[93] See Ofgem *Targeted Charging Review: Consultation* and *Significant Code Review Launch Statement* (2017)
[94] See Ofgem *Embedded Benefits: Impact Assessment and Decision on industry proposals* (Jun 2017)

Launch of smart systems and flexibility plan	July 2017	**Positive** – strong messages from government and the regulator that flexibility is a key component of the UK energy system – storage specifically mentioned as a key enabling technology
Consultation around the de-rating of storage within the CM	July 2017	**Negative** – the de-rating of storage in the CM, on the basis of storage being only able to supply its capacity for a short period of time, will impact significantly on business cases. Whilst some projects are still bidding in and winning contracts, the timing of the proposal after the auction guidelines were published is of particular concern to investors and may limit future participation.
Reduction of distribution use of system (DUoS) 'Red Band' charges	April 2018	**Negative** – the flattening of the evening peak delivery charge for large energy users is a blow to business cases for behind the meter storage projects. The Targeted Charging Review could mean that delivery charges are set to change even further.
Ofgem decision around RO accreditation for three 5 MW solar PV farms retrofitting co-located storage	September 2017	**Positive** – permitting ROCs to be claimed for generation that has been diverted into storage is a gateway decision that will drive RO accredited generators to consider installing co-located storage more readily
HMRC confirm 5 per cent VAT for solar and storage installed together	September 2017	**Positive** – a small financial benefit, but one that was welcomed by the solar industry and storage sector.

The first wave

The first wave of electricity storage projects in the UK, focussed predominantly on frequency response contracts, are now beginning to connect and come online.[95] In addition to this storage projects are actively bidding into the CM[96], despite the reduction in expected revenues following the de-rating that has now coming into effect.[97]

These markets are highly competitive and with the rationalisation of the frequency response services[98], it is likely that National Grid's procurement of rapid-response flexible capacity may reach saturation.[99] As a

[95] E.On's 10MW Blackburn Meadows EFR battery was completed in September 2017
[96] See EMR Delivery Body provisional results for T-1 auction for 2018/19
[97] See BEIS Capacity Market Consultation – *Improving The Framework* Government Response
[98] See National Grid *Product Roadmap for Frequency Response & Reserve* document (Dec 2017)
[99] Claire Spedding (Head of Business Development at National Grid) discussion at Regen Energy Storage: The Next Wave launch event, Nov 2017

result developers to need to look at alternative revenue streams, to drive the business case for the 'next wave' of storage projects.

In Regen's publication Energy Storage: The Next Wave, a key conclusion was that price arbitrage could become one of the key revenue streams for storage, especially with access to more volatile and potentially profitable electricity price markets such as the Balancing Mechanism.

Ofgem are in the process of clarifying the regulatory framework for storage[100], which could unlock some of the regulatory barriers preventing storage from securing these higher value markets.[101] Another key conclusion was the potential benefits of the co-location (and direct connection) of storage with standalone generation and high energy users behind-the-meter.

The timescales of development of the storage market is summarised in Figure III-1.

Wave 1 - Led by response services (Now-2020)

- Focus on grid and network services (including frequency response & DSR)
- First applications for C&I 'behind the meter' models and co-location
- Domestic and community scale early adopters.

Wave 2 - Co-location business models become viable (Early 2020's)

- Market for C&I high energy users/generators grows rapidly
- Co-location projects with solar PV and wind become viable
- The domestic and community storage market expands.

Wave 3 – Market expansion and new business models (Mid/Late 2020's)

- Price arbitrage and new trading platforms develop
- Storage enables local supply markets, private wire and virtual markets
- Domestic electricity storage becomes common
- Most new solar and wind farms now include electricity storage to harness low marginal cost energy and price arbitrage
- Heat storage and electricity storage are increasingly integrated.

Figure III-1 - Waves of development of the storage market

The Regen future growth scenarios for electricity storage have been developed using what is currently considered to be the most likely future or emerging business models, see Figure III-2.

[100] See Ofgem *Clarifying the regulatory framework for electricity storage: Licensing* publication (Oct 2017)
[101] Non-intermittent generation is able to secure higher value generation Duos credit payments

Figure III-2 - Regen energy storage business models

1. Response service - Providing higher value ancillary services to transmission and distribution network operators, including frequency response.

2. Reserve service - Specifically aiming to provide short/medium term reserve capacity for network balancing services.

3. Commercial and industrial - Located with a higher energy user (with or without on-site generation) to avoid peak energy costs and peak transmission and distribution network charges, while providing energy continuity

4. Domestic and community - Domestic, community or small commercial scale storage designed to maximise own use of generated electricity and avoid peak electricity costs

5. Generation co-location - Storage co-located with variable energy generation in order to a) price/time shift or b) peak shave to avoid network curtailment or reinforcement costs

6. Energy trader - The business model that references the potential for energy supply companies, local supply markets and/or generators using storage as a means of arbitrage between low and high price periods - likely aggregated - and peak shaving.

An energy storage growth and operation model was developed alongside WPD's 2017 energy storage industry consultation. Within this model a set of technical parameters were defined for storage projects, including the relative ratio of power (MW) to energy (MWh), for each of the business models above.

15. Battery storage

There is one 15.4 MW battery project currently in the south west and a further pipeline of 216 MW.

Over the medium and long-term batteries are expected to grow significantly on the distribution network as technology costs reduce and they are able to capture value such as flexibility services to network operators.

A further source of income is arbitrage between high and low electricity cost periods along with the co-location with renewables to maximise income.

Table 15-1: WPD south west scenarios battery storage capacity growth.

Storage capacity in 2032 (MW)	Two Degrees	Consumer Power	Slow Progression	Steady State
Response services	114	152	97	51
Reserve Services	79	89	67	50
High energy user	152	190	80	65
Domestic/community	180	180	80	50
Co-location	150	150	80	45
Energy Trader	100	100	85	43
Total	**775**	**861**	**489**	**303**

15.1. Baseline

There is currently only one MW scale storage project in the WPD register of connected projects within the licence area. This battery is providing frequency response services to National Grid.[102]

Site Name	Location	Export Capacity (kVA)	Network Connection
Lockleaze Battery Storage	**Bristol**	**15,789**	**33 kV**

Pumped hydro is another technology that can provide storage for the network but there are no pumped hydro projects currently connected or in the connection enquiries database in the south west area.

For the South West licence area, some key considerations for storage deployment include:

- Relatively low activity in the CM across all technologies with storage in the licence area traditionally making up around 2 per cent of the total market
- Distribution network is heavily constrained in the south west at present, driving both the need for flexibility and export constraint bypassing (as an operation of co-location), but also potentially acting as a barrier to large scale deployment of storage in the licence area
- Access to grid connection points also less available than other areas of the network such as the midlands where the spine of the electricity network is located.
- Industrial demand is also proportionally lower in the region than the rest of the UK, driving fewer opportunities for large scale storage co-located with high energy users

[102] http://hazelcapital.com/hazel-capital-commissions-the-lockleaze-15mw-battery-storage-project-in-bristol/

15.2. Pipeline

WPD data shows there to be 18 storage projects, totalling 216 MW with accepted connection offers in the south west.

Research shows that most of the pipeline (around 137 MW) was hoping to receive government contracts for CM or frequency response. However, only a limited amount of storage projects will in reality achieve these contracts in the short-term. Therefore, the pipeline has been staggered for a longer time period that other technologies reflecting that the flexibility market size is expected to grow during 2020s.

The pipeline projects have been allocated to storage business cases on the basis of Regen research. Those looking to provide government flexibility services have been allocated half capacity to response and half to reserve services. Storage projects are likely to try and provide both simultaneously.

The majority of the pipeline is projected to go ahead at full capacity in the higher growth scenarios with capacities being lowered for larger projects in Steady State and Slow Progression. In all scenarios the commissioning dates have been spread out into the 2020s.

15.3. Technology growth prospects

Network capacity

The overwhelming majority of existing storage sites are distribution network connected[103] and concentrated in an arc running from the south east, through the midlands to the north of England, following the main industrial centres of Great Britain and the main spine of the electricity network.[104]

Access to a good distribution network connection is key for siting storage projects, along with proximity to demand and/or

In the future it is expected that the key factors for the location of storage projects will continue to be access to a grid connection point but increasingly also about proximity to energy demand (to off-set high energy usage) along with co-location with existing generation plant (specifically PV).

With the network constrained in the south west, storage sites may struggle to find good network connections, but with the large amount of PV and onshore wind in the licence area is likely to drive growth with proportionally more co-location opportunities than other parts of the UK.

Future revenue streams

Though the long-term need for flexibility is undisputed the existing business case for battery storage is challenging (see Table III-1). Flexibility markets and system needs are current key revenues for storage however these revenues are uncertain and falling.

[103] Echoed by response to WPD storage consultation, where respondents stated 96 per cent of storage capacity would be connected on the distribution network

[104] Regen analysis of the geographic distribution of the EFR and Capacity Market

Policy and regulatory landscape for storage is mixed but long-term need for system flexibility remains

The loss of embedded benefits[105], flattening of peak distribution network charges the derating of storage in the CM along with the saturation in the flexibility markets are expected to significantly dampen the market in the short-term.

In addition to this, none of the winners of the 2016 EFR tender or the 2016 CM auctions (T4 and Transitional Arrangement) were located in the south west area. Spatial analysis of National Grid's FFR programme is unable to be undertaken, due to the month-on-month nature of FFR procurement and the lack of individual project information within National Grid's FFR market information.

Analysis of recent CM auctions shows there to be relatively few distribution network connected south west storage projects winning CM contracts, a summary of results of recent auctions is given in Table 15-2.

Table 15-2: Storage projects in the south west qualifying for CM contracts

Auction	Delivery Year	Storage Projects Prequalified		Storage Projects - Winners		
		No. Projects	Capacity (MW)	No. Projects	Capacity (MW)	SW Proportion of All Storage Winners (%)
T1 2017/18	2018/19	6	27	2	2.5	2.4
T4 2017/18	2021/22	10	67	3	18	12

Technology cost reductions

The anticipated continued fall in battery storage costs will be a key future growth driver. There have been several reports produced by market analysts[106] [107] pointing to a step change in cost reduction in battery costs through innovation, supply chain efficiency, new competition and investment in large scale manufacturing facilities.

Anecdotal evidence from the recent CM auctions, including record low auction clearing prices[108], suggests that commercial prices are already below previous market benchmarks

Several reports and analysts have projected that battery costs could fall from circa $400-500 per kWh today to under $150 per kWh in the early 2020s. The majority of storage investment and deployment in the short term is expected to focus on solid state batteries such as lithium-ion.[109] In the longer term, electricity storage technology may see some diversification, with flow batteries, compressed air and flywheels seeing increased interest.

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105 See Ofgem *Embedded Benefits: Impact Assessment and Decision on industry proposals* (Jun 2017)
106 See Lazard *Levelized Cost of Storage Analysis v3.0* (Nov 2017)
107 See Bloomberg New Energy Finance *Lithium-Ion Battery Costs and Market* (Jul 2017)
108 2017 T1 clearing price was £6/kW/year and 2017 T4 clearing price was £8.40/kW/year.
109 100 per cent of respondents to WPD's *Energy Storage Growth Scenarios and Operating Modes* consultation stated that solid-state batteries will be deployed within 18 months (Jul 2017)

