7000 Acres

7000 Acres Response to the Tillbridge Solar Project Ltd Application on the subject of:

The role of Solar in Energy Provision and Decarbonisation

Deadline 2 Submission – 14th November 2024

Contents

Executive Summary:

Written Representation: The Role of Solar in Energy Provision and Decarbonisation

This paper considers the need for the Tillbridge Solar Project, as a large-scale ground mounted solar, in the context of:

1. **The landscape of UK Climate Change and Energy policies**, referencing recent Government publications, and by implication, how much large-scale ground-mounted solar may be needed.
2. **The National Policy Statements,** in particular how these have evolved during the development of the Tillbridge scheme and will continue to develop.
3. **Published Reviews of Progress on UK Decarbonisation**, referencing recent reports that have considered what must be the priorities to decarbonise the UK electricity system.
4. **The Capacity of Solar and UK Electricity System Considerations**, including the energy capabilities of solar power, its contribution to electricity supply and the implications of intermittent generation.
5. **The Potential for Rooftop Solar as an Alternative Solution to Solar Capacity Targets**, and how such development, in conjunction with sensitive ground-mounted solar schemes can achieve Government solar capacity objectives.
6. **The Connection of Solar to the Electricity System**, in particular the power and voltage needs of solar panels.
7. **The Role of Battery Energy Storage Systems** in terms of supporting the solar scheme and their wider role in the energy market.
8. **The Tillbridge Statements of Need,** in which there are notable omissions and sections have been drafted using partial or misleading information.
9. **Advice from the National Energy System Operator to the UK Government on Clean Power by 2030.**

We recognise the need to decarbonise and that solar has a role to play, however, the energy benefits it delivers are limited, owing to:

- The low load-factor of solar in the UK, between 9-11%, because the UK is one of the lowest areas of solar gain, globally.
- The mismatch between when solar produces the bulk of its power (summer days) and when it is needed.
- Periods with excess solar energy, leading to significant curtailment (wastage) from having insufficient capability to store solar energy from the summer for use in the winter.
- The resultant need for the full capacity of solar to be covered by other forms of generation to meet peak winter demand.

In terms of those benefits, the developer has persisted in providing over simplistic and misleading information as part of its application, regarding the role solar power can play in the future of electricity supply, for instance by stating that the UK has high areas of solar gain when it has globally low levels of solar gain, providing the impression that the scheme can power 300,000 homes, and overstating the role solar can play in security of supply.

It is crucial that the limitations to benefits are fully understood, particularly when weighing up the harms arising from ground mounted solar development at such a scale. This harm stems from the fact that solar has an extremely low power density, which means that a solar scheme of the capacity proposed by the Tillbridge Solar Project uses a colossal amount of space.

Using so much land has a tremendous, concentrated impact on the immediate area and its people, but consuming such huge areas of land also puts a wider pressure on land use which may serve to impede decarbonisation by competing for land needed for direct decarbonisation. The UK Climate Change Committee asserts we will need to lose some of this land to plant trees (6CB calls for between 30-70kha of tree planting per year) and develop peatland to sequester carbon. Land will also be needed for energy crops, there are fears that climate change will change the yields of UK farmland and rising sea levels have the potential to further impact farmland. All of which is before any further expansion of urban development is considered.

Quite simply, over committing agricultural land to such inefficient land use as ground mounted solar could very quickly become a cause for regret.

With regard to energy policy, the landscape with regard to solar is evolving. While solar is not part of the UK Government's Ten Point Plan for Decarbonisation, the ambition for solar has grown considerably between 2022 and 2023, now seeking to achieving 70GW of installed capacity by 2035. Similarly, the National Policy Statements have evolved, and even the 2024 NPS suite do not foresee large-scale ground mounted solar of the size proposed by the Tillbridge Solar Project.

The NPS EN-1 advocates "good design", including the importance of the functionality of the development. This WR will describe the constraints around the functional contribution solar can make to energy and decarbonisation, which are limited to the point where the benefits do not outweigh the harms arising from ground mounted solar installation at such a large scale.

What is strongly consistent, however throughout all Government energy policy and strategy announcements, as well as the historic and new NPS suite, is the important principle of efficient land use, something that is increasingly recognised as being vital as UK land faces tremendous pressures from all quarters. The "Skidmore Review" also echoes this with a call for a "Mission for Rooftop Solar", recognising the increasing importance of managing land use as a part of decarbonisation, and the need for a clear plan on how we manage competing demands on land.

There is no explicit policy for such large-scale ground mounted solar development in the UK. Quite apart from this, there is growing evidence that the UK can largely meet its 70GW solar capacity ambition from sufficient available rooftop solar capacity on suitable commercial and domestic buildings, with none of the same adverse consequences of ground mounted solar, and fewer implications on National Grