Energy scenarios research:

Considering landscape when powering our future

Photograph from Land Art Generator, of the Energy Duck, a submission to LAGI 2014 Copenhagen, by Hareth Pochee, Adam Khan, Louis Leger, Patrick Fryer. Energy Technologies: photovoltaic panels, hydraulic turbines. Annual Capacity: 400 MWh

Contributors:

This paper has been produced for CPRE cpre.org.uk

CPRE fights for a better future for the English countryside, working locally and nationally to protect, shape and enhance a beautiful, living countryside for everyone to value and enjoy.

CPRE would like to thank the Trustees of the Esmée Fairburn Foundation, whose support for CPRE's wider Sustainable Energy and the Countryside project has funded this research.

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This paper has been produced by Regen regensw.co.uk

Regen is a mission-led, centre of sustainable energy expertise with significant experience of developing and analysing energy scenarios from the bottom up.

Regen works at the heart of the sustainable energy sector. Widely recognised, respected and valued for our trusted, independent advice, in-depth understanding of the sector, expert team of specialists and approach to collaborating and building connections within the public and private sector, we pride ourselves on our evidence based approach, developing strong narratives and undertaking proactive work across the UK to support the decarbonisation of the energy system for the last 14 years.

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The landscape analysis contained within this paper has been undertaken by The Landmark Practice. The Landmark Practice is an environmental consultancy established in Bristol, with specialist knowledge in environmental planning, landscape and ecology.

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Context

Generating energy is at the heart of human society. The relationship between humans and energy has shaped our landscapes for centuries, if not millennia.

We are in the midst of a massive shift in our energy system driven by technological innovation and the imperative to tackle climate change. Just a few years ago electricity was generated by 50 large power stations. Today we are approaching 1 million distributed electricity generators in the UK.

We need to better understand what impact this changing energy system will have on the landscape and how energy infrastructure can be built in the right way and in the right locations to gain support from communities across the UK.

Study aims

CPRE commissioned this study of the changing energy system and the impacts on landscape to:

- assess future energy scenarios that could meet the UK's energy needs and climate obligations under the Paris Agreement
- identify potential landscape impacts and opportunities in England arising from two key scenarios
- produce evidence to inform decision-making on energy that integrates the landscape agenda

The study's hypothesis is that a smart, flexible energy system, supported by a strong innovation and design framework, would minimise negative impacts of new energy infrastructure and secure new opportunities for landscape enhancement.

Methodology

The study considers how varying 2030 future energy scenarios, consistent with the UK's commitments under the Paris Climate Change Agreement, might affect both the physical features that combine to create a landscape and understanding of how humans perceive and assign a cultural value to the landscape; and, therefore, how they respond to change.

Five future energy scenarios were initially considered and two chosen for further analysis: National Grid's Gone Green scenario and Imperial College London's Mega Flex scenario. The Imperial College scenario aims to explore the role of flexibility in minimising the construction of energy generation infrastructure and is, therefore, useful in considering the landscape impacts of different approaches to our future energy system.

The study takes as a starting point the European Landscape Convention (ELC) and uses its principles to inform how the effects of energy infrastructure on the landscape under the two scenarios are assessed.

Conclusions and recommendations

Our findings showed the landscape assessment of the future energy scenarios examined to be mixed across both scenarios. Whilst a smart and flexible approach does reduce the amount of energy infrastructure, the key for reducing landscape impacts of this infrastructure is ensuring there is a clear design and innovation framework.

There is no silver bullet that will address the carbon impact of our energy system without having some impact on our landscape. The impact of the transition comes down to the chosen trajectory of our decarbonisation pathway, and this will remain uncertain until clear policies are put in place to deliver these commitments that add up to the scale of change required.

Considering societies’ response to this energy transition and the impact on our landscape and wider environment is hugely important to its success. This study highlights the need for a comprehensive approach and calls for:

1. The forthcoming Emissions Reduction Plan to include:

    - a clear objective for the energy system
    - a clear end state that sets out what success looks like and how it will be measured
    - a detailed trajectory that sets out the steps by which the UK will achieve this
    - a supportive policy pathway that includes the measures necessary to enable delivery
    - a strategic environmental assessment of energy scenarios used to inform the Emissions Reduction Plan

2. Government to embed the principles of the ELC into its policy framework, enabling a positive approach to energy in the landscape which supports innovative design and considers the potential for multi-functional landscapes.

3. National and local government to invest in a programme of public engagement around the zero carbon transition, involving stakeholders in the policy making process at an early stage and working with system operators to further explore and share the potential benefits of wider public engagement and understanding of the issue of peak demand management and its impacts.

4. Strategic consideration of measures across the energy agenda, as set out below:

Commitment

- Improved societal understanding of zero carbon energy transition
- Strategic environmental assessment of energy scenarios, policies and plans
- Local energy planning that positively engages communities

Minimising power demand

- Energy efficiency standards across all sectors of the economy
- Zero carbon building standards for all new development
- Policy and planning to drive innovation

Shifting peak demand

- Adoption of smart meters and Time of Use Tariffs
- Integration of solar PV and storage into buildings
- Managing electrification of transport to minimise charging at peak periods

Management of peak demand

- Policy and planning support for Demand Side Response
- Planning support for distribution of wind energy to increase resilience

Utilisation of existing infrastructure

- Policy support for repowering existing sites and network connections
- Innovative decommissioning requirements
- Integrate consideration of land use into public decision making

2050 net zero carbon energy

- Increased investment in R&D for emerging technologies such as marine energy
- Support for district heating and integration of the gas and electricity
- Design infrastructure for a decarbonised society

1. Introduction

1.1 Viewing energy transitions through a landscape lens

1.1.1 The energy system we use today has undergone a series of transitions, from early reliance on wood and water, to a system based on coal and then oil. During each transition, there has been an associated societal shift.

1.1.2 The current transition requires significant investment in our energy infrastructure in response to much of it being at the end of its intended life; changing patterns of demand; and decarbonisation objectives. As part of this process it is important to consider how investment can lead to positive improvements for the landscape.

1.1.3 Historically, the location of energy infrastructure in the UK was closely related to the source of the fuel stock and the type of and installation mode of the distribution network. Wind pumps and wind mills were sited in flat lands and arable areas, to power land drainage and cereal milling. This change created a profound cultural and visual impact on the pre-industrial British landscape, but society, in general, became habituated to that impact, not least because the power generated contributed to economic and social development.

1.1.4 The siting of coal and oil-fired power stations, which are among the largest and most recognisable industrial complexes of the 20th-century, was heavily influenced by the cost and logistical demands of transporting the raw resource. As such, they were conventionally sited close to the point of coal mining, or to the port/railhead where the fuel supply made landfall from international supply routes. In essence, even in the late 20^{th} Century, 'energy' landscapes were generally perceived in the context of their role in resourcing society.

1.1.5 The emergence of modern renewable energy technologies towards the end of the 20th century changed the landscape impact of energy production, by directing energy infrastructure to the points where the renewable energy resources were in optimum supply. These areas include hills and coasts used to harness wind energy, greenfield sites for large scale solar photovoltaics (PV) and, to a lesser extent, coastal locations for tidal power. Infrastructure development required to generate and distribute energy, therefore, began in some cases to affect landscapes that had previously been relatively unindustrialised, including rural and coastal landscapes that are highly valued for their tranquillity.

1.1.6 Landscapes are valued for many reasons; for their cultural services, tranquillity and aesthetic quality and also the provision of ecosystem service functions that are critical to national, regional and local economic growth. These can for example include wealth created by agriculture, tourism and recreational activities and economic benefits derived from improved environmental management and climate change regulation, notably via carbon sequestration. These functions are as yet poorly quantified and the value that is placed on landscape, rarely considers the value landscapes provide to the energy system on which we all rely. It is for this reason that landscape and visual impacts of energy infrastructure are often debated when considering local delivery of national energy policy and international climate considerations.

1.1.7 Without this shift to a zero carbon energy system, explained later in this report, climate change is predicted to have dramatic effects on our landscape, caused by both natural processes and human adaptation responses. Based on current knowledge, such effects include: increased coastal flooding and erosion, loss of low-lying areas to sea level rise, increased river flooding, and a shift in current plant and animal species distribution in response to their changing climatic niche.

1.1.8 Societal and cultural mitigation and adaptation to climate related events and trends will equally and significantly affect the character and perception of the landscape. Essential infrastructure will be directed to higher land, whilst land development, management approaches and standards respond to changing demands. Such changes are likely to be most noticeable in the currently more populated lowland and coastal areas, with a consequently disproportionate effect.

1.1.9 **Managing and balancing a well-considered energy transition that minimises the impacts of climate change, requires not only a coherent and stable policy framework, but a significant shift in the way society engages with our energy system.**

1.2 The current opportunity to shape our energy future

1.2.1 The last national assessment of how new energy infrastructure may impact on the landscape was carried out in 2010, as part of the suite of six National Policy Statements (NPSs) for energy infrastructure.

1.2.2 The Appraisal of Sustainability (AoS) for the Overarching NPS for Energy (EN-1) states that: 'The development of a mix of generating technologies will deliver large scale and, in some cases, tall structures, in both existing industrial locations and in new greenfield/ offshore/coastal settings. Many of these structures are likely to be in predominantly rural, remote areas, including areas of high landscape value.'[1] It goes on to conclude that 'significant negative effects for landscape, townscape and visual receptors are likely as a result of the plan implementation in the short, medium and long term, with opportunities for mitigation limited'.

1.2.3 With significant increases in distributed generation across the UK's power network over the last seven years and advances in smart technology and now energy storage, the NPSs and their AoSs reflect a time gone by. They are also now considered inadequate to support sustainable delivery of the scale and range of new energy infrastructure needed to meet the challenges of the UK's climate change commitments. In addition, the opportunities for avoiding and mitigating landscape impacts considered by the NPSs and the AoSs are potentially much greater than these documents set out, for reasons explored later in this report.

1.2.4 The Government has, to some extent recognised the scale of the infrastructure challenge our country faces and established the National Infrastructure Commission (NIC) to provide expert, impartial advice. The NIC's central task is to publish a National Infrastructure Assessment (NIA), which is expected to be the broadest in scale and time in the world, and to advise on infrastructure requirements and policies up to 2050. Following its publication, which is expected mid-2018, the Government is expected to endorse some of the recommendations in the NIA as well as produce a new suite of NPSs in response to it.

[1] DECC (2011), National Policy Statement for Electricity Networks Infrastructure (EN-5)

1.2.5 **Given this once in a generation opportunity to contribute to the future of the energy system, CPRE has invited Regen to compare two contrasting future energy scenarios that would be sufficient to put us on a path to meet our climate change commitments under the Paris Agreement. Although a high-level analysis, strategic assessment of the two contrasting scenarios provides some clarity of the potential range of effects of future energy infrastructure deployment on the landscape, and an indication of strategies, policies and approaches that will be needed to accommodate development.**

2. This study and a net zero carbon energy system

2.1 Purpose of this study

2.1.1 The aims of this study are to:

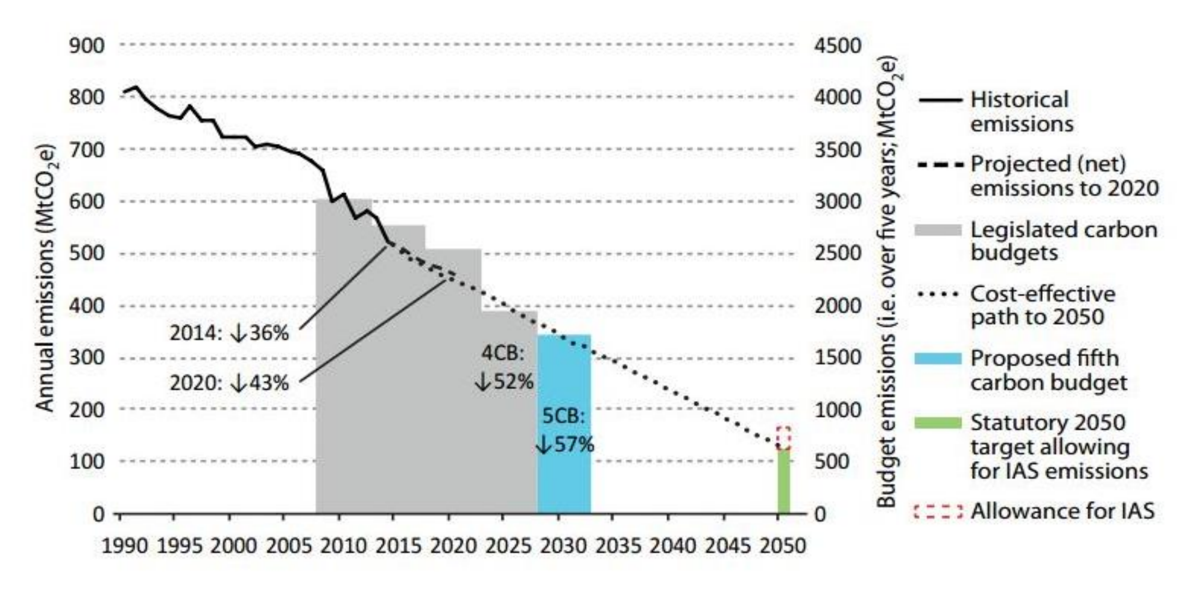
- assess future energy scenarios that could meet the UK's energy needs and climate obligations under the Paris Agreement
- identify potential landscape impacts and opportunities arising in England from two key scenarios
- produce credible evidence to inform decision-making that integrates the landscape agenda to inform delivery

2.1.2 Through this study, we examine the nature and extent of the zero carbon transition; progress made to date, what still needs to unfold and the potential impact on the landscape different pathways might have.

2.2 UK commitments and the decarbonisation of the power sector

2.2.1 The Climate Change Act 2008 commits the UK to at least an 80 per cent reduction in greenhouse gas emissions by 2050. This key piece of UK legislation is being implemented through a series of carbon budgets shown below in Figure 1.

Figure 1: The recommended fifth carbon budget emissions reduction path to the UK's 2050 target. Source - Committee on Climate Change[2]



Source: DECC (2015) *Final UK greenhouse gas emissions national statistics: 1990-2013*; DECC (2015) Provisional UK greenhouse gas emissions national statistics; DECC Energy Model; CCC analysis.
Notes: Data labels show reductions in annual emissions relative to 1990. Historical emissions are on a 'gross' basis (i.e. actual emissions). Projections and carbon budgets are on the current budget accounting basis: net carbon account excluding international aviation and shipping (IAS), but allowing for IAS to be included in the 2050 target.

[2] Committee on Climate Change (2016), The fifth carbon budget – a balanced path to a necessary goal

2.2.2 In October 2015, the CCC published a report on Power Sector Scenarios to inform the fifth carbon budget. It highlights some key messages which should be borne in mind, including:

- the 2020s will be a crucial decade for the future of the power sector, with key decisions around new investment needed to replace generation from retiring coal and nuclear capacity and to meet potential increases in demand
- a portfolio approach to power generation will be vital
- to maximise the value of investments and secure security of supply, it will also be vital to improve the flexibility of the power sector[3]

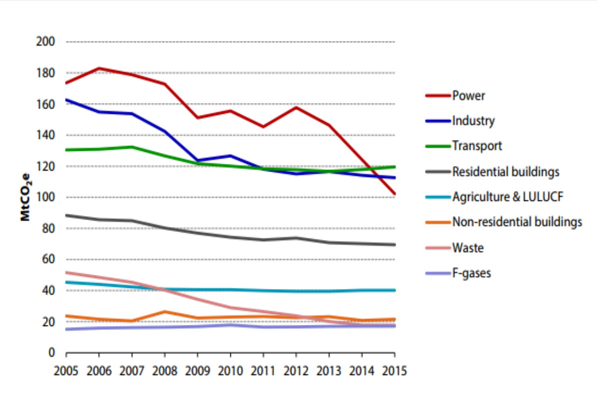
2.2.3 In 2016, the Government enacted the fifth carbon budget which sets targets to 2032. The UK has demonstrated a strong track record in meeting the first, second and third carbon budget targets, predominantly through renewables and the closure of coal generation in the power sector and deindustrialisation. However, the Government has acknowledged we are not on track to meet the fourth carbon budget or the target of a 57 per cent reduction in carbon emissions by 2032 set in the fifth carbon budget.

2.2.4 The current carbon budget targets are derived as a contribution to a global path aimed at keeping global average temperature rise to around 2°C on the lowest cost path to 2050. The Paris Agreement, signed by world leaders who came together to strengthen the global response to the threat of climate change, agreed to keep global temperature rise this century well below 2°C above pre-industrial levels. It was also agreed to pursue efforts to limit the increase even further to 1.5°C. The Paris Agreement entered into force on 4 November 2016, 30 days after it was ratified by at least 55 per cent of the parties to the convention, accounting for at least an estimated 55 per cent of the total global greenhouse gas emissions. All Parties are required to put forward their best efforts.

2.2.5 To achieve a carbon budget in the UK commensurate with the Paris Agreement's objectives of keeping global warming within 1.5°C and taking a fair share of the global carbon budget[4], the Committee on Climate Change (CCC) have highlighted that this requires strengthening and potentially overachieving on current efforts towards 2°C. With little progress being made in other sectors of the economy and recognition that we will need to capture the carbon emitted from many of these sources[5], it is clear we need to continue to reduce the carbon intensity of the UK power system. This means reducing fossil fuel generation, starting with the phase out of coal, and replacing this with a range of low and increasingly zero carbon technologies.

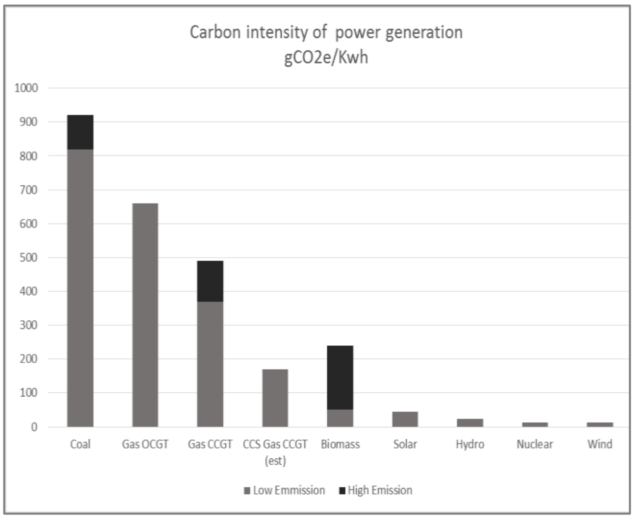
[3] Committee on Climate Change (2015), Power sector scenarios for the fifth carbon budget
[4] Committee on Climate Change (2016), UK climate action following the actions following Paris Agreement, & Committee on Climate Change (2015), The scientific and international context for the fifth carbon budget
[5] Committee on Climate Change (2016), UK climate action following the actions following Paris Agreement, & Committee on Climate Change (2015) The scientific and international context for the fifth carbon budget

Figure 2: Emissions reduction since 2012. Source: CCC 2016



Source: DECC (2016) *Provisional GHG statistics for 2015*; DECC (2016) *Final GHG statistics for 1990-2014*; CCC analysis.
Notes: Chart shows temperature-adjusted emissions in power, residential and non-residential buildings. This smooths out the large changes in heating emissions between years with mild and cold winters to give a clearer impression of genuine progress.

Figure 3: Carbon intensity of power generation technologies. Data source: IPPC 2014



2.2.6 The current mix of electricity generation technologies means that we are emitting around 371 gCO_2 per kWh. Reductions in carbon intensity to date have been achieved through the closing of coal fired power generation and the increase in renewable energy capacity, predominantly wind and solar power. In developing their scenarios for 2030, the CCC recognises the investments that are already underway, which taken together they estimate, would reduce the carbon intensity of UK electricity to around 250 gCO_2 per kWh by 2020 and 200 gCO_2 per kWh by 2030 [6]. To meet the commitment we made in the fifth carbon budget we need to reduce the carbon intensity of our power system to between 100 and 50 gCO_2 per kWh by around 2030.

2.2.7 **To put ourselves on a path to fully decarbonise and achieve a net zero carbon power sector by 2050, we need to over achieve on our current commitments and commit to achieving closer to 50 gCO_2 per kWh by 2030.**

UK power sector emissions

2010
156 $MtCO^2e$
Power Carbon intensity 499 gCO^2e/kWh

2015 Progress
102 $MtCO^2e$
Power Carbon intensity 370 gCO^2e/kWh
falling to 200-250 g CO^2e/kWh by 2020

2030 Target
Saving needed of 71 $MtCO^2e$
Power intensity 50-100 g CO^2e/kWh

50g CO^2e/kWh would put UK on track for Paris Agreement

2.2.8 It is expected that the new UK Emissions Reduction Plan due to be published in 2017 will set out how the Government plans to catch up with its emission reductions to meet the fourth carbon budget, as well as consider our obligations under the Paris Agreement, including the achievement of net zero emissions by 2050.

2.2.9 The next steps in the decarbonisation of the energy system in the UK and globally will challenge the way we currently think about energy. The CCC highlight that there is already a significant policy gap between the projected UK emissions and the fifth Carbon Budget target[7].

[6] Committee on Climate Change (2015), Power sector scenarios for the fifth carbon budget
[7] Committee on Climate Change (2016), Meeting Carbon Budgets - 2016 Progress Report to Parliament

2.3 Our approach and smart hypothesis

2.3.1 This study involves consideration of how strategic energy scenarios might affect both the physical features that combine to create a landscape and understanding of how humans perceive and assign a cultural value to the landscape; and, therefore, how they respond to change. For the purposes of this study it is acknowledged that the scale of change that our energy system and landscape will experience through this zero carbon transition is substantial and that no form of energy generation and distribution will have an entirely neutral effect on the landscape.

2.3.2 **The scenarios examined through this study seek to explore how nuances in the approach taken to managing our future energy infrastructure could influence the shape, extent and spread of the resulting effects on the landscape. Whilst this may require society to make a shift in its perception of, and approach to, the landscape as a resource at least in the short term, there is also a real opportunity to frame energy infrastructure delivery strategies with the objective of positively influencing the process of landscape change and embed energy generation into our landscapes more thoughtfully.**

2.3.3 Such a shift in society's response to the landscape change will affect not only the material features of a particular setting, but also the cultural evaluations and emotional attachments that people build into these material forms. As such, the assessment of landscape effects in this study addresses, at a high level, both physical change and cultural responses.

2.3.4 The study follows professional guidance set out by the Landscape Institute and the Institute of Environmental Management and Assessment (IEMA) in Guidelines for Landscape and Visual Impact Assessment (GLVIA3) and takes as a starting point, the European Landscape Convention (ELC) and uses its aims to inform how objectives and criteria are formulated to assess effects. The ELC was the first international instrument to recognise the importance of landscape and was ratified by UK Government in March 2007. The ELC was introduced by the Council for Europe, a body separate to, and indeed established well before, the European Union and it will therefore remain valid post-Brexit.

2.3.5 Understanding the subtlety of the relationship between people and the landscape is key. Although we mainly experience landscape by sight, many other sensory factors can contribute to the personal experience of a particular place. Inevitably, therefore, human perception of landscape, its function and value, is appreciated in different ways by different receptors, from policy makers to developers, land managers to local residents and visitors, leading to conflicting interests and contrary opinions on landscape values.

2.3.6 Many of the cultural constructs around how we place value on our landscape and how we traditionally view our energy system are built into the current planning system. Challenging our current thinking on both the way we generate, use and supply energy, as well as how energy is integrated into our landscape, is important to supporting the societal shift that needs to take place as part of the zero carbon energy transition[8].

2.3.7 **The key question is for this study is what approach should be taken to the zero carbon energy transition to minimise negative impacts and secure new opportunities for**

[8] Devine-Wright, (2011)

landscape enhancement. Our hypothesis is that a smart, flexible energy system, supported by a strong innovation and design framework would be the best approach to achieve this. Although the scale of change that is required to our current energy system amounts to nothing less than a revolution in the provision of energy, this challenge affords us the chance to re-define our relationship with energy, not only the way we use it, but the way it is generated, how it reaches us and the impact this has on our landscape and wider environment.

2.3.8 The first steps to explore what is meant by a smart, flexible energy system that is able to accommodate significant volumes of intermittent, variable and inflexible low and zero carbon generation to meet our future energy needs have been taken by the National Infrastructure Commission (NIC) through their report on 'Smart Power'. Their central finding is that the integration of three key innovations; interconnection, storage, and demand flexibility, could save consumers up to £8 billion a year by 2030, help the UK meet its 2050 carbon targets, and secure the UK's energy supply for future generations[9]. This financial saving in part reflects a saving of investment in new infrastructure development and therefore a potential reduction in the impact in our landscape. The NIC has issued a call for evidence to provide input to the development of its National Infrastructure Assessment, offering a valuable opportunity for CPRE and others to input into the UK's policy approach to infrastructure development. How a smarter approach could reduce the overall impact of our energy system on our landscape is something that this paper seeks to explore.

2.4 The current pathway to decarbonisation

2.4.1 The route to achieving complete decarbonisation of our power system has not yet been mapped out. Many scenarios have been intimated, but what is certain is that none of them will come about without clear policy direction, investment and technological innovation.

2.4.2 Policy has shaped the pathway to decarbonisation that we are currently on. Whilst considerable progress has been made in the power sector, heat and transport remain significantly further behind in identifying viable decarbonisation pathways.

2.4.3 **However, even in the power sector, the options that could be adopted to replace the ageing generating capacity that will need to come offline during the 2020s and therefore determine in part what can be achieved by 2030, are bounded by the practical challenges of developing and deploying large scale generation.** For example:

- a new nuclear programme could be adopted, but given that the next decade will see most of the existing nuclear power plants decommissioned, and the long lead time to bring forward new plants, as demonstrated by Hinkley C, the most optimistic nuclear scenario to 2030 is to retain the existing share of approximately 25 per cent of generation

- carbon capture and storage (CCS) could be adopted to decarbonise gas and potentially biomass fired power stations – although it must be noted that CCS is not as low carbon as other options and that given the current state of CCS technology

[9] National Infrastructure Commission (2016), Smart Power

development and the cost challenges faced by CCS projects, the consensus is that CCS will have a limited impact in the short term

- other technologies such as wave and tidal power could be accelerated and could well play a significant role in the future generation mix, but with the exception of tidal range, it is unlikely that marine energy will have a significant impact on carbon emissions in the next decade. The role of tidal range will depend very much on the success of tidal lagoon demonstration projects

2.4.4 In addition, the substantial deployment of distributed generation that we experienced over the past decade, especially solar power, has led to the need to examine how our existing electricity distribution network and transmission grid infrastructure can accommodate increased levels of intermittent, variable and inflexible generation capacity going forward. As a result, investment in grid flexibility, including interconnectors with mainland Europe and an increasing focus on the role that storage technologies can provide to improve grid stability are key policy areas under scrutiny.

3 Future Energy Scenarios

3.1 The use of future energy scenarios

3.1.1 The initial aim of this study is to assess future energy scenarios that could meet the UK's energy needs and climate obligations under the Paris Agreement. This means putting the UK on the path to net zero emissions by 2050, which from our assessment of the science and the market, we concluded as requiring an energy system carbon intensity of 50 gCO_2 per kWh by 2030.

3.1.2 Examining these scenarios in detail and breaking them down to establish what development may take place where, based on a detailed knowledge of the energy sector, provides a bottom up analysis which allows us to examine the potential landscape impacts of these scenarios undertaken by section.

3.1.3 To understand the transformation required to our energy system, decision-makers routinely use energy scenarios that model projected changes to the energy mix required to meet specific objectives. These models consider a wide range of issues, and although they do not provide exact projections, they are the best available tool to assess the magnitude of the challenges that lie ahead and provide useful benchmarks for designing policies to achieve specific objectives at the least cost. This study looks at five different scenarios and then assesses the potential impact on the English landscape of two differing approaches.

3.2 Changing patterns of demand

3.2.1 Forming the basis of any energy scenario is the baseline of how we expect our energy needs and demands to change over time. The UK's demand for energy will have a significant effect on both the scale and mix of electricity generating capacity and supporting infrastructure that is needed and, therefore, its impact on the landscape.

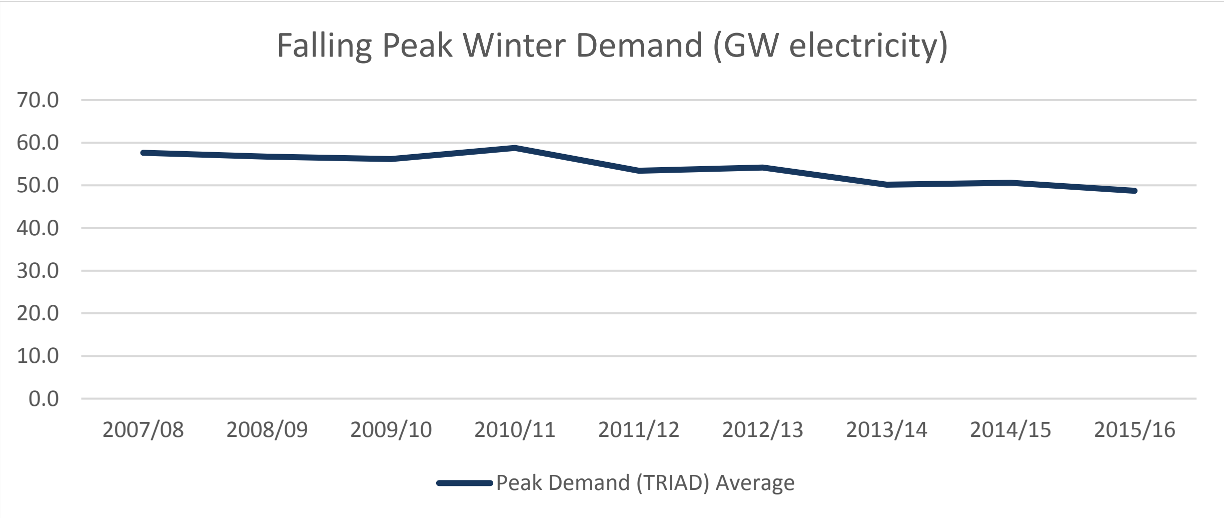
3.2.2 In considering energy demand, it is important to consider both the overall energy requirement of the UK economy and the 'peak' or maximum energy demand which typically occurs during winter evenings between five and seven pm. While the overall energy demand determines the annual generation needed and therefore the annual CO_2 emissions, the peak energy demand plays a major role in determining the absolute scale of generation capacity needed, as well as the infrastructure needed to deliver energy to consumers. Minimising energy demand, through greater energy efficiency, and reducing energy peak demand using smarter approaches could reduce the overall energy infrastructure requirements and therefore the impact of our future energy system on the landscape.

3.2.3 Overall UK demand for electricity has been flat or falling slightly year on year, despite population increasing. Initial growth in the early part of this century has now been offset by falling energy demand since 2010. Demand for electricity in 2015 was at a similar level to 1995 at around 290 TWh per year.

3.2.4 Demand for electricity is split roughly equally between domestic, industrial and other demand including commercial and public services. Electricity reduction has been most pronounced in the industrial sector. This is because growth drivers such as economic growth, population growth and new applications, have been offset by increased energy efficiency and the reduced energy intensity of the UK economy.

3.2.5 The level of peak electricity demand has also fallen, especially since 2010. Whereas in 2010 a typical winter peak demand, as measured during the Triad peak period[10], for electricity would be circa 58 GW, in recent years this has fallen to around 50 GW. National Grid uses the forecast of peak demand to determine how much overall generation capacity is needed, including capacity on standby, to ensure that the UK has sufficient capacity margin in place to ensure wintertime energy security. This has a direct impact on the Capacity Market, and the payments made to ensure that standby capacity is available. Over the longer term, peak demand also heavily influences the amount of grid and network infrastructure required in the UK.

Figure 4: Falling Peak Winter Demand. Data source: National Grid Triad Data Reports 2007-16



3.2.6 There are several reasons why peak demand has fallen. Partly the fall is in line with the overall demand reduction. The changing mix in the UK energy demand may also have had impact, although the relative shift towards domestic and non-industrial demand could in fact have seen peak demand rise. The most significant factor however, has been the increase in pro-active demand side management by energy users, who are able to shift demand away from peak price periods. In other words, we are beginning to see the impact of Time of Use Tariffs (ToUTs) for half-hourly billed consumers and a more sophisticated response by energy users to avoid peak charge periods.

3.2.7 Currently, this demand side shift is almost exclusively taking place in the higher energy industrial and commercial users; however, the potential to extend the impact of Demand Side Response to other energy users and across the domestic sector is the subject of

[10] The Triads are the three half-hour settlement periods with highest system demand and are used by National Grid to determine charges for demand customers with half-hour metering and payments to licence exempt distributed generation. They can occur in any half-hour on any day between November to February inclusive but are separated from each other by at least ten full days.

significant interest, especially when considering mechanisms to mitigate potential demand spikes resulting from the electrification of elements of the heat and transport sectors. As ToUTs and half hourly billing is rolled out with smart meters, we can expect to see greater demand flexibility across the economy. For example, as of 1 April 2017 many farmers and agriculture users have moved across to half-hourly tariffs.

3.3 Reducing total and peak electricity demand

3.3.1 Demand for electricity in the UK is expected to continue to change, although the extent to which electricity demand changes over time will depend on a number of critical factors, where as-yet the policy direction remains unclear.

3.3.2 The expected electrification of at least some transportation and heat demand will increase overall electricity demand. The roll-out of electric vehicles is expected to increase demand significantly, with scenario estimates in the range of 12-21 TWh by 2030 in the two scenarios that we examine in this study. Even these estimates may be conservative if electric vehicle uptake is accelerated through clearer policy direction.

3.3.3 The electrification of heat is more complex. In 2013, the Government[11] expected that ground and air source heat pumps, which use electricity as a top-up heat supply, would be deployed extensively across the UK. So far, the uptake of heap pump technology has been slower than expected. This is one reason why heat decarbonisation is so far behind schedule. However, deployment could increase more quickly in the coming years thanks to cheaper and more efficient technology, if there was policy support for this approach. The scenarios examined through this study have included an additional 9-28 TWh of electricity demand related to heat pump adoption.

3.3.4 Against the anticipated growth in demand through electrification and economic growth, all the future energy scenarios that we have examined have assumed a high degree of future energy efficiency measures, for example 90 TWh of electricity energy efficiency measures across all sectors, or a reduction through efficiency measures of around 20 per cent by 2030. The delivery of energy efficiency measures going forward will therefore be critical and without these measures, the future UK energy system will be far larger, with a far greater physical impact on our landscape.

3.3.5 The recent fall in peak energy demand would be reversed if consumers charge electric vehicles, or boost heat pump output during the peak demand period between five and seven pm on winter evenings. To prevent this happening, and to further shift demand into off-peak periods, it will be essential to continue the adoption of smart meters, incentivisation of demand side shift through ToUTs and to embed smart technology into vehicle charging control systems and other appliances.

3.3.6 The lack of policy support to drive down both overall and peak energy demand in the future is of real concern. Reduced emphasis on, and support for, energy efficiency measures and the shelving of zero carbon new buildings policies increase the scale of the energy challenge. Delays to rolling out of smart meters and the lack of engagement to encourage consumers to shift their demand away from peak periods will cause problems as demand increases. For

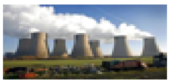
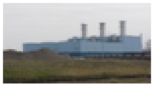
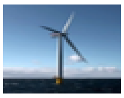
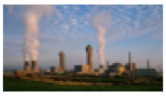
[11] DECC Low Carbon Delivery Plan (2013)

system operators to factor in a reduction in peak demand from consumers, in addition to relying on contracted Demand Side Response services, will require much greater evidence and certainty, but this would have significant impacts on the overall generation capacity required.

3.4 The changing mix of British electricity generation capacity

3.4.1 The current electricity system includes a mixture of fossil fuelled technologies, nuclear power and renewable energy. Supporting this energy mix is also 4 GWhr of interconnection capacity and 2.8 GW of storage capacity.

Figure 5: Changing British electricity generation since 2010

	2010/11	Closed* since 2010	New added	Current 2015/16	Expected to be closed by 2030
Coal 	26 GW	**13.3 GW**		12.8GW	**12.8 GW**
Gas 	30.2 GW	**4.5 GW**	8.5GW	33.7 GW	**16.5 GW**
Renewables 	8.6 GW		24.8 GW	33.3 GW	**3.5 GW**
Nuclear 	10.7 GW	**1.4 GW**		8.9 GW	**7.7.GW**
	77.8 GW	**22.9 GW**	**33.2 GW**	**90 GW**	**41.4 GW**

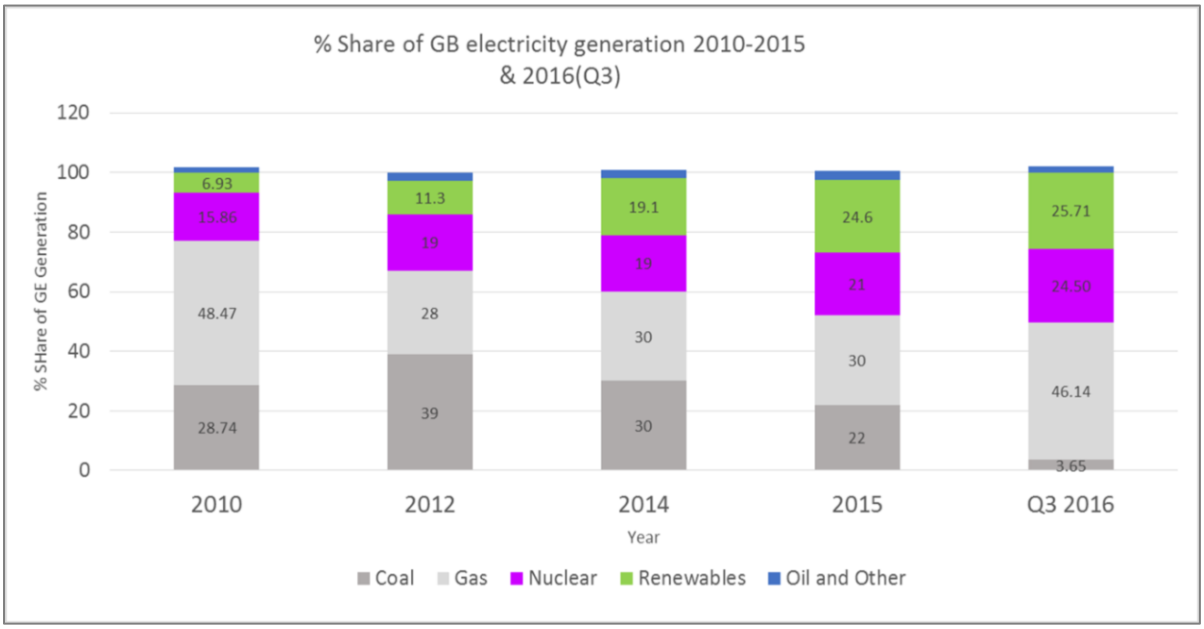
* Closed, partially closed, converted to biomass or mothballed

3.4.2 A summary of the British energy generating capacity mix can be seen in Figure 5: Changing British electricity generation since 2010 above. This also includes plants that are expected to come to the end of their life between now and 2030, demonstrating the extent to which the system needs replacement capacity between now and 2030.

3.4.3 The UK Government has committed to removing coal from our energy mix due to its carbon intensity, the result of which is illustrated in **Figure 6** below. In early 2017, the Government consulted on how 'the closure of the remaining coal fired power stations in Great Britain takes place in a way that minimises the impact on the electricity system and provides certainty for investors to enable them to invest in lower carbon alternatives in good time to replace the lost capacity'[12]. The energy scenarios in this report assume that coal is removed from the Great British energy mix before 2030. A summary of the changing energy mix can be seen in **Figure 6** below.

[12] BEIS (2016), Coal Generation in Great Britain

Figure 6: Percentage share of British electricity generation over time. Data source: DUKES energy trends 2016



3.4.4 The future of other fossil fuel generation is less clear. Currently we are more reliant on gas in today's electricity mix than in recent years due to the demise of coal-fired generation. This not only highlights the need for CCS going forward, but also raises other questions.

3.4.5 The scenarios in this study, to a greater or lesser extent, demonstrate an expectation that conventional gas for electricity production will continue in the short and medium term, but will increasingly be used to provide peaking capacity i.e. it will be used to meet peak demand and to supplement variable generation. This will incur a system cost to have gas generation, or any other form of peaking capacity on standby. It also has a potential landscape cost, depending on the nature of this standby generation. As we move to a position of net zero emissions by 2050, conventional gas fired power will need to be an energy source of last resort, used only to meet truly exceptional peak demand or loss of supply events.

3.4.6 How decarbonisation of the heat sector affects the way we use gas is also becoming of increasing interest. For heat, energy efficiency in buildings and processes is obviously key, but creative ways of using the gas network are also being considered. These include increasing the contribution of green gas to the network; and increasing the distribution channels for heat (heat networks), which would potentially enable an additional element of balancing through Combined Heat and Power (CHP) to produce heat using excess low carbon electricity. However, without large scale heat distribution networks or significant innovation, this is unlikely to offer the scale of solution in the UK that it may in some other countries[13].

[13] Harris M. (2011), Thermal Energy Storage in Sweden and Denmark: Potentials for Technology Transfer *IIIE Master thesis.*

3.5 Analysing the scenarios

3.5.1 There are a range of organisations that have produced future energy scenarios, all of which are premised on slightly different objectives. These scenarios are often heavily focused on the electricity sector, with assumptions about the extent of electrification to the heat and transport sectors as discussed above. This is also the approach taken in this study due to the scope and timescales involved. Published energy scenarios were used, as these are supported by detailed assumptions and modelling set out in their source documents for further reference.

3.5.2 2030 was taken as a reference point because 2050 scenarios would be too generic to incorporate any spatial analysis of the impacts from a landscape perspective. A 2030 stepping stone to 2050 was chosen because the CCC and others have used this as a benchmark date for comparison and there is some scope to make assumptions about the type of developments that would come forward and where these may be. For example, one way to achieve net zero carbon by 2050 is to utilise CCS, but the technical solution to achieving this has not yet been developed, so it makes it impossible to comment on its impact on the English landscape. However, even within the 2030 timeframe, there are many unknowns due to the lack of policy measures supporting this objective.

3.5.3 The context for this study is achieving a power sector commensurate with the objectives set out within the Paris Agreement. As set out earlier the power sector needs to achieve net zero carbon emissions by 2050, and for this to be achieved, the lower end of the current carbon budgets of 50-100 gCO_2 per kWh need to be achieved by 2030.

3.5.4 An analysis of these widely-used scenarios was undertaken to compare the varying aspects of their make-up. Data was extracted from the scenarios to provide a comparable summary of the potential energy mix in 2030, which can be seen in summary in Figure 7 below.

Method

Five different energy scenarios were examined at a key point in time - 2030.

They were reconstructed to compare how they varied in their composition of electricity generating capacity at this critical point on our pathway to decarbonisation by 2050.

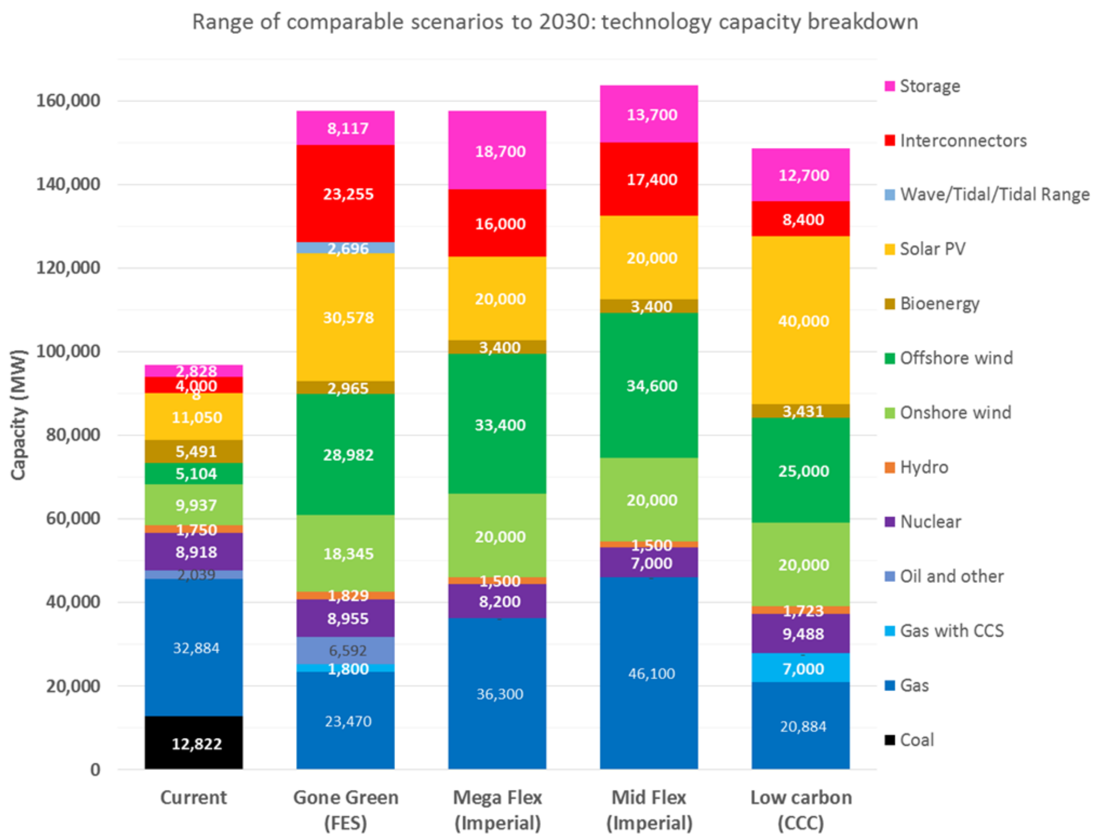
↓

The objective of achieving a target carbon intensity of the power system of 50 gCO_2 per kWh by 2030 was set and any of the scenarios that would not enable the achievement of this objective were dismissed.

↓

The scenarios were then analysed and compared.

Figure 7: Energy scenario 2030 capacity comparison



The scenarios examined were:

- National Grid's Future Energy Scenario - Gone Green
- Two scenarios by Imperial College London (Mega Flex and Mid Flex)
- A low carbon scenario published by the CCC

3.5.5 **National Grid's Gone Green scenario**[14], developed by National Grid as part of its Future Energy Scenarios work, was the only one of the four scenarios explored by National Grid which could put us on a path to achieving a target carbon intensity of the power sector of 50 gCO_2 per kWh by 2030. National Grid's Gone Green scenario describes a future where policy interventions and innovation are both ambitious and effective in reducing greenhouse gas emissions. The focus on long term environmental goals, high levels of prosperity and advanced European harmonisation ensure that the UK 2050 carbon reduction target is achieved. As a result, this scenario focuses on driving forward low carbon technologies including wind and solar, with gas playing an important role as peaking capacity, alongside energy storage, Demand Side Response and 23.3 GW of supporting electricity import capacity by 2030.

[14] National Grid (2016), Future Energy Scenarios 2016

3.5.6 **Two scenarios by Imperial College London[15].** These are known as Mid Flex and Mega Flex. These scenarios examine the role of flexibility in the system. The scenario requires slightly less generation capacity than National Grid's Gone Green scenario, mainly because more wind is installed and less solar PV. It includes less nuclear power, less PV, less Combined Cycle Gas Turbine capacity (CCGT), less interconnectors, but substantially more storage and the use of Open Cycle Gas Turbine (OCGT) capacity to help meet peak demand.

3.5.7 Also considered was an **ultra-low carbon scenario published by the CCC** in October 2017 in their power sector scenarios report for the fifth carbon budget, also based on Imperial's modelling.

As can be seen in Figure 7, across the range of scenarios, they all involve a broad mix of technologies to achieve a target carbon intensity of the power system of 50 gCO_2 per kWh by 2030. In identifying which two scenarios to compare, we chose scenarios that demonstrate the most significant contrast in approach. **The chosen scenarios were National Grid's Gone Green scenario and Imperial College London's Mega Flex scenario, to examine the value of the role of flexibility in minimising the construction of unnecessary infrastructure.**

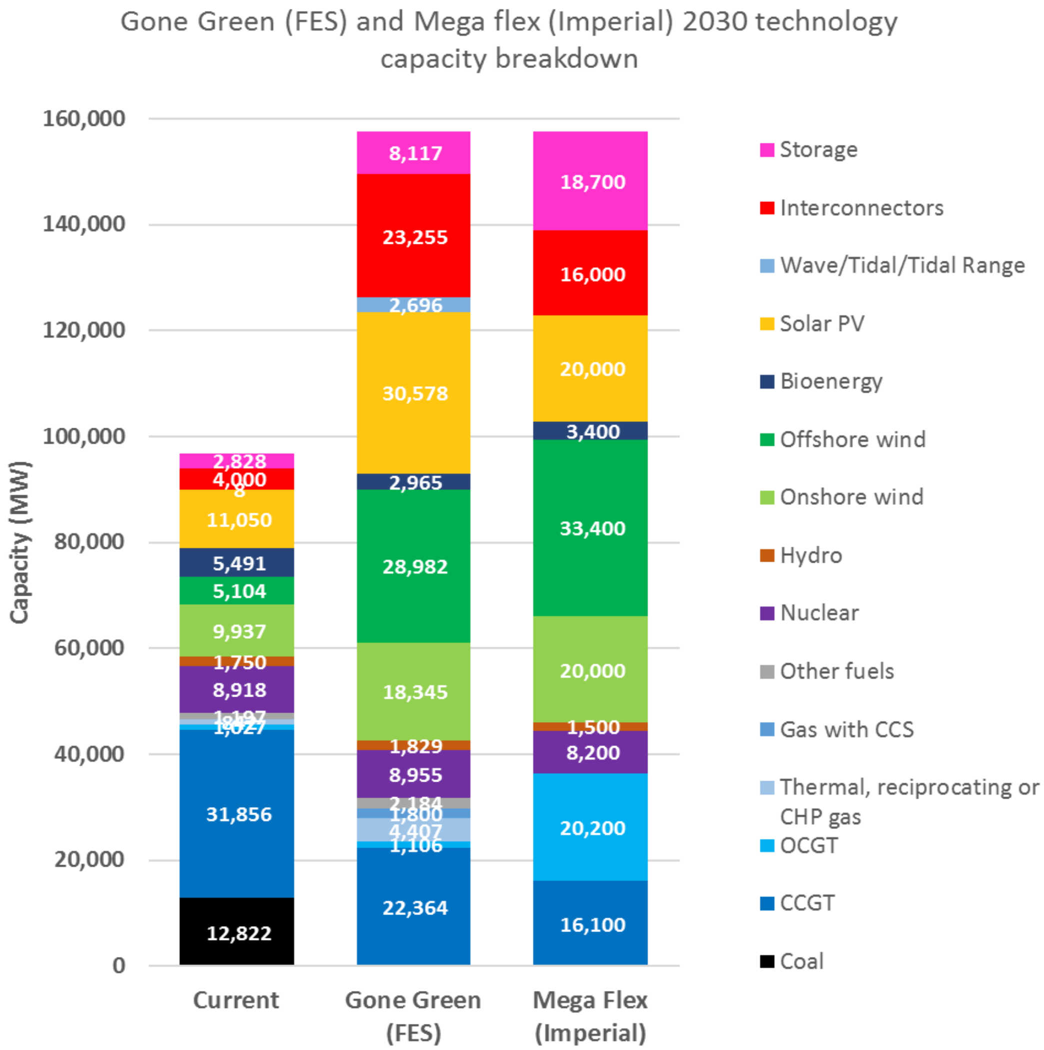
Method

Two contrasting scenarios were then chosen for further examination.

3.5.8 Under National Grid's Gone Green scenario the capacity of the whole system including storage and interconnection in Great Britain in 2030 is 161,862 MW with 130,490 MW of installed generation capacity. Under the Mega Flex scenario the capacity of the whole system in Great Britain is 157,500 MW with 122,800 MW installed capacity. A comparison of the makeup of these two scenarios against the current baseline can be seen in Figure 8 below.

[15] Strbac G. & Aunedi M. (2016), Whole-system cost of variable renewables in future GB electricity system: Joint industry project with RWE Innogy, Renewable Energy Systems and ScottishPower Renewables, Imperial College London Publication

Figure 8: Comparison of two chosen scenarios' capacity in 2030



3.5.9 The second aim of this study was to identify potential landscape impacts and opportunities arising from two key scenarios in England. The scenarios that were analysed are not extremes, but have been developed based on differing assumptions and from different perspectives, so represent different flavours for comparison.

3.5.10 Both scenarios include:

- a mix of all available technology options
- a significant baseline of non-variable capacity
- significant levels of low carbon capacity including wind and solar

3.5.11 Variations occur in the detail of these scenarios resulting from the assumptions that they are built upon. These are complex, but details can be found at:

- Gone Green: http://fes.nationalgrid.com/fes-document/

- Mega Flex:
  www.e3g.org/docs/Whole-system_cost_of_variable_renewables_in_future_GB_electricity_system.pdf

3.5.12 Key comparisons include the assumptions they make about:

- total electricity demand in 2030 including underlying assumptions about energy efficiency uptake across the economy, the impact on electricity demand resulting from the electrification of heat and transport

- levels of flexibility within the system, the uptake of smart technology, expected levels of Demand Side Response and the impact of demand shift resulting from behavioural change compared to the need for backup capacity

- how peak demand is managed and technology de-rating factors

- political commitment and economic prosperity and thus the temporal impact of policy measures

- the scale of generation capacity plant and whether this connects to the transmission grid or distribution network

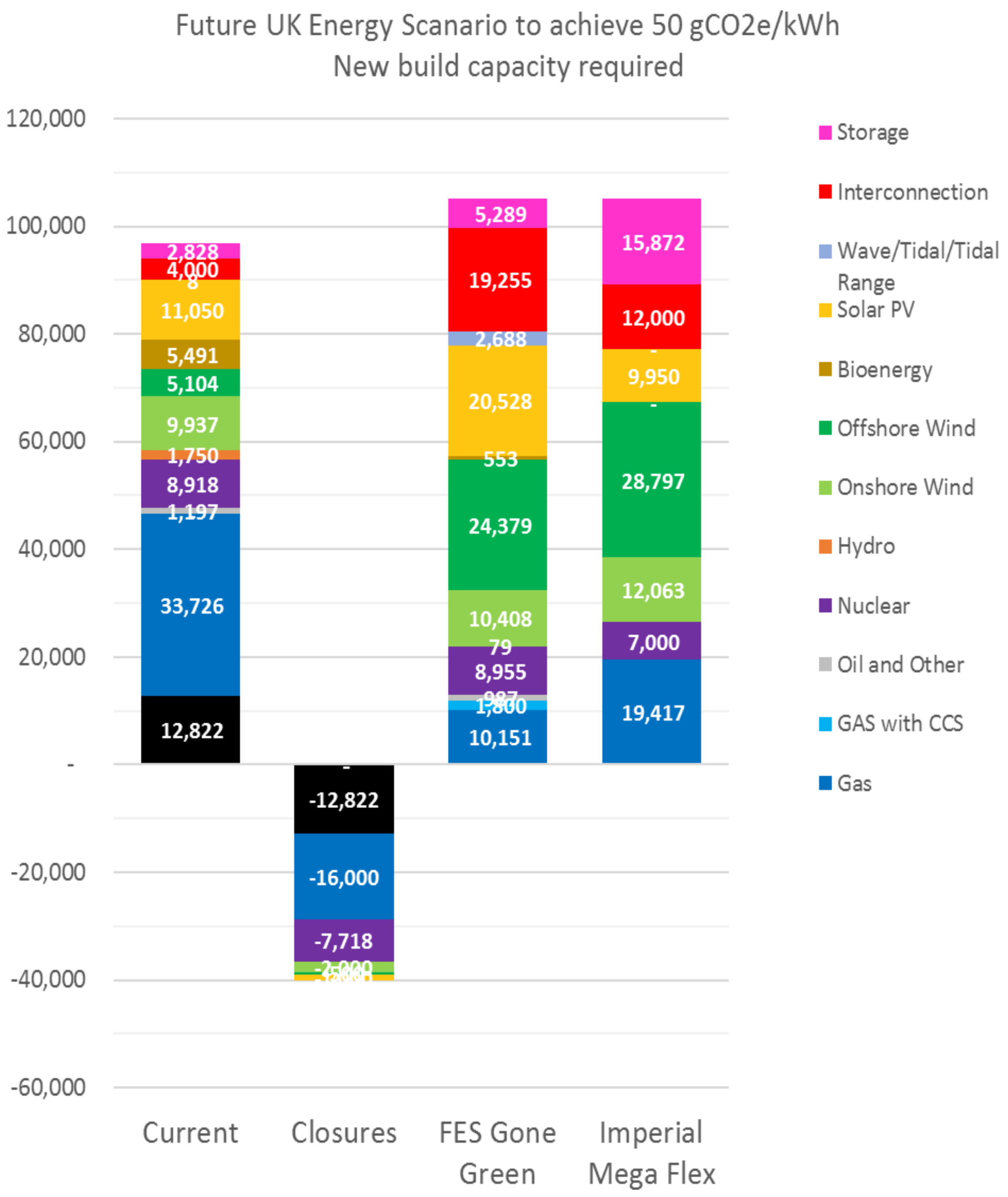
Gone Green		Mega Flex	
346 TWh	Annual demand	355 TWh	Annual demand
61 GW	Peak demand	52 TWh	Annual demand

3.5.13 At this point the analysis began to build up a picture of how these scenarios could unfold spatially. Judgements[16] were made about how much of the capacity could potentially be developed in England, drawing on what could be assumed about the locations of development and which landscapes these would most likely effect, for example coastal, rural or urban landscapes or seascapes.

3.5.14 The re-use of existing sites and infrastructure is of critical importance to minimise landscape effects of these scenarios. This analysis is based upon this premise. An analysis of new build capacity required was therefore undertaken, which can be seen in Figure 9 below.

[16] See Figure 10 for details.

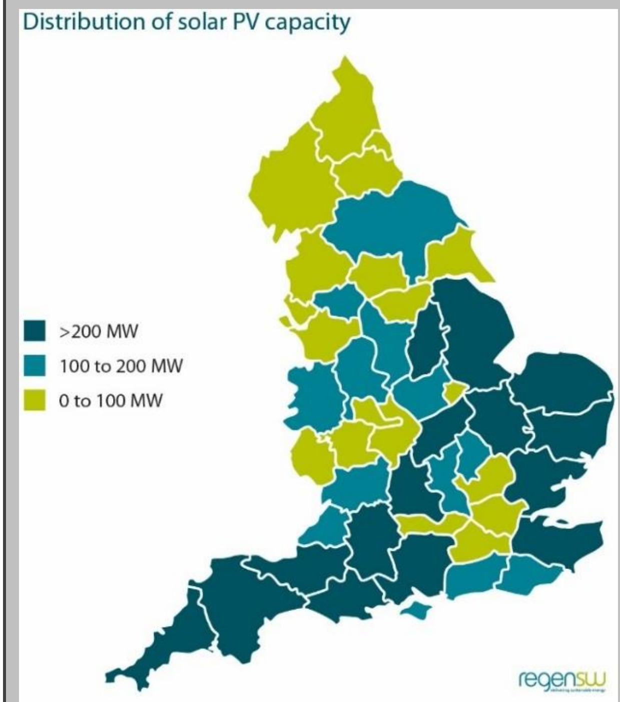
Figure 9: Energy scenario new build capacity comparison

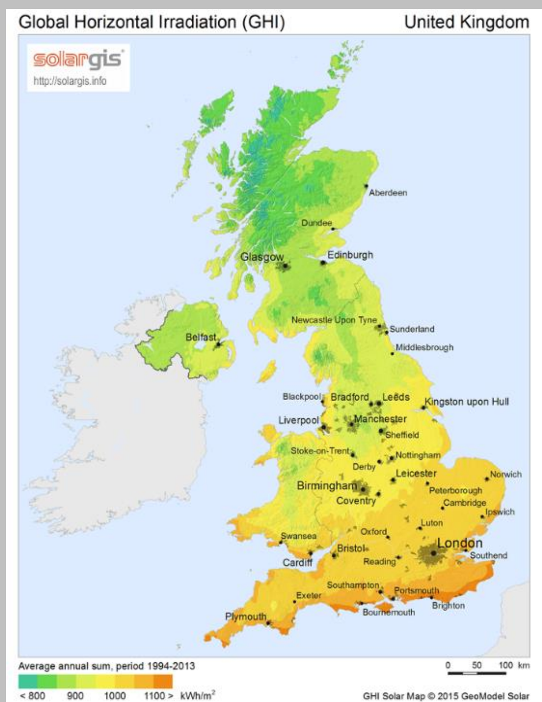


3.5.15 A summary of this analysis can be seen in Figure 10 below.

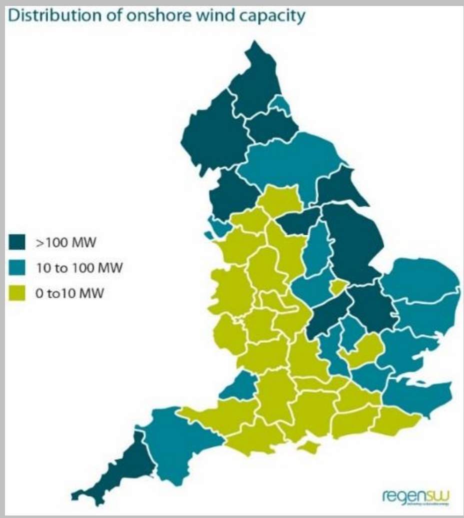
Figure 10: Assumptions behind spatial breakdown of scenarios

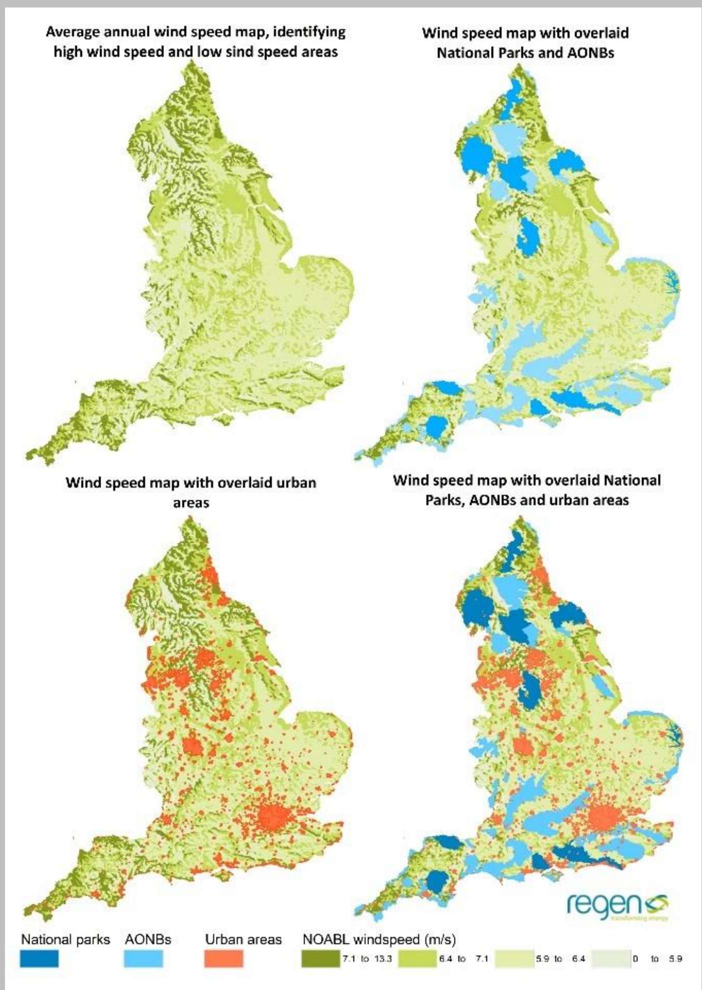
Technology	Assumptions	Key policy issues and factors enabling or restricting deployment	Landscape type most affected
Gas	Based on previous build patterns, it is assumed that between 80% and 94% of the necessary gas capacity will be built in England, with the remainder elsewhere in Great Britain	• Support for CCS development • The priority for role of gas in the energy mix needs to be clarified, whether that is providing baseload capacity CCGT, peaking capacity OCGT or flexibility through CHP	**Industrial / urban**
Nuclear	Assumption that development takes place on existing sites currently seeking extensions	• Commitment to nuclear programme and timing of development of new capacity	**Coastal**
Hydro	Assumption that development will follow recent trends. Small scale hydro development	• Rates of return	**Rural / urban**
Solar PV	Allocation based on current trend analysis	• Drive to increase PV integration into the built environment • Low carbon new development	**Coastal, rural and urban**
Geographical distribution of solar PV at end of Q1 2016 used to inform spatial distribution of future solar PV and irradiation data from Global Horizontal Irradiation			

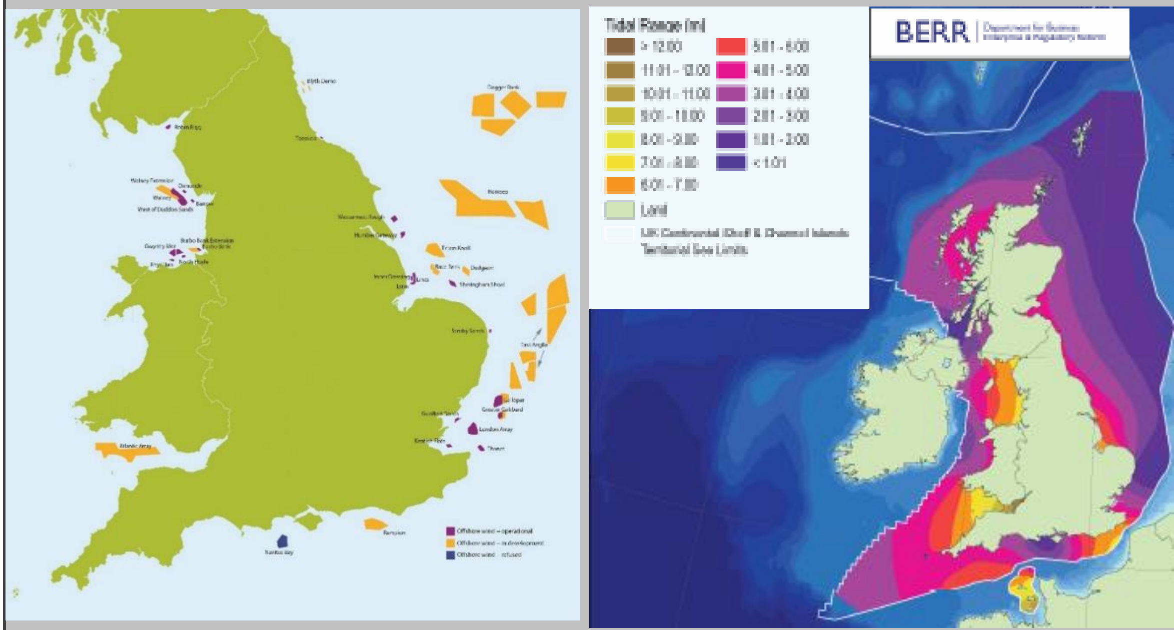




Onshore wind	Based on recent trends	• Current planning policy for onshore wind power in England significantly impacting upon future deployment figures	**Rural**
Geographical distribution of onshore wind at end of Q1 2016 used to inform spatial distribution of future onshore wind and English wind resources			





Offshore wind	Based on existing project pipeline	• Continued rounds of Contracts for Difference	**Seascapes, coastal**
Existing pipeline of offshore wind projects used to inform the spatial distribution of future onshore wind and Mean spring tidal range resources 			
Marine	Based on existing pipeline of tidal stream in Scotland, wave power in England, the majority of which in Cornwall with the remaining capacity coming from tidal range in Wales	• R&D investment in wave and tidal stream • Policy position on tidal lagoons	**Seascapes, coastal**
Bioenergy	Scenarios include overall reductions in capacity.		**Rural, industrial**
Storage	Assumed that any additional pumped hydro storage would not be in England due to geography. Based upon current applications Assumptions around battery storage vary for each scenario For Gone Green: • industrial and commercial storage assume 70% in England following existing demand patterns • community storage assume 75% in England	• Policy support for large scale storage measures such as compressed air storage • Regulatory support for battery storage[17]	**Urban, rural**

[17] Regen SW (2016), Energy Storage – Towards a commercial model 2nd Ed.

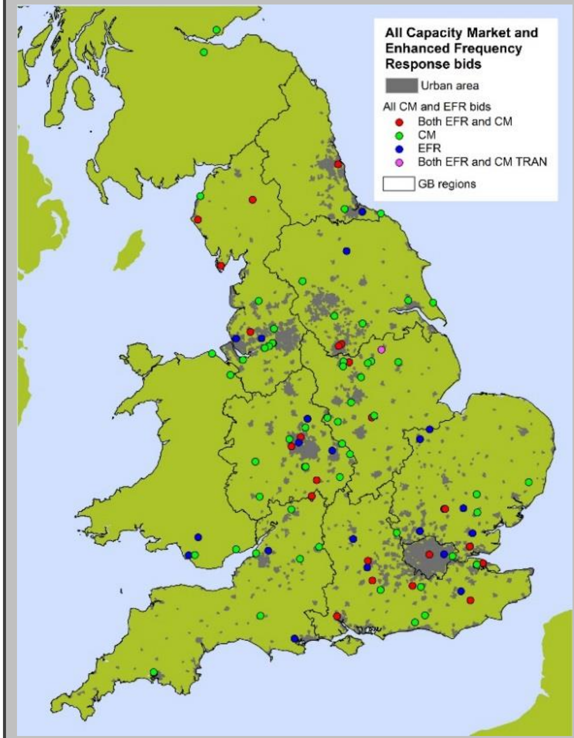
following existing PV installation patterns

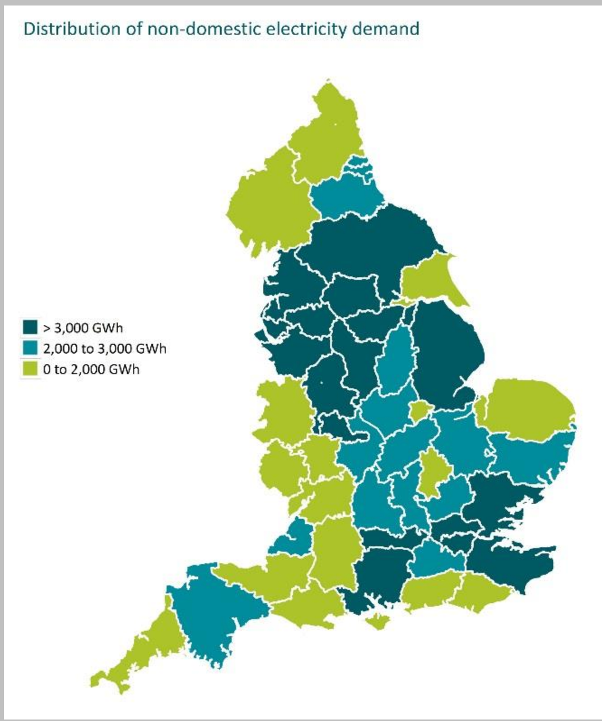
- co-located storage assume 50% in England following existing PV and wind installation patterns

For Mega Flex:

- response services delivering 16% of the market, with 75% of this located in England, following a geographical pattern similar to the locations of the enhanced frequency response bids seen below
- reserve services, delivering 32% of the market, with 30% in England following a geographical pattern similar to the locations of the capacity market bids seen below
- commercial and industrial storage, delivering 20% of the market, with 70% in England, following existing demand patterns
- own use and community, delivering 16% of the market, with 75% in England, following existing PV installation patterns
- co-location contributing 16% of the market, with 50% in England following existing PV and wind installation patterns

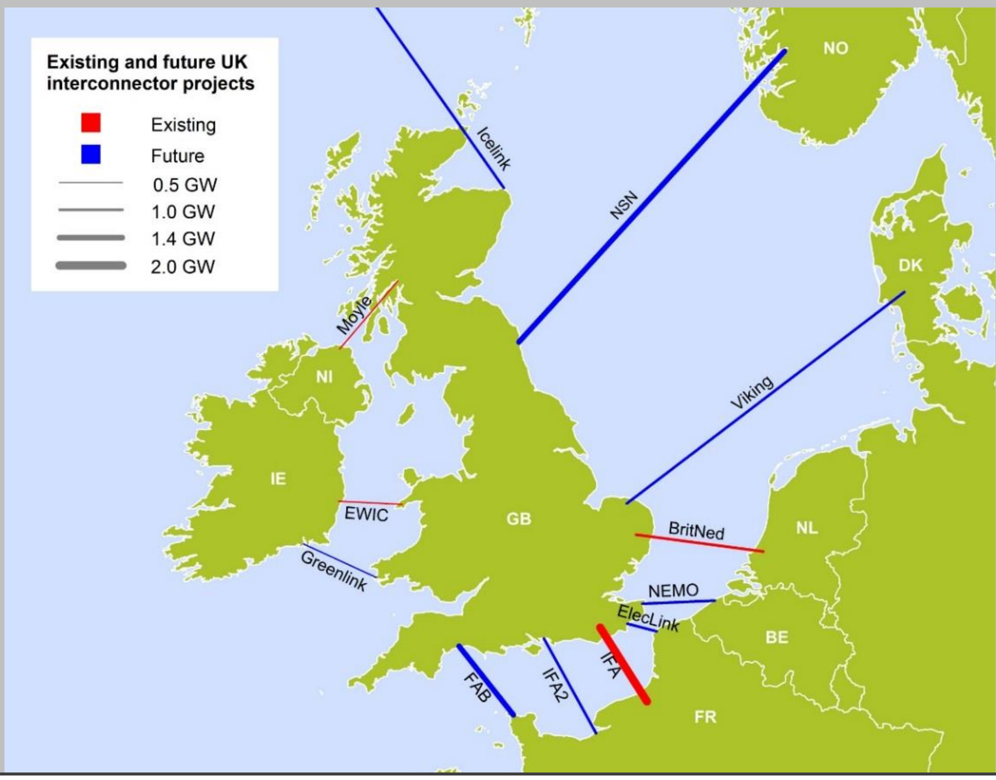
Example of trend maps used to inform geographic spread of future storage





Inter-connectors	Based on the new capacity in the pipeline. Additional capacity under the GG scenario not assigned	• Harmonisation with European energy market post-Brexit	**Coastal**

Existing pipeline of interconnection projects used to inform future spatial distribution



Further details can be found in Annex 1.

4 Landscape assessment

4.1 Approach to assessing the landscape effects of the scenarios

4.1.1 Once a technological breakdown and spatial distribution of the scenarios had been allocated (as set out above), the landscape assessment could be undertaken.

4.1.2 The landscape assessment was undertaken by The Landmark Practice and follows professional guidance set out by the Landscape Institute and the Institute of Environmental Management and Assessment (IEMA) in Guidelines for Landscape and Visual Impact Assessment (GLVIA3). The approach that has been developed takes as a starting point the European Landscape Convention (ELC) and uses its aims to inform how objectives and criteria are formulated to assess effects.

4.1.3 The method of approach and selection of objectives and criteria has been further supported by a literature review of current guidance and research documents prepared for Natural England (NE), Department for Environment, Food and Rural Affairs (DEFRA) and Scottish Natural Heritage (SNH).

4.1.4 For this study, the method of approach (as summarised below) drew on some of the key stages of Strategic Environmental Assessment (SEA), as follows:

Understanding the key characteristics of the technologies within each scenario

Understanding how the landscape may change as a result of the scenario

Determining the objectives and criteria to assess this change

Using these objectives and criteria to determine the effects of the scenario

Assessing the potential to mitigate impacts and secure wider opportunities

4.1.5 Where possible, broad changes to landscape characteristics and people's perceptions were considered. These included land take, development type and associated infrastructure (scale, mass, nature and location), proximity to people, change and duration of experience and understanding.

4.2 Defining landscape objectives and criteria

4.2.1 Defining the landscape principles, objectives and criteria is fundamental to assessing potential impacts and also provides the hierarchy against which the significance of effects of the energy scenarios can be judged. Based on the seven generic principles set out in the ELC[18], objectives and criteria were prepared for this study. The ELC principles therefore provide the fundamental and overarching framework within which project specific objectives and criteria are defined.

4.2.2 Due to the high level of the assessment, the objectives and criteria are general. Whilst a SEA at local plan level would include eight to ten objectives, only five of those identified by ELC guidance were defined as meaningful to this study. That is due to the extensive geographical (national) scale of this assessment and the current level of knowledge on the predicted likelihood, nature, scale and location of significant effects on the landscape[19,20]. These principles are:

1	***Recognise the landscape in a holistic sense***
2	***Apply to all landscapes***
3	***Involve people***
4	***Integrate landscape***
5	***Raise awareness of the importance of landscape***

4.2.3 Deferred Baseline: Any policy, action or decision has the potential to impact on the landscape. ELC Article 6c, Identification and Assessment, accordingly advocates baseline landscape assessment to set a context for describing and understanding the effects of landscape change. This is addressed by principle 4, and is carried forward through tools such as Landscape, Seascape and Historic Character Assessments. Landscape characteristics, forces and pressures should then be analysed alongside changes and effects. ELC guidance[21] sets out guidelines against which relevant bodies can incorporate the content of the ELC and give expression to its intent.

4.2.4 This study is, however, concerned with the assessment of the effects of two alternative scenarios at a given point in the future (2030), and recognition of the imperative, thereafter, to make the structural changes in systems of energy generation, distribution and use required to achieve emissions reduction of at least eighty per cent in 2050 from 1990 levels.

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[18] LUC (2009), European Landscape Convention Guidance Part 2: Integrating the Intent of the ELC into Plans, Policies and strategies, published on behalf of Natural England

[19] SNH (undated), Landscape Considerations in Strategic Environmental Assessment

[20] Landscape Institute and IEMA (2013), Guidelines on Landscape and Visual Impact Assessment, 3rd ed. Hoboken: Taylor and Frances. *Para 1.17.*

[21] LUC (2009), European Landscape Convention Guidance Part 2: Integrating the Intent of the ELC into Plans, Policies and strategies, published on behalf of Natural England

4.2.5 It would be misleading to make any assessment now of the impact of change in delivery of energy infrastructure between the current (2017) landscape baseline and the scenarios proposed for 2030, and beyond in 2050.

4.2.6 Nonetheless, whilst no accurate or meaningful objective can be proposed to address this principle, the assumption can be made, based on historic trends and current knowledge of future needs, that the British landscape will continue to evolve and change into the future. This continued change will be in response to social, economic and environmental drivers, not least of which will be the need for land use adaptation to address climate change. As such, the 'likely' landscape impacts of developments under each scenario are considered in broad terms.

4.2.7 The principles and key messages and the way in which they were converted, where appropriate, into 'proposed objectives' and 'criteria' against which they will be measured, is summarised below:

4.2.8 **Principles 2 and 3: 'Recognise landscape in the holistic sense intended by the ELC' and 'Apply to all landscapes'**. The ELC, Article 1 provides a clear definition of landscape and advocates that a holistic approach should be taken. Article 2 Scope of the ELC goes on to state that landscape covers 'natural, rural, urban and peri-urban areas' as well as 'land, inland water and marine areas.' This includes all landscapes, whether they are outstanding, commonplace or degraded. Equal consideration should be given to protected landscapes as well as to ordinary every day landscapes where the majority of people live, and which are highly valued and affect people's quality of life. Such values will be different for different people at different times of year and during their lives.

4.2.9 Recent research indicates that the 'landscapes and ecosystems that are most valued by people are diverse, have a strong and recognisable character (sense of place), support abundant wildlife, are relatively accessible, and offer relative tranquillity – the ability to get away from it all.'[22] People also have the strongest attachments to places where they live and/or work, and may be resistant to changes in these places[23]. Although special places, such as Dartmoor or the Lake District, are visited less often, they hold strong emotional attachments to visitors, evidencing ELC's intent that 'all landscapes matter.'

4.2.10 A study by Defra, prepared to inform Natural Environment policy, considered public perceptions of existing UK landscapes and ecosystems, and potential future changes to these. The report found that the countryside and greenspace were 'crucial or very important to quality of life', and when interrogated further, some broad preferences for certain landscapes and ecosystem types were apparent. 'Firstly, the coast; secondly, mountains and hills, water, rivers and streams, and woodlands (with the wide range of social benefits provided by woodland having been extensively researched), and rural villages; thirdly, field systems, hedgerows and field walls, and country lanes; and finally, bogs and marshes and moorland'[24].

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[22] LUC (2011), Public Perceptions of Landscape and Ecosystems in the UK, Defra NE0109: Social Evidence Review To Inform Natural Environment Policy.
[23] The Research Box, LUC & Minter R. (2009), Experiencing Landscapes: capturing the cultural services and experiential qualities of landscape, produced for Natural England
[24] LUC (2011), Public Perceptions of Landscape and Ecosystems in the UK, Defra NE0109: Social Evidence Review To Inform Natural Environment Policy.

The report guidelines concluded that:

- landscape should be recognised in its own right
- landscape should be recognised as a whole, including natural, cultural and perceptual attributes
- landscape exists at all scales
- landscape should be all encompassing
- all landscapes should be considered in all conditions, outstanding or ordinary

Proposed Objective: To protect, enhance and restore landscape.

Criteria:
Will environmental problems related to landscape (if they exist) be resolved or exacerbated (i.e. improvements to degraded or spoiled landscapes, eroding or erosion of character or cumulative or synergistic change)?
Is the value of the landscape and its vulnerability to change likely to be affected as a result of its key characteristics or cultural heritage or local distinctiveness (i.e. sensitivities associated with artistic, cultural or historic associations, historic continuity, high degree or naturalness, role in separating settlements or providing a backdrop to settlements)?
Is the energy scenario likely to have an effect on areas of landscapes which have a recognised international, national or local status (i.e. World Heritage Site, National Park, AONB, Heritage Coasts, Registered Park and Garden or local landscape designation)?
What will be the magnitude and /or spatial extent of effects on the landscape, including the geographical area likely to be affected (considering extent of land take, scale and mass of either buildings and /or infrastructure through replacement, upgraded, extended development and decommissioning)?
Will the scenario have an effect on everyday landscapes adjacent to where people live and /or work?

4.2.11 **Principles 5 and 7: 'Involve People' and 'Raise Awareness of Landscape'.** The ELC recognises that landscape is a result of people's perceptions, how they experience and value landscape and, consequently, how it affects their quality of life. Landscape is a product of all senses, and in understanding the landscape it is essential that these perceptual and experiential qualities are considered.

4.2.12 ELC Article 5D seeks to establish procedures for participation in landscape policies at all levels, while Article 6A seeks to raise awareness of the value of landscapes to everyone, their role and changes to them, and recognising that everyone has a duty to look after the landscape. Consultation with the public to determine how landscape is valued is advocated (Article 6D).

4.2.13 One of the five key principles for Landscape Character Assessment is to ensure that there is an 'understanding of how the landscape is perceived and experienced by people'[25]. People's perceptions and experiences of landscapes vary, and an appreciation of the landscape is not just visual, as 'we understand landscape using all our senses (hearing, sight, touch, smell and taste)'[26]. Value judgements are also based on political and life experiences, people 'who have experienced or are at least aware of past change to landscapes and ecosystems are often better able to understand and accept future changes' [27]. The guidelines concluded that:

- appraisal techniques should be used to involve people
- there should be a greater awareness of the importance and values of landscape

Proposed Objective: To improve public understanding and enjoyment of landscape.

Criteria:
What will be the magnitude and spatial extent of the scenarios' effects on people's enjoyment of the landscape, including people likely to be affected in the context of their sensitivity to landscape change? Is it a landscape enjoyed by a large number of people through everyday life or by fewer people seeking solace, tranquillity, naturalness and remoteness, and other sensory attributes?
To what extent will the magnitude and spatial extent of effects on receptors using National Trails and open access land affect their enjoyment of the landscape?

Proposed Objective: To improve the public understanding of landscape change.

Criteria:
Will the nature of the scenario, its duration and change, improve public understanding of landscape and acceptance of future change?

4.2.14 **Principle 6 'Integrate Landscape'.** One of the key aims of the ELC is to integrate landscape into planning, (Article 5D), and it is increasingly recognised that landscape can provide a wide range of benefits and services through ecosystem services. Multiple functions may include groundwater protection, flood management, climate regulation, biodiversity and cultural heritage.

[25] Tudor C., Natural England (2014), An Approach to Landscape Character Assessment
[26] SNH (undated), Talking About Our Place, Topic Sheets, p.9.
[27] LUC (2011), Public Perceptions of Landscape and Ecosystems in the UK, Defra NE0109: Social Evidence Review To Inform Natural Environment Policy.

4.2.15 In terms of the implications for plans and programmes at a strategic level, greater consideration should be given to how any area of land can deliver multiple benefits in a positive and planned way. The guidelines concluded that:

- multi-functional landscapes should be promoted
- landscape should be integrated into all sectoral policies that have a direct or indirect influence on landscape
- defined landscape objectives for any given geographic area should be considered setting out specific landscape sensitivities associated within different types of development

Proposed Objective: *To* recognise the range of functions and benefits that landscape can offer.

Criteria:
Will the presence of development associated with the scenario and its delivery achieve multiple benefits to the landscape (i.e. mitigation measures associated with sectors such as solar PV can include reinstatement of historic landscape features and enhancement of hedgerow biodiversity value and connectivity in the landscape)?

4.2.16 For each scenario, and in accordance with the SEA Directive, consideration was given, where possible, to likely significant effects and whether such effects were 'secondary, cumulative, synergistic, short, medium and long term, permanent and temporary, positive and negative effects'[28]. This information, where feasible, is included for each scenario. The assessment of effects used a 'traffic light' code for positive, neutral, negative and uncertain effects, and the scale of effect was considered, as well as the certainty as to whether the effect would occur.

4.2.17 It should be noted that synergistic and cumulative effects were considered in general terms for both scenarios, since each scenario will generate more than one form of development. A 2015 study on cumulative effects of landscape change[29] concluded that when assessing cumulative landscape and visual effects, the assessment should focus on the total change resulting from all proposed development. Alongside this assessment of overall effect, consideration should be given to its duration and permanence.

4.2.18 The report also notes that assessments carried out in relation to SEA / SA are likely to identify more significant effects where:

- 'the developments/proposals intensify changes to landscape character such that they change key landscape characteristics or transform the landscape into a different landscape type

[28] European Parliament, Council of the European Union (2001), Strategic Environmental Assessment Directive 2001/42/EC of the European Parliament and of the Council of 27 June 2001 on the assessment of the effects of certain plans and programmes on the environment, Official Journal L 197, P.0030-0037, *Annex 1 footnote*
[29] Cumulative Effects: Building a Natural England Approach to Landscape Change, (June 2015)

- the developments/proposals adversely affect special qualities of protected landscapes
- proposals are clearly visible together in views from the selected viewpoints or routes (viewpoints in protected landscapes and views from National Trails will be of most interest to Natural England)
- proposals detract from, or conflict with, existing features of the view that contribute to visual amenity
- proposals 'fill' a view such that they alter the character of a view/ visual amenity'

4.3 Results of the assessment of landscape effects

4.3.1 A summary of the assessment of the two different scenarios can be seen in Annex 2. For both scenarios, the nature of effects will depend on the type of technology, its specific locational requirements and the timing/duration of deployment.

4.3.2 Due to the high level nature of the information describing the possible scenarios, and in the absence of a detailed evidence base against which to test assumptions around the landscape effects of each type of energy infrastructure, the following assessment and conclusions are broad, and largely generic, in scope.

4.4 Gone Green scenario landscape effects summary

4.4.1 National Grid's Gone Green scenario focuses on driving forward a wide range of low carbon technologies, including wind and solar; with gas playing an important role as peaking capacity alongside energy storage, Demand Side Response and 23.3 GW of supporting electricity import capacity by 2030.

4.4.2 Under this scenario the capacity of the whole system including storage and interconnection in Great Britain in 2030 is 161,862 MW with 130,490 MW of installed generation capacity. Total capacity for renewables would be 88,474 MW by 2030, of which 58,635 MW would be new build. For the purposes of this study it is assumed that the replacement of existing capacity will be encouraged on existing sites. An assumption has been made that England will facilitate approximately 37,602 MW of this based on previous trends and other key factors.

- The key landscape issues associated with this scenario are land take and impact on highly valued landscapes. The scenario includes significant new nuclear capacity and levels of interconnection beyond those currently being considered. Through the expansion of existing nuclear sites and new infrastructure at the point of landfall of the interconnectors, these developments could have a significant impact on the highly valued coastal environment.
- This scenario includes a significant amount of CCGT, which would also have landscape character and visual amenity impacts associated with a large land take, scale and mass of the structures on site, stacks, infrastructure electricity transmission pylons and lines feeding into the grid.

- The geographical area required to deliver new renewable energy capacity, particularly through solar and wind power, both on and offshore, is also significant. Whilst some development will be accommodated in landscapes which have already experienced a change through recommissioning, and by use of brownfield sites and rooftops with zero 'new' land take, other landscapes which have not historically been affected by energy infrastructure, will now be needed to meet demand. Assuming continued political and popular support for the statutory protection of nationally valued landscapes, it should be anticipated that pressure for deployment of the required solar and wind development will be concentrated in any, or all, landscapes that are not subject to the highest levels of environmental protection i.e. sites, features and areas designated as of national or international landscape or other environmental value. Outside such areas, in 'ordinary' landscapes there are therefore likely to be impacts on public enjoyment of the landscape.

- Moderating factors should also be considered. The landscape effects of some technologies are temporary in nature, there is capacity for the form, size and efficiency of technologies to be modified to create less dominant effects on the landscape, and the perception of the visual impact of energy structures may be tempered by intelligent design and planning, and by investment of effort in changing public perception of the role of renewable energy in addressing climate change priorities. The landscape effects of particular solar and wind power infrastructure may be temporary in nature, so long as the location for such infrastructure is not reused (see paragraph 3.5.15).

- The exact nature of the effect on many of the criteria remains uncertain due to the limited location specific information available. This assessment finds that, based on the information currently available, mixed, uncertain and positive effects will be generated as a result of the Gone Green scenario.

4.5 Mega Flex scenario landscape effects summary

4.5.1 The Imperial College London's Mega Flex scenario was chosen to compare to that of National Grid's Gone Green scenario in order to examine the value of the role of flexibility in minimising the construction of unnecessary infrastructure.

4.5.2 The Mega Flex scenario requires slightly less generation capacity than the Gone Green scenario, mainly because more wind is installed and less solar PV. It includes less nuclear power, less PV, less CCGT capacity, fewer interconnectors, but substantially more storage and OCGT capacity to help meet peak demand. OCGT is generally assumed to be smaller than CCGT, less efficient, more expensive per kWh and with a higher carbon outcome. It is however considered cheaper to build and fire up to meet peak demand, so it is run at a very low capacity factor in this scenario for this purpose.

4.5.3 Under the Mega Flex scenario the capacity of the whole system in Great Britain is 157,500 MW with 122,800 MW installed capacity. Total capacity for renewables by 2030 will be 78,300 MW with 51,743 MW new build, and we are assuming that England will facilitate approximately 33,966 MW of this.

4.5.4 Compared to Gone Green, Mega Flex has slightly more onshore and offshore wind, but less solar PV. It has been assumed that a wide geographic spread across the UK would be needed to reduce the reliance upon single weather systems, particularly as a significant proportion of Europe's offshore wind capacity is based in the southern area of the North Sea.

4.5.5 This scenario is supported by a range of other flexible measures including a substantial amount of storage and interconnection. This storage is likely to be located close to existing demand, grid infrastructure and/or generation.

4.5.6 Mixed, uncertain and positive effects will be generated as a result of this scenario. Sea take will be higher for offshore wind, whilst land take is more limited, with less new land taken for solar than the Gone Green approach. Many on and off shore wind developments will be located in new sites in landscapes not traditionally used for energy infrastructure, although OCGT and new storage facilities will require land take on both green and brownfield sites. Subject to other land management and/or development drivers, there may be opportunities to direct such investment towards recommissioned, brownfield or industrial sites, or be co-located with other technologies. Such options offer opportunities for utilising landscapes which may already be eroded in character, and integrating energy development with wider benefits, such as biodiversity enhancement and new leisure opportunities.

4.5.7 Overall land take in traditionally rural landscapes for this scenario is less marked than anticipated for the Gone Green scenario. The focus of development is likely to be close to existing development and/or demand and therefore, possibly, more acceptable within a landscape already characterised by existing infrastructure, and by social habituation to ongoing landscape change, especially if policy encourages design approaches that offer multi-functional benefits and enhance existing landscapes. Local landscapes are nonetheless valued, and use of brown and greenfield sites is likely to be subject to intense popular pressure to deliver effective, and potentially costly, mitigation measures that address negative landscape impacts. Effects on people's enjoyment of familiar landscape will be influenced by the location of development in relation to their valued local landscape, and the capacity of the landscape to absorb the above changes in energy infrastructure alongside other changes associated with unrelated economic and social drivers.