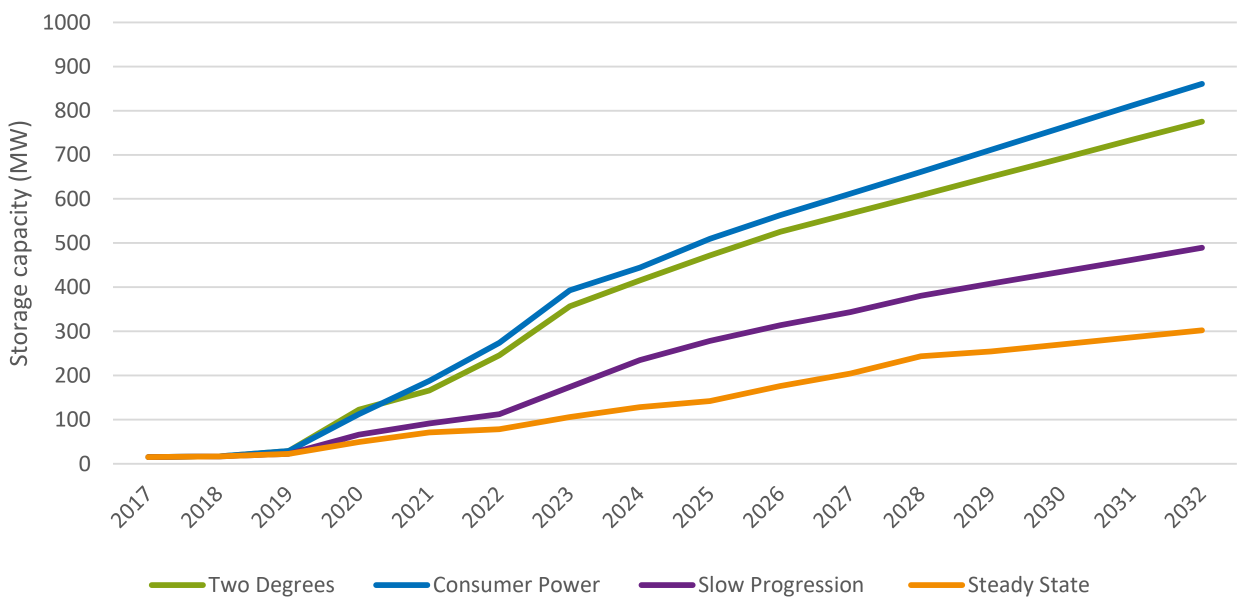
Solid state battery technology costs are expected to continue to fall and new technologies such as flow batteries have potential for future growth.

A key consideration is how individual technology capabilities align with system needs. The rapid response capabilities of lithium-ion batteries align well with the high value rapid response programmes (such as FFR and EFR). Whereas a potential need for longer duration storage in the future may align with other variations of storage technology. This principle is already being reflected in policy and regulatory decisions, such as the significant de-rating of shorter duration battery storage in the CM.[110]

It is expected that storage ratios between MW power and MWh storage capacity will move away from 1:1 to systems with much high storage ratios 1:3 or 1:4.

15.4. Scenario results

Figure 15-1: WPD south west scenarios battery storage capacity growth.



[110] See National Grid *Duration-Limited Storage De-Rating Factor Assessment – Final Report* (Nov 2017)

Table 15-3: Assumptions for factors influencing growth in storage capacity

Two Degrees	• Technology costs continue to reduce leading to strong growth in the short and medium term. • Lower energy use and lower need for battery capacity for flexibility services as proportionally more is provided by demand side response. This leads to this being the second highest scenario. • There is high co-location and domestic storage due to high deployment of domestic and commercial renewables in this scenario but a lower proportion of standalone response and reserve services than Consumer Power.
Consumer Power	• The highest scenario for energy storage as the market is driven by a growth in flexibility services at national and regional level and a large market for response and reserve services • There are high numbers of commercial and industrial batteries installed as users work to manage their energy profiles to minimise cost. • Domestic and co-location storage is the same as Two Degrees.
Slow Progression	• Storage capacity grows modestly with an improvement towards mid-2020s as technology costs reduce and network constraints are addressed. • Some government support and network service revenues available but lower economic growth means these are lower than Two Degrees or Consumer Power.
Steady State	• Storage capacity in the licence area continues to grow slowly but remains limited by network capacity constraints • Lack of policy and regulatory support for storage

Relationship to FES 2017 and 2015 Scenario report

Our analysis of storage growth models has changed significantly since the 2015 south west scenarios report, the high growth scenarios in 2018 are around double what was projected previously. This reflects the significant growth in the industry in the last few years.

The scenarios are broadly consistent with FES 2017 expectation of the overall battery market size and growth expectations. However, in contrast to FES 2017, our research has indicated that nearly all batteries will be deployed on the distribution networks.

Distribution of technology across ESAs

The additional capacity in the scenarios that is not already in the pipeline have been distributed according to the following factors.

Table 15-4: Distribution factors for the storage operating models

Storage Business Model	Distribution Factors
1. Response service	Distribution based upon existing distribution of connection applications
2. Reserve service	Distribution based upon existing distribution of connection applications
3. Commercial and industrial	Proportion of commercial and industrial land space
4. Domestic and community	Distribution of rooftop solar PV
5. Generation co-location	Distribution of ground mounted solar PV and wind