5 Conclusions

5.1 Was our hypothesis supported?

5.1.1 The key question for this study was, 'what approach should be taken to the zero carbon transition to minimise negative impacts and secure new opportunities for landscape enhancement?' and our hypothesis was that a smart, flexible energy system, supported by a strong innovation and design framework would be the best approach to achieve this.

5.1.2 On the surface, our findings showed the landscape assessment of the scenarios examined to be mixed across both scenarios. Whether or not our hypothesis is supported therefore hinges on how the transition is felt by society, how it's implementation is managed and whether it is truly supported by a strong innovation and design framework.

5.1.3 This is due in part to the fact that the steps to achieve decarbonisation of our energy system are not yet clear and so the level, type and timing of investment to achieve certain goals can vary significantly, but also because there is no silver bullet that will address the carbon impact of our energy system without having some impact on our landscape.

5.1.4 The conclusions that we have been able to draw from the study come from our analysis of the timing, nature, location and extent of the potential impacts and not just how these elements vary across the scenarios, but the way in which they will impact people in different ways.

5.1.5 The hypothesis that a smarter system will have lesser impact on the landscape can be supported by the fact that less large scale infrastructure would be needed to support the system. However, exactly how much less, comes down to the way in which the system is managed and society's attitude to risk and mitigation of that risk.

5.1.6 As the role of system operation extends down to the distribution network level and local energy markets begin to emerge, we expect to see a significant shift in this area.

5.1.7 The need to integrate technology into the system to improve its efficiency will mean that unless societies response to energy technology in the landscape shifts, the impact will be felt by more people and therefore under ECL principles where all landscapes have intrinsic value, this would not support our hypothesis.

5.1.8 However, the impact of this process could be that people continue to become more aware of the energy infrastructure around them and the role it is playing in serving their needs. Despite impacting a greater number of people, if the result is to stimulate changes in behaviour, supported by improved communications, new technology, pricing and incentives, all of which enable improved management of our energy networks and grids and a subsequent reduction in the need for peaking capacity, this would support our hypothesis.

5.1.9 The need for continued research and development into highly efficient low and zero carbon energy sources, information collection and management, and devices and materials which integrate energy saving and generation into our everyday landscapes are the key to minimising impact on the landscape. This does however need to be supported by societal acceptance of the need improve how we manage energy. The digital age is increasing our reliance on power and our risk mitigation strategies to ensure we have access to the power we need when we need it are key to how the impact of the transition is felt over time.

6.1 Policy recommendations

6.1.1 Examining the scenarios in this manner has, however, drawn out a number of recommendations relating to the principles examined:

Principle 1: Landscape impacts should be an integral feature of a clear UK energy policy

6.1.2 The decarbonisation objective of our current energy transition is clear. However, the end state has yet to be defined, so what this looks like and the trajectory of the zero carbon transition is still very much up for debate. Clarity is therefore needed about the route to achieving decarbonisation of our energy system.

6.1.3 The end state of this transition should soon be clarified and brought into line with our commitments under the Paris Agreement, with a much clearer trajectory mapped out through the new Emissions Reduction Plan expected later this year.

6.1.4 Clarity on the objective and the key milestones to achieve this will be vital to direct investment and avoid the potential problem of redundant stranded assets; a situation which could occur if investment in new least cost infrastructure to address the energy gap takes place, which then ends up being left idle as carbon regulations tighten over time.

6.1.5 Of paramount importance to achieving our commitment to decarbonise is to address the policy gaps that currently exist, not only to achieve our carbon budgets, but to put us on the path to achieve our commitments under the Paris Agreement. There are a number of policies that are assumed in the scenarios to have been implemented that are currently missing from the national policy framework, such as a zero carbon homes policy.

6.1.6 The trajectory of our decarbonisation pathway will remain uncertain until clear policies are put in place to deliver these commitments that add up to the scale of change required.

6.1.7 Scenario planning can offer some insight into these pathways. They need to be built upon a realistic policy framework for delivery that will support decision-making. Some recommendations of policy areas which should be urgently revisited or addressed are set out below:

Figure 11

Commitment

- Improved societal understanding of zero carbon energy transition
- Strategic environmental assessment of energy scenarios, policies and plans
- Local energy planning that positively engages communities.

Minimising power demand

- Energy efficiency standards across all sectors of the economy
- Zero carbon building standards for all new development
- Policy and planning to drive innovation

Shifting peak demand

- Adoption of smart meters and Time of Use Tariffs
- Integration of solar PV and storage into buildings
- Managing electrification of transport to minimise charging at peak periods

Management of peak demand

- Policy and planning support for Demand Side Response
- Planning support for distribution of wind energy to increase resilience

Utilisation of existing infrastructure

- Policy support for repowering existing sites and network connections
- Innovative decommissioning requirements
- Integrate consideration of land use into public decision making

2050 net zero carbon energy

- Increased investment in R&D for emerging technologies such as marine energy
- Support for district heating and integration of the gas and electricity
- Design infrastructure for adecarbonised society

6.1.8 There is clearly a pressing need to devise and implement cogent pathways to deliver new energy infrastructure. The resulting energy developments will create significant effects across the British landscape, modifying landscape services and therefore how we see the landscape. Landscape therefore needs to be considered at a strategic level in the development of energy scenarios to support delivery.

6.1.9 If energy scenarios do not consider the impacts of change on the landscape and engage the public at an early stage, essential energy developments are likely to be resisted and challenged. The scenarios considered by this study demonstrate the restricted approach to the formulation of any kind of energy strategy, driven by technology and cost considerations, rather than holistic attention to wider environmental constraints, opportunities and consequences.

6.1.10 Wider consideration of the landscape as a multifunctional provider of services, a driver of economic productivity and quality of life is critical to anticipate, understand and manage the changes that will result.

6.1.11 What is clear from our analysis is that the way in which the energy transition unfolds will determine the nature of the re-appraisal of the form, function and value of some contemporary and familiar landscapes. Considering 'landscape' in its broadest sense provides a useful context for understanding our energy transition[30]. While energy landscapes generally become 'normalised' over time.

6.1.12 It is therefore vital that these issues are dealt with at a strategic level. One approach would be to undertake comprehensive strategic environmental assessment of energy scenarios, policies and plans published by Government. Undertaking the basic landscape assessment of current published scenarios set out in this report has highlighted the level of spatial understanding that is required in order to make valid assumptions upon which an assessment can be made. The ability to make judgements about spatial distribution of development will improve as the policy pathway to the delivery of the zero carbon transition matures.

Policy recommendation: **The Emissions Reduction Plan must include a clear objective and end state that sets out what success looks like and how it will be measured; and a detailed trajectory that sets out the steps by which the UK will achieve this objective, and a supporting policy pathway to achieve this. A strategic environmental assessment of energy scenarios designed to explore the Emissions Reduction Plan should be undertaken.**

Principle 2: The ELC should be used to enable a positive approach to the design of energy in the landscape

6.1.13 The Convention provides a context to support effective energy transition, to promote public understanding and, ideally, informed support for appropriately scaled and sited energy technologies. As such, a post-Brexit UK Government would be wise to embed the principles of the ELC in energy policy at all levels.

[30] Bridge G., Bouzarovski S., Bradshaw M. & Eyre N. (2013), Geographies of energy transition: Space, place and the low-carbon economy *Energy Policy* 53, 331-340.

6.1.14 The Overarching NPS on Energy states that the landscape and visual effects of energy projects 'will vary on a case by case basis according to the type of development, its location and the landscape setting of the proposed development'[31]. Whilst the document accords with the ELC in terms of its definition of landscape and takes a holistic approach to determining the value of all landscapes, it lacks detailed consideration of how a positive approach can be achieved to address the landscape and visual impacts of energy deployment. For example, innovation and design, driven by a clear policy direction and improved awareness, could fundamentally shift our approach.

6.1.15 Looking to the development of different technologies, the landscape and visual effects of developments will vary depending on the type, location and proximity to visual receptors. Positive steps have started to improve design in energy developments, based on increased understanding of the landscape and visual impacts associated with such technologies, and recognition of the importance of the landscape on quality of life[32]. These positive steps have resulted in best practice improvements in relation to energy development design, for example.

6.1.16 Referring to contextual landscape characteristics to enable decisions to be made over the relative position of developments to each other, their variation in height, form and levels of inter visibility:

- reducing the overall scale, mass and land take to minimise effects
- drawing references from the surroundings to reduce visibility
- integrating development into the landscape with avoidance, where feasible, of skylines and ridgelines
- utilising existing landscape features to maximum benefit to integrate the development into its surroundings and reduce light pollution
- reusing existing energy sites where possible

6.1.17 Where infrastructure cannot be concealed in sensitive landscapes or in landscapes that would benefit from more variety, future designers could also borrow the approach of celebrating, rather than hiding, infrastructure development, exemplified by the design of Trawsfynydd Power Station by Sir Basil Spence, with landscape design by Dame Sylvia Crowe[33]. They could also look to achieve innovation in design, perhaps taking inspiration from initiatives such as Land Art Generator[34], that seek to change our appreciation of energy infrastructure.

Policy recommendation: **Government should embed the principles of the ELC into its policy framework, enabling a positive approach to energy in the landscape and supporting innovative design.**

[31] DECC (2011), Overarching National Policy Statement on Energy, (EN-1)
[32] National Grid (2017), North West Coast Connections project: Document navigation booklet: A guide to our consultation documents
[33] Coflein (2017), Trawsfynydd Power Station, Grounds and Gardens [online]
[34] http://landartgenerator.org [online]

Principle 3: People are at the heart of the energy transition and its impacts

6.1.18 The zero carbon transition *will* impact on new landscapes in new ways, requiring a societal shift in the way energy is viewed to enable innovation, whether in types of technology or indeed their design, and ultimately acceptance.

6.1.19 Our analysis shows that we need to continue if not accelerate recent trends for greater system flexibility and decentralisation of energy generation with low carbon technologies, including wind and solar if we are to achieve an efficient, zero carbon power sector commensurate with delivering our commitments under the Paris Agreement. In addition, investment should focus on landscapes already affected by energy infrastructure and urban landscapes where more of the energy demand is located, making the most of opportunities to secure multiple benefits for landscapes. A smart approach to managing our energy infrastructure can potentially alter the balance of the spatial and societal effects resulting from the energy transition.

6.1.20 An increased focus on design, demand management and associated storage, will begin to challenge some of our long-standing assumptions about urban spatial form, the density of settlement, transport infrastructure, building design and choice of materials in the future.

6.1.21 Locating energy generation close to demand for example will almost certainly result in more people being locally affected by landscape change. However, the corollary of co-locating generation close to centres of population is a reduced need for long distance transmission infrastructure, which can have severe impacts on visual amenity, landscape character and ecology. How society would deal with the need to balance localised impacts of generation close to the point of demand, against effects of distributed generation on more distant but traditionally valued landscapes, is key to public and community acceptance or rejection of future energy strategies. This is something that would benefit from further exploration.

6.1.22 As with previous energy transitions, the zero carbon transition needs to be supported by a societal transition, changing the way energy is viewed in relation to its use, generation and supply.

6.1.23 Ultimately public acceptance and support for future energy policy delivery will depend on popular and stakeholder understanding of the need for change and, particularly, the pace of change required to achieve decarbonisation of energy use and the choices that exist. New energy infrastructure of any kind will modify the use and perception of the landscape, with potential for both negative and positive outcomes. A key principle for making the shift to a zero carbon system is therefore investment in dedicated effort to educate and engage public and stakeholder interest in both the wider environmental benefits of appropriate new energy infrastructure, and in policy formulation from the earliest stage, with the view to identify acceptable routes to achieving UK commitments.

6.1.24 Society needs to be informed of, and brought with, decision makers and the sector on this journey. Leaving this issue for an under resourced local planning system to unravel, for example by failing to give a clear steer, is proving to be wholly unsustainable. Some suggestions as to how this could be explored further, at least at the community level, have been examined by CPRE and the Centre for Sustainable Energy in Future Energy Landscapes, 2016. In order to comply with the principles of the ECL, specific engagement at the national level on landscape impacts and opportunities from the zero carbon transition should be carried out, such as through the development of the National Infrastructure Assessment.

Policy recommendation: **National and local Government need to invest in a programme of engagement around the zero carbon transition and involve stakeholders in the policy making process at an early stage.**

Principle 4: Effective public understanding of and engagement in the energy transition could lead to reductions in peak demand, reducing infrastructure needs

6.1.25 Our hypothesis stated that a smart, flexible energy system, supported by a strong innovation and design framework could minimise the impact on our landscape of the twenty first century zero carbon transition. What this analysis has shown is that even with flexibility at the heart of a future energy scenario, the scale of the transition required means that significant volumes of new generation capacity will still be required. The value that flexibility offers is the potential reduction in overall generation capacity required. However, unless this flexibility extends to our management of peak demand, scenarios still include excessive peak demand capacity that operates at very low capacity factors with resulting impacts upon our landscape and indeed consumer bills.

6.1.26 To address this requires a change in our approach as energy consumers – away from expecting to be able to access endless energy supplies whenever we demand. Changing this fundamental would enable a change in the level of acceptable risk the system operators are prepared to operate under. Addressing this issue would therefore enable greater confidence in the impact of ToUTs and other Demand Side Response options which would support the case for less peak demand capacity.

6.1.27 In addition to this, consideration of meeting our peak demand needs in the way we build generation capacity is also important. For example, ensuring that our wind capacity is well distributed across the UK to benefit from different weather systems and reduce the likelihood of the incidents where wind power cannot contribute to peak demand, enabling reduced derating factors. Further exploration of these issues by the system operators could support the case for reduced investment in new generation capacity.

Policy recommendation: **System operators should further explore and share the potential benefits of wider public engagement and understanding of the issue of peak demand management and its impacts.**

Principle 5: Multi-functional approaches offer the opportunity to build public support for energy in the landscape transition could lead to reductions in peak demand, reducing infrastructure needs

6.1.28 Innovative approaches to energy in the landscape could help to drive public awareness and support. In particular, where feasible, landscapes should serve a number of functions, informed by a landscape strategy and driven by robust and effective policy. Key objectives of policy to achieve this could be:

- to integrate consideration of land use into public decision making and investment

- to optimise the use of land, taking account of the interactions between different uses

- to provide a cogent basis for taking account of the value of land in land use planning and management decisions

6.1.29 Integrating measures to mitigate and adapt climate change with wider benefits, can help secure acceptance for landscape change. Tidal lagoons can, for example, generate zero carbon electricity and improve flood management while offering new recreational opportunities.

Policy recommendation: **In considering energy in the landscape, the potential for more multi-functional landscapes should be explored.**

Annex 1. Spatial analysis of scenarios

Existing Baseline	Gone Green	Mega Flex		
Key characteristics	Key characteristics	Key characteristics	Landscape effects	Comments
Total GB system capacity in 2017, 96,829 MW	Total GB system capacity in 2030, 161,862 MW, with **130,490 MW** of installed capacity	Total GB system capacity in 2030, 157,500 MW with **122,800 MW** of installed capacity		
Total GB renewables capacity in 2017 33,338 MW	Total GB renewables capacity in 2030 **88,474 MW,** with **58,635** MW new build	Total GB renewables capacity in 2030, **78,300 MW** with **51,743 MW**		
• **GB hydro capacity in 2017 of 1,750 MW**	In 2030, total of **1,829 MW** with **79 MW** of new build in GB of which we assume **24 MW** is in England of a small scale	Total GB capacity of **1,500 MW**, which is less than current capacity	• Location specific • Size of reservoirs /dam dependent on size of generator and topography • Change in landscape character (loss of features/character) and visual amenity as a consequence • New infrastructure works associated with development	Hydro has been significantly affected by the changes to the feed in tariff, as it is a technology that doesn't have the potential for significant cost reductions due the high level of civils associated with each scheme. The potential for small scale hydro is therefore small, but would still need a change in policy direction to support its full utilisation

• **GB bioenergy capacity of 5,491 MW in 2017**	In 2030, total of **2,965 MW** of capacity which is less than there is currently Much of the existing capacity will come offline but increases in capacity are expected in: • AD, 478 MW small scale • Biomass CHP, 1728 MW of distribution network scale and 190 MW of small scale • 3235 MW of large, transmission scale plant biomass	Total GB capacity of **3,400 MW** which is less than current capacity All technologies will come offline, but one increase is expected in: • Large, transmission scale plant biomass of 3400 MW	• Visual amenity and erosion of character in terms of tranquillity and light pollution • Visual impacts associated with stacks and associated plumes • Potential perceptual impacts associated with noise and odour • Buildings varying in scale and mass	
• **GB marine energy capacity 8 MW in 2017**	In 2030, total GB capacity of **2,696 MW**. Tidal stream has not developed in the way that was expected when this scenario was produced. It is now assumed that this could be met through: • 400 MW of tidal stream in Scotland • 200 MW of wave power in England, with about 150 MW in Cornwall • The remaining 2069 MW in Wales in the form of tidal range	The mega flex scenario does not include an explicit contribution from marine energy	• Off shore breakwater structures or wave heads (in a visible colour for marine safety reasons and lit at night) and raised above sea level with associated underwater pipelines • Common landing areas to connect shoreline pipes to sea • Onshore power station with transformers and ancillary	It should be noted that tidal stream has not developed in the way that was expected when the Gone Green scenario was produced. As a result of lack of investment in tidal stream, this is progressing much more slowly than anticipated, leading to the opportunity to harness tidal range power through tidal lagoons being pursued. It is therefore assumed that the majority of the impact will now come through tidal lagoons in Wales by 2030, but policy will need to be redirected to achieve a balanced marine energy portfolio

			buildings up to 8m high with vehicular parking and access road • Alterations to shoreline to accommodate • Change seascape / landscape character • Change in visual amenity	
• **GB PV capacity 11,050 MW in 2017**	90% of existing capacity is expected to close and will need to be repowered. The scenario has a total of **30,578 MW** of capacity in 2030, with 20,528 MW of new build in the UK Based on current distribution, it is assumed that England will host 18,000 MW of this An assumed breakdown could be: • Rooftop domestic 3,000 MW • Rooftop industrial 1,500 MW • Ground mounted industrial 2,500 MW • Ground mounted rural 10,000 MW	In this scenario, new build in England would be substantially less at **9,950 MW** Based on current distribution, it is assumed that this could be: • Rooftop domestic 2,000 MW • Rooftop industrial 2,000 MW • Ground mounted industrial 1,500 MW • Ground mounted rural 2,000 MW • Brownfield including airfield 1,500 MW	• Land take variable however likely to be negative given the proportion of land take on greenfield sites and low proportion of zero land take and brownfield sites considered • Landscape and visual amenity effects given the height and extent of such developments which can be mitigated through careful siting and design • Multi-functional opportunities within green field sites and brownfield	The current policy objective of achieving the lowest cost approach has driven development onto green fields. With the end of subsidies, it seems likely that future solar development will increasingly be located next to demand or co-located with storage to shift power export to peak demand periods

	• Brownfield including airfield 1,000 MW			
• **GB onshore wind capacity 9,937 MW in 2017**	In 2030, total GB capacity of **18,345 MW** Of this **10,408 MW** of new build would be required Based on existing trends, it is assumed that **2,602 MW** of this new build will be in England It is assumed that based on existing trends: • Large scale development in areas currently without onshore would total **802 MW** • **1,000 MW** of large scale wind would be in areas with existing wind projects in the landscape • **650 MW** of wind would be distributed across farms in England in the form of 100-500kw scale individual turbines	In the Mega Flex scenario, there is **20,000 MW** of onshore wind power, with **12,063 MW** of new build in GB. Based on existing trends, it is assumed that **3,016 MW** of this new build will be in England It is assumed that based on existing trends: • Large scale development in areas currently without onshore would total **1,216 MW** • **1,000 MW** of large scale onshore wind would be in areas with existing wind projects in the landscape • **650 MW** of wind would be distributed across farms in England in the form of 100-500kw scale individual turbines • **150 MW** of small scale wind of less than 100kw scale	• Large structures with often significant landscape and visual effects spanning over wide areas • Cumulative effects generated associated with large and small scale turbines within existing locations rather than eroding new landscapes • Loss of landscape character / features in new locations • Structures associated with grid connections relatively small on site • Proximity to visual receptors • Siting of new access tracks can be visually prominent	Mega Flex scenario will accommodate more on shore turbines than the Gone Green scenario on new sites and have a higher proportion of wind in locations without development

	• **150 MW** of small scale wind of less than 100kw scale			
• **GB offshore wind capacity 5,104 MW in 2017**	In 2030, total GB capacity of **28,928 MW** Of this **24,379 MW** of new build would be required. This could be in the form of approximately: • **17,000 MW** in England • **7,000 MW** in Scotland	The mega flex scenario assumes **33,400 MW** of offshore wind capacity, with **28,797 MW** of new build: • We can assume approximately the same breakdown as in Gone Green with a slight uplift to **18,000 MW** in England and **8,000 MW** in Scotland. • Plus, a further **3,000 MW** from additional sites in England, including Atlantic Array 1000 MW in the Bristol Channel, Navitas Bay 1,000 MW in the English Channel, and Celtic Array in the Irish Sea 1,000 MW	• Visual amenity subject to proximity to coast • Seascape character impacts particular coastal and in terms of onshore infrastructure • Landscape and visual impacts associated with onshore grid connections and associated electricity pylons and cables • Cumulative and synergistic effects • Public opinion of people's attitudes • New grid connections, new transmission sites	The contribution of Offshore wind to the energy mix of the UK will be increased if there is geographical spread around the UK to encompass a multitude of weather regimes. This is especially important because offshore wind in northern Europe is clustered in the single weather system in the North Sea
GB current generation, 8,918 MW of nuclear capacity	This scenario includes **8,955 MW** of new nuclear power	Less new nuclear needed totalling **7,000 MW** Hinkley C built and extensions to 2/3	• Landscape and visual amenity effects will be localised to specific sites	Land take is about comparable with coal and gas fired station and on shore wind. Total land take for 1,000 MW is between 100 to 1,000 ha Key is siting and design responding to existing landscape and visual receptors

	Assume development is on existing sites currently seeking extensions: • Hinkley C **3,200 MW** Extensions /additions to 2/3 sites of up **to 5,755 MW:** • North Wales, Horizon, up to 2,700 MW • England, Moorside, Cumbria up to 3,400 MW • Other potential sites in England: Oldbury, South Gloucestershire, Sizewell, Suffolk, Bradwell, Essex	existing sites but on a smaller scale	seeking extensions and additions • Given the scale of extensions and landtake cumulative effects will be experienced	For both scenarios the following is required - ideally coastal location due requirements for large volumes of cooling water however the changing seascape character and foreshore have led to the consideration of inland sites responding to climate change proofing Buildings and cooling towers are up to 60m high. Buildings will include reactor, turbines main control, services and maintenance buildings as well as a cooling water pump house or tower, generator building and water treatment facility Potential light pollution in rural locations or protected landscapes and disturbance through noise Visual impact associated with electricity pylons, transmission lines and associated infrastructure including access road. Transmission lines may be extensive given the coastal / rural location – whilst lines can accommodate farming or wildlife corridors it will cause fragmentation of landscapes Presence long term - permanent and no decommissioning Exclusion zones of between 500 to 1500m depending on land prices, land availability and reactor size which can generate positive benefits on landscape character long term
2017 GB capacity of pumped and large scale storage 2,828 MW **This is currently includes pumped hydro storage of 1,728 MW plant at Dinorwig in Wales**	A total of **8,117 MW** in GB with **5,289 MW** new build: • **1,338 MW** pumped and large scale storage across GB needed. Any additional pumped hydro storage would not be in England because of the upland geography required • There is currently 900 MW planned by SSE in Scotland.	Mega flex includes a substantial additional amount of storage totalling **18,700 MW,** of which **15,872 MW** is new build This new capacity is assumed to be **876 MW** of new pumped or large scale storage, so this can be assumed to take place in Scotland The remaining **15,000 MW** is assumed to be battery storage.	• Landscape and visual impacts through landtake and presence of buildings and associated infrastructure in the landscape • Impacts will vary depending on the development types • Compressed air storage will require a number of above ground buildings	

	• Large scale storage in England would need to be compressed air storage, in mines or salt cavern areas. This would need further investment and support to take place. • In GB, new battery storage of 3,951 MW. We can assume: • **170 MW** of industrial and commercial storage (assume 70% of this 119MW in England) • **551 MW** of own use and community storage (assume 75% in England 386 MW) • **1,230 MW** of co-located storage. (assume 50% in England 615 MW mainly co-located with PV)	We have allocated this as follows for analysis: • Response services, which are batteries up to 50 MW in scale delivering 16% of the market, with 75% of this located in England, which = **1,800 MW** • Reserve services, which are batteries up to 10 MW in scale, delivering 32% of the market, with 30% in England which = **1,440 MW** • Commercial and industrial storage, which would be batteries of around 5 MW in scale, delivering 20% of the market, with 70% in England, which = **2,100 MW** • Own use and community, which are small batteries less than 5 MW, delivering 16% of the market, with 75% in England, which = **1,800 MW** • Co-location, which would be smaller batteries when co-located with PV and larger batteries when co-located	including thermal energy storage and turbines as well as a converter and compressor impacting on visual and landscape character • Proposals for battery storage plants will be focused in industrial locations, on brownfield sites and collocated with generation reducing land take and therefore erosion of landscape character	

		with wind. Assuming this contributes 16% of the market, with 50% in England (mainly with solar), which = **1,200 MW**		
4,000 MW Interconnectors (with Europe)	**23,255 MW** of interconnectors including **19,255 MW** of new build capacity in GB. There are currently 8,300 MW of new planned capacity which can be assumed to go ahead. England: • Channel Tunnel 1,000 MW • Richborough, 1,000 MW • Budleigh Salterton, Devon, 1,400 MW • Chilling, Hampshire 1,000 MW • Bicker Fen, Lincolnshire, 1,000 MW Wales: • Pembrokeshire, 500 MW Scotland: • Blyth, 1,400 MW There is also a proposal to connect to Iceland	Mega flex includes **16,000 MW** of interconnectors, of which **12,000 MW** would be new build in GB As with Gone Green, we can assume the locations of 8,300 MW. Locations for remaining 3,700 MW has yet to be determined	• Localised landscape and visual impacts associated with development along part of the south and east coastline • Erosion of shoreline character associated with convertor/under ground stations and on shore connections to submarine cables • Visual effects from over ground substation/convertor, electricity pylon towers and transmission lines, vehicular parking and access road though it is assumed that landtake and buildings are relatively low	

	from Scotland at 1,000 MW. The locations for remaining 11,000 MW has yet to be determined			
12,822 Coal (power station)	NA	NA	NA	
31,856 MW Combined cycle Gas Turbines	Total **22,364 MW** in GB of which only **6,508 MW** new build Based on previous build patterns, it is assumed that 92% of this will be built in England at **5987 MW**	Total **16,100 MW** in GB of which new build **244 MW**	Landscape character and visual amenity impacts associated with a large land take, scale and mass of the structures on site, stacks, infrastructure electricity transmission pylons and lines feeding into the grid	
Currently there is 1,027 MW of Open Cycle Gas Turbine (OCGT) in GB	This scenario assumes a total of **1,106 MW** in GB of which **78 MW** is new build and the remainder is recommissioned Based on previous build patterns, it is assumed that 94% of this will be built in England at **73 MW**	A total of **20,200 MW** capacity under Mega Flex of which **19,173 MW** is new build. Based on previous trends, it is assumed that 94% of this is built in England, totalling **18,022 MW**	Landscape character and visual amenity impacts associated with a large land take, scale and mass of the structures on site, stacks, infrastructure electricity transmission pylons and lines feeding into the grid. Impacts will be less than MF for new build	

There is currently 842 MW of conventional thermal gas in GB	This scenario assumes a total of **1,207 MW** of conventional thermal gas in GB, of which **365 MW** new build It is assumed that this would be scattered around the country close to the 33/132kV network. It is therefore assumed that 80% would be in England, totalling **292 MW**	NA	Landscape character and visual amenity impacts associated with a large land take, scale and mass of the structures on site, number of stacks/plumes, infrastructure including electricity transmission pylons and lines feeding into the grid	
Thermal CHP	**3,200 MW** new build in GB, connecting to the distribution system (**2348 MW**) and small scale (**852 MW**) It is assumed that this would be scattered around the country close to the 33/132kV network. It is therefore assumed that 80% would be in England, totalling **1,878 MW** and **681 MW** respectively in England	NA	Landscape character and visual amenity impacts associated with a large land take, scale and mass of the structures on site, stacks, infrastructure electricity transmission pylons and lines feeding into the grid. Location specific and tend to be concentrated in North East, Yorkshire/Humber and the North West	
Gas Carbon Capture and Storage (CCS)	Assumes **1,800 MW** new build, which is likely to take the form of one plant in Scotland. Storage solution yet to be developed	NA	Landscape character and visual amenity impacts associated with a large land take, scale and mass of the structures on site, number of stacks/plumes,	

			infrastructure including electricity transmission pylons and lines feeding into the grid. It is assumed a coastal location is required	
366 MW of existing oil plant	Scenario has **700 MW** in total of which **334 MW** would be new build. Assume 80% in England at **267 MW**	NA	Landscape character and visual amenity impacts associated with a large land take, scale and mass of the structures on site, number of stacks/plumes, infrastructure including electricity transmission pylons and lines feeding into the grid. Often sited in industrial locations where the cumulative effects are likely to be localised	

138 MW of existing diesel	**1,485 MW** in total of which **1,347 MW** new build. Assume 80% in England at **1,077 MW**	NA	Landscape character and visual amenity impacts associated with a large land take, scale and mass of the structures on site, number of stacks / plumes, infrastructure including electricity transmission pylons and lines feeding into the grid. Often sited in industrial locations where the cumulative effects are likely to be localised	
694 MW of other existing fossil fuel generation which will be decommissioned	NA	NA	NA	

Annex 2. Landscape Assessment

Gone Green Scenario

Summary of key technologies under this scenario: Under this scenario it has been assumed that the main concentration of technologies in England which will involve new build of renewables, will focus on PV (18,000 MW compared to 20,528 MW at a UK level), offshore wind (17,000 MW compared to 24,379 MW in the UK), onshore wind (2,602 MW compared to 10,408 MW in the UK) and nuclear (8,955 MW based on Hinkley C and 2/3 additional sites a little less than UK's current nuclear energy generation totalling 8,198 MW). These developments will be supported by a range of other technologies which will top up demand during peak periods and over the winter. These include:

- Storage technologies of which 1,120 MW out of 3,951 MW will be based in the UK and be new battery storage facilities, a combination of industrial/commercial, own use/community and collocated Uncertainties exist around certain energies such as compressed air storage which would be large scale and would support other storage facilities as discussed above
- Interconnectors of which 5,400 MW are confirmed to be built out in England out of 8,300 MW proposed in the UK with remaining locations for 11,000 MW in the UK undetermined
- Gas of which 92% will be provided within England in the form of combined gas cycle turbines (6,128 out of 6,508 MW in the UK) and open cycle gas turbines (71 MW out of 78 MW), 80% conventional thermal gas (292 MW out of 365 MW) and thermal CHP (2559 MW out of 3,200 MW), as well as 80% oil (267 MW out of 334 MW) and diesel (1,077 out of 1,347 MW in the UK) It should be noted that the total MWs for new build of thermal gas, thermal CHP, oil and diesel are relatively low and figures for gas carbon capture and storage have yet to be determined
- Tidal stream will be 200 MW out of GB's capacity of 2,696 MW
- There will be a small increase in capacity in terms of hydro throughout the UK with only 24 MW out of 79 MW of new build and a lower proportion of biomass (2,965 MW across the UK) compared to current figures of 5,491 MW

Remaining energy development will utilise existing sites through recommissioning.

Objective	Criteria	Nature of Effect: Positive / Negative	Direct/Secondary / Cumulative	Scale	Permanency/ reversibility	Certainty of effect (High, Medium or Low)	Comments
Principle 2: Recognise Landscape in the Holistic Sense intended by ELC **Principle 3: Apply to All Landscapes** **To protect, enhance and restore landscape**	Will environmental problems related to landscape (if they exist) be resolved or exacerbated (i.e. improvements to degraded or spoiled landscapes, eroding or erosion of character or cumulative or synergistic change)?	**+/ =/ -**	**D/S /C**	**R/ N**	**P/ R**	**M**	Mixed effects will be generated on landscape and visual amenity subject to whether proposals will resolve or exacerbate environmental problems. The nature of effects will depend on the type of technology and its locational requirements, generating direct, secondary and cumulative effects, which will be regional to national in scale and medium in terms of the certainty of effect. Due to the varying types of developments considered there will be both permanent (associated with nuclear) and reversible effects (associated with solar and wind). Through this scenario there will be negative effects on landscape /seascape character resulting from new build and associated land /sea take of 18,000 MW of PV predominately on rural green field sites, the siting of a further 2,604 MW of new onshore wind turbines and 17,000 MW of offshore wind. To support these technologies 5,400 MW of interconnections will be constructed, their onshore connections causing localised effects on the coastline alongside the development of combined gas cycle turbines and tidal stream again resulting in negative effects. Positive or neutral effects will result from the recommissioning, extensions or alterations to existing sites to accommodate an increase in capacity. Examples include onshore wind, rooftop domestic, and industrial and ground mounted industrial, as well as battery storage collocated with other facilities or incorporated into appropriate scaled structures in keeping with their surroundings. In terms of nuclear it is assumed that land within exclusion zones has already been set aside for future growth with adequate mitigation in the form of planting. Within such locations effects should be contained and relatively localised. Cumulative effects will inevitably result when considering all developments as a whole based on different locational requirements.

Objective	Criteria	Nature of Effect				Certainty of effect (High, Medium or Low)	Comments
		Positive / Negative	Direct/Secondary / Cumulative	Scale	Permanency/ reversibility		
	Is the value of the landscape and its vulnerability to change likely to be affected as a result of its key characteristics or cultural heritage or local distinctiveness (i.e. sensitivities associated with artistic, cultural or historic associations, historic continuity, high degree or naturalness, role in separating settlements or providing a backdrop to settlements)?	**?**	**D/S /C**	**R**	**P/ R**	**M**	On the assumption that current national policies will continue to ensure the protection of high valued landscapes and heritage assets, it is assumed that only a small percentage of such nationally valued landscapes will be affected. It is, however, likely that landscapes close to settlements and which could fall within Green Belt designation or under locally designated policies will be vulnerable to change, and landscapes adjacent to areas of high value will reach or become close to capacity. Similarly an increase in offshore wind will impact on the setting of protected landscapes, as well as their function in terms of providing a backdrop to coastal settlements. The same effects could apply to new build of PV and solar development.
	Is the energy scenario likely to have an effect on areas of landscapes which have a recognised international, national or local status (i.e. World Heritage Site, National Park, AONB, Heritage Coasts, Registered Park and Garden or Local Landscape designation)	**?**	**D/S /C**	**R**	**P/ R**	**M**	On the assumption that current national policies will continue to ensure the protection of high valued landscapes and heritage assets, it is assumed that only a small percentage of such nationally valued landscapes will be affected. It is however likely that landscapes close to settlements and which could fall within Green Belt designation or under locally designated policies will be vulnerable to change, and landscapes adjacent to areas of high value will reach or become close to capacity. Similarly an increase in offshore wind will impact on the setting of protected landscapes, as well as their function in terms of providing a backdrop to coastal settlements. The same effects could apply to new build of PV and solar development.

Objective	Criteria	Nature of Effect				Certainty of effect (High, Medium or Low)	Comments
		Positive / Negative	Direct/Secondary / Cumulative	Scale	Permanency/ reversibility		
	What will be the magnitude and /or spatial extent of effects on the landscape including the geographical area likely to be affected (considering extent of land take, scale and mass of either buildings and /or infrastructure through replacement, upgraded, extended development and decommissioning)?	**+/-**	**D/S /C**	**R**	**P/ R**	**M**	Mixed effects will be generated on this criterion. The scenario focuses on a high proportion of new build associated with offshore wind and PV, which will demand a high land /sea take and generate negative, cumulative effects. Similarly negative, cumulative effects will be experienced through the siting of combined gas turbines plus other gas, diesel and oil development. Whilst the spatial extent of such development will be high, some effects will be irreversible. Development will have specific locational requirements and therefore may generate regional effects. Positive effects will be generated through the concentration of development on brownfield sites, through recommissioning and by extensions / alterations of previously deployed development. Collocation of PV, storage development and extensions associated with nuclear plants will ensure the magnitude and spatial extent is localised and, if already planned for, could be already accommodated through existing mitigation measures.
	Will the scenario have an effect on everyday landscapes adjacent to where people live and /or work?	**?**	**D/S /C**	**R/ L**	**P/ R**	**M**	There is uncertainty over the effects generated on this criterion. This scenario focuses on development within rural areas where population concentrations and land values are likely to be lower than closer to/in centres of population. If current national policies continue to ensure the protection of high valued landscapes and heritage assets, it is likely that landscapes close to settlements, and those which could fall within Green Belt designation or under locally designated policies, will be vulnerable change, as rural landscapes reach or become close to capacity and opportunities to connect to the grid decline. Within this scenario some development is located on brownfield, industrial sites and community / domestic use (PV and Battery storage), farms (onshore wind) and may therefore have an effect on people's everyday lives.

Objective	Criteria	Nature of Effect				Certainty of effect (High, Medium or Low)	Comments
		Positive / Negative	Direct/Secondary / Cumulative	Scale	Permanency/ reversibility		
Principal 5: Involve People **To improve public's understanding and enjoyment of landscape**	What will be the magnitude and spatial extent of the scenario's effects on people's enjoyment of the landscape, including people likely to be affected in the context of their sensitivity to landscape change? Is it a landscape enjoyed by a large number of people through everyday life or by fewer people seeking solace, tranquillity, naturalness and remoteness and other sensory attributes)?	**+/-**	**D/S /C**	**R**	**P/ R**	**M**	Mixed effects will be generated on this criterion. The focus of this scenario is on renewable energy and the extent of land / sea take (in the case of offshore wind and PV), and tidal stream, will, based on current locational requirements, be relatively high and concentrated in rural areas or the coast, where people are attracted to appreciate coastal and estuarine views.
	To what extent will the magnitude and spatial extent of effects on receptors using National Trails and open access land affect their enjoyment of the landscape?	**+/-**	**D/S /C**	**L**	**P/ R**	**L to M**	Mixed effects will be generated, given the locational requirements for the majority of development which, it is assumed, could be located close to National Trails and / or open access land. Structures will vary in permanence and whilst some, due to their height and scale, could integrate into the landscape in a sensitive manner (small scale PV, battery storage and wind) others, such as large scale on and offshore wind, nuclear power stations and gas turbines, will be visually prominent and affect people's enjoyment of the landscape. Depending on their location relative to the route / open access land, the structures, its overall height, mass and associated features (such as stacks and plumes), development(s) may be noticeable in the landscape.
To improve the public understanding of landscape change	Will the nature of the scenario, its duration and change improve public's understanding of landscape and acceptance of future change?	**?**	**D/S**	**N**	**P**	**L to M**	Effects associated with this criterion are uncertain. Communication and active engagement with communities is essential to educating people of the ever changing landscape and how change can be accommodated. The degree to which people's understanding of the drivers to delivery of new energy infrastructure developments (including the need for adaptation to climate change and emerging technologies) will be dependent on national policies to drive engagement forward in line

Objective	Criteria	Nature of Effect: Positive / Negative	Direct/Secondary / Cumulative	Scale	Permanency/ reversibility	Certainty of effect (High, Medium or Low)	Comments
							with ELC's objectives, to developer's commitments to sustainable modes of development, and to recognition of the intangible financial value of landscape to the national economy.
Principle 6: Integrate landscape **To recognise the range of benefits and functions that landscape can offer**	Will the presence of development associated with the scenario and their delivery achieve multiple benefits to the landscape (i.e. mitigation measures associated with sectors such as solar PV can include the reinstatement of historic landscape features and enhancement of hedgerow biodiversity value and connectivity in the landscapes improving biodiversity connectivity)?	**+**	**D/S**	**R**	**P/ R**	**M**	Development could, through careful planning and design, provide opportunities for multi-functional landscapes supporting a range of benefits, including creation/enhancement of recreational opportunities, climate change and adaption measures (such as buffer strips, cross field hedgerows and uncultivated areas), and sustainable drainage measures to reduce water infiltration rates. It is assumed that such features would remain a permanent feature in the landscape.
Evaluation and Summary	Although further research is required to generate a meaningful contribution to discussion of emerging policy, and the exact nature of the effect on many of the criteria remains uncertain due to the limited location specific information available, this assessment finds that, based on the information currently available, mixed, uncertain and positive effects will be generated as a result of the Gone Green scenario. • The Gone Green scenario focuses on renewable energy technologies, the landscape effects of which are reversible in nature. • Other technologies including nuclear, gas, oil and diesel, are also required in the mix to meet demand during peak periods. The landscape effects of these developments will be irreversible. • Land /sea take associated with the Gone Green scenario is extensive, with both solar and onshore wind to be accommodated in new landscapes, and added to landscapes where development already exists (by recommissioning sites or by increasing concentrations / extending development areas), thereby generating cumulative effects. In the absence of information about the future siting requirements of 11,000 MW of interconnectors, and the requirement for compressed air storage, it is not possible to assess the effects of these technologies, alone or cumulatively with other developments, on the landscape. Mixed, uncertain and positive effects will be generated as a						

Objective	Criteria	Nature of Effect				Certainty of effect (High, Medium or Low)	Comments
		Positive / Negative	Direct/Secondary / Cumulative	Scale	Permanency/ reversibility		
	result of this scenario. The assessment (which needs to be supported by further research at a baseline level) indicates that greater consideration needs to be given to the sensitivity of the landscape and its capacity to absorb change. Judgements cannot be made as to the exact nature of the effect on many of the criteria due to the limited location specific information available. Whilst the scenario seeks to focus on renewables which are reversible in nature, other permanent technologies are required such as nuclear, gas, oil and diesel to meet demand during peak periods. Land /sea take with this scenario is extensive with both solar and onshore wind accommodated in new landscapes as well as adding to landscapes where development already exists by recommissioning sites or by increasing concentrations / extending development areas generating cumulative effects. A number of unknowns also exist in terms of the future siting of 11,000 MW of interconnectors and the requirement for compressed air storage.						

Key

Effect Dimensions			
Positive	+		
Neutral	=		
Negative	-		
Uncertain	?		
Mixed effects	+/-		
Scale:		Direct	**D**
National	**N**	Indirect / Secondary	**I**
Regional	**R**	Cumulative	**C**
Local	**L**	Synergistic	**S**
Permanency:			
Reversible	**R**		
irreversible	**I**		

Mega Flex Scenario

Summary of key technologies under this scenario: Under this scenario there will be a wide range of new build technologies which will be constructed. Key technologies based on MW output are as follows:

- Open cycle gas turbines (18,022 MW out of 19,173 MW)
- Storage technologies with 8,340 MW based in England out of 15,872 MW in the UK. Storage for this scenario will have a greater focus on response, reserve and commercial/industrial new battery storage facilities. It is assumed that pumped scale storage or large scale storage which will take place in Scotland
- Offshore wind (21,000 MW compared to 28,797 MW in the UK)
- Onshore wind (3,016 MW compared to 12,063 MW in the UK)
- PV (9,000 MW compared to 9,950 MW at a UK level)
- Nuclear (7,000 MW based on Hinkley C and 2/3 additional sites less than UK's current nuclear energy generation totalling 8,198 MW)
- Interconnectors of which 5,400 MW are confirmed to be built out in England out of 8,300MW proposed in the UK with remaining locations 3,700 in the UK undetermined (less)
- Combined gas cycle turbines (223 MW out of 244 MW in the UK)

There will be a small increase in capacity in terms of hydro throughout the UK with only 30% of new build allocated for England based on current trends and a lower proportion of biomass (3,400 MW across the UK) compared to current figures of 5,491 MW. It should be noted that there are no developments associated with thermal gas, thermal CHP, oil and diesel and figures for gas carbon capture and storage have yet to be determined.

Remaining energy development will utilise existing sites through recommissioning.

Objective	Criteria	Nature of Effect				Certainty of effect (High, Medium or Low)	Comments
		Positive / Negative	Direct/indirect	Scale	Permanency/ reversibility		
Principle 2: Recognise Landscape in the	Will environmental problems related to landscape (if they exist) be resolved or exacerbated (i.e. improvements to	+/ =/ -	D/ S/ C	N/ R	P/ R	M	Mixed effects will be generated on landscape and visual amenity subject to whether proposals will resolve or exacerbate environmental problems. The nature of effects will depend on the type of technology and its locational requirements generating direct, secondary and cumulative

Objective	Criteria	Nature of Effect				Certainty of effect (High, Medium or Low)	Comments
		Positive / Negative	Direct/indirect	Scale	Permanency/ reversibility		
Holistic Sense intended by ELC **Principal 3: Apply to All Landscapes** **To protect, enhance and restore landscape**	degraded or spoiled landscapes, eroding or erosion of character or cumulative or synergistic change)?						effects which will be regional to national in scale and medium in terms of the certainty of effect. Due to the varying types of developments considered there will be both permanent (associated with gas turbines and nuclear) and reversible effects (associated with PV and wind). Negative effects will be associated with a change in landscape /seascape character resulting from new build and associated land /sea take of 21,000 MW offshore turbines and 18,022 MW open cycle gas turbines, alongside further new build relating to wind and PV onshore as well as storage batteries (although the latter will be relatively small scale in size). For offshore wind the scale of effect will be national with additional sites proposed in the Bristol Channel, English Channel and Irish Sea. Other key developments will be open cycle gas turbines which will new build and require high land take. These technologies will be supported by nuclear and interconnectors which could also generate negative effects on landscape. Positive or neutral effects will result from the recommissioning, extensions or alterations to existing sites to accommodate an increase in capacity, and through sensitive landscape mitigation introducing positive measures to degraded landscapes through reinstatement of hedgerows and trees. Sites such as PV and battery storage will be relatively small in size. For the former the focus is on rooftop domestic /industrial and ground mounted industrial whilst for battery storage collocated with other energy development such as PV or wind, commercial/industrial use, and own use / community. It should be possible for such storage facilities to be incorporated into appropriate scaled structures in keeping with their surroundings and designed in a sensitive manner. In terms of nuclear less land take is required under this scenario. Cumulative effects will inevitably result when considering all developments as a whole based on different locational requirements.

Objective	Criteria	Nature of Effect: Positive / Negative	Nature of Effect: Direct/indirect	Nature of Effect: Scale	Nature of Effect: Permanency/ reversibility	Certainty of effect (High, Medium or Low)	Comments
	Is the value of the landscape and its vulnerability to change likely to be affected as a result of its key characteristics or cultural heritage or local distinctiveness (i.e. sensitivities associated with artistic, cultural or historic associations, historic continuity, high degree or naturalness, role in separating settlements or providing a backdrop to settlements)?	**?**	**D/ S/ C**	**R**	**P/ R**	**M**	On the assumption that current national policies will continue to ensure the protection of high valued landscapes and heritage assets, it is assumed that only a small percentage of such nationally valued landscapes will be affected and not significantly. It is however likely that landscapes close to settlements and which could fall within Green Belt designation or under locally designated policies will be vulnerable change, and landscapes adjacent to areas of high value will reach or become close to capacity. Similarly an increase in offshore wind will impact on the setting of protected landscapes as well as their function in terms of providing a backdrop to coastal settlements. Effects under this scenario are likely to generate significant negative effects on this criterion given the scale of offshore wind and open cycle gas turbines envisaged. Effects will remain uncertain however, due to uncertainties over the exact location of developments.
	Is the energy scenario likely to have an effect on areas of landscapes which have a recognised international, national or local status (i.e. World Heritage Site, National Park, AONB, Heritage Coasts, Registered Park and Garden or Local Landscape designation?)	**?**	**D/ S/ C**	**R**	**P/ R**	**M**	On the assumption that current national policies will continue to ensure the protection of high valued landscapes and heritage assets, it is assumed that only a small percentage of such nationally valued landscapes will be affected. It is however likely that landscapes close to settlements and which could fall within Green Belt designation or under locally designated policies will be vulnerable change, and landscapes adjacent to areas of high value will reach or become close to capacity. Similarly an increase in offshore wind will impact on the setting of protected landscapes as well as their function in terms of providing a backdrop to coastal settlements. Effects under this option are likely to generate significant negative effects on this criterion given the scale of offshore wind and open cycle gas turbines envisaged, Effects will remain uncertain however, due to uncertainties over the exact location of developments
	What will be the magnitude and /or spatial extent of effects on the landscape including the geographical	**+/ -**	**D/ S/ C**	**N/ R**	**P/ R**	**M**	Mixed effects will be generated on this criterion. The scenario focuses on a high proportion of new build associated with offshore wind and onshore open cycle gas turbines which will demand a high land /sea take and generate negative, cumulative effects. Whilst the spatial extent of such

Objective	Criteria	Nature of Effect: Positive / Negative	Direct/indirect	Scale	Permanency/ reversibility	Certainty of effect (High, Medium or Low)	Comments
	area likely to be affected (considering extent of land take, scale and mass of either buildings and /or infrastructure through replacement, upgraded, extended development and decommissioning)?						development will be high, some effects such as wind and PV (on and offshore) will be reversible. Development will have specific locational requirements and may therefore generate regional to national effects. Compared to the GGS, effects of nuclear development and MW generated from interconnectors will be lower with less land take. Positive effects will be generated through the concentration of development on brownfield sites, through recommissioning and extensions/alterations. Through this scenario there is a greater focus on storage technologies and particularly battery with a high proportion used for commercial/industrial/own/community use and some collocated with wind and PV. Although PV is relatively small compared to the GGS all will be located on rooftop domestic/industrial and ground mounted industrial. Other technologies such as nuclear will absorb new development on their existing sites.
	Will the scenario have an effect on everyday landscapes adjacent to where people live and /or work?	+/-	**D/ S/ C**	**R/ L**	**P/ R**	**M**	There will be mixed effects generated on this criterion. This scenario focuses on development within rural areas where population concentrations and land values are likely to be lower than closer to/in centres of population. If current national policies continue to ensure the protection of high valued landscapes and heritage assets, it is likely that landscapes close to settlements, and those which could fall within Green Belt designation or under locally designated policies, will be vulnerable change, as rural landscapes reach or become close to capacity, opportunities to connect to the grid decline and facilities are located closer to demand centres. Within this scenario some development is located on brownfield, industrial sites and community / domestic use (PV and Battery storage), farms (onshore wind) and may therefore have an effect on people's everyday lives.

Objective	Criteria	Nature of Effect				Certainty of effect (High, Medium or Low)	Comments
		Positive / Negative	Direct/indirect	Scale	Permanency/ reversibility		
Principal 5: Involve People **To improve public's understanding and enjoyment of landscape**	What will be the magnitude and spatial extent of the scenario's effects on people's enjoyment of the landscape, including people likely to be affected in the context of their sensitivity to landscape change? Is it a landscape enjoyed by a large number of people through everyday life or by fewer people seeking solace, tranquillity, naturalness and remoteness and other sensory attributes)?	**+/-**	**D/ IS /C**	**R**	**P/ R**	**M**	Mixed effects will be generated on this criterion. The focus of this scenario is on renewable energy and the extent of land/sea take (in the case of offshore wind and PV), and tidal stream, will, based on current locational requirements, be relatively high and concentrated in rural areas or the coast, where people are attracted to appreciate coastal and estuarine views.
	To what extent will the magnitude and spatial extent of effects on receptors using National Trails and open access land affect their enjoyment of the landscape?	**+/-**	**D/ S/ C**	**L**	**P/ R**	**L to M**	Mixed effects will be generated, given the locational requirements for the majority of development which, it is assumed, could be located close to National Trails and / or open access land. Structures will vary in permanence and whilst some, due to their height and scale, could integrate into the landscape in a sensitive manner (small scale PV, battery storage and wind) others, such as large scale on and offshore wind, nuclear power stations and gas turbines, will be visually prominent and affect people's enjoyment of the landscape. Depending on their location relative to the route / open access land, the structures, its overall height, mass and associated features (such as stacks and plumes), development(s) may be noticeable in the landscape.

Objective	Criteria	Nature of Effect: Positive / Negative	Direct/indirect	Scale	Permanency/ reversibility	Certainty of effect (High, Medium or Low)	Comments
To improve the public understanding of landscape change	Will the nature of the scenario, its duration and change improve public's understanding of landscape and acceptance of future change?	**?**	**D/ S**	**N**	**P**	**L to M**	Effects associated with this criterion are uncertain. Communication and active engagement with communities is essential to educating people of the ever changing landscape and how change can be accommodated. The degree to which people's understanding of the drivers to delivery of new energy infrastructure developments (including the need for adaptation to climate change and emerging technologies) will be dependent on national policies to drive engagement forward in line with ELC's objectives, to developer's commitments to sustainable modes of development, and to recognition of the intangible financial value of landscape to the national economy.
Principle 6: Integrate Landscape **To recognise the range of benefits and functions that landscape can offer**	Will the presence of development associated with the scenario and their delivery achieve multiple benefits to the landscape (i.e. mitigation measures associated with sectors such as solar PV can include the reinstatement of historic landscape features and enhancement of hedgerow biodiversity value and connectivity in the landscapes improving biodiversity connectivity)?	**+?**	**D/ S**	**R**	**N**	**L to M**	Development could, through careful planning and design, provide opportunities for multi-functional landscapes supporting a range of benefits, including creation/enhancement of recreational opportunities, climate change and adaption measures (such as buffer strips, cross field hedgerows and uncultivated areas), and sustainable drainage measures to reduce water infiltration rates. It is assumed that such features would remain a permanent feature in the landscape.
Evaluation and Summary	Informed judgement cannot be offered on the exact nature of the effect on many of the criteria due to the limited location specific information available. In the context of the information available to inform this assessment, preliminary observations can be made as follows: • The Mega Flex scenario requires less generation capacity than the Gone Green Scenario, taking a more flexible approach to grid management and meeting peak demand • A wide range of technologies is proposed, with the main focus in terms of MWs generated accruing to offshore wind and open cycle gas turbines • These technologies are supported by other technologies which offer lower levels of capacity and include a high proportion of storage technologies, plus PV, nuclear, interconnectors and combined gas						

Objective	Criteria	Nature of Effect				Certainty of effect (High, Medium or Low)	Comments
		Positive / Negative	Direct/indirect	Scale	Permanency/ reversibility		
	• Both on and off shore wind development will be located in new sites in new landscapes, generating extensive use of the marine landscape for offshore wind, but limited land take • Open cycle gas turbines will require land take on green or brownfield sites • The approach is supported by small scale response, reserve and commercial/industrial new battery storage facilities, on recommissioned sites, brownfield or industrial sites, or collocated with wind or PV • Mixed effects will be generated on landscape and visual amenity depending on the form of development and its locational requirements • For some technologies, such as storage batteries, and depending on their size, impacts can be reduced and/or mitigation incorporated in development, by deployment of appropriate scaled structures in keeping with their surroundings and designed in a sensitive manner • The Mega Flex technologies have the potential to create wide ranging landscape and visual effects which, based on current information, will be mixed, uncertain and, in some circumstances, positive for the landscape • Although overall land take in rural areas for this scenario is less, since the focus of development is likely to be close to existing development and/ or demand, effects on people’s enjoyment of the everyday landscape will, subject to location, be eroded with associated significant negative effects. • Deployment of the Mega Flex scenario will require policy to emphasise the sensitivity of the landscape and its capacity to absorb change, particularly in respect of landscapes with key characteristics, and those of national value						

Key

Effect Dimensions			
Positive	+		
Neutral	=		
Negative	-		
Uncertain	?		
Mixed effects	+/-		
Scale:		Direct	**D**
National	**N**	Indirect / Secondary	**I**
Regional	**R**	Cumulative	**C**
Local	**L**	Synergistic	**S**
Permanency:			
Reversible	**R**		
Irreversible	**I**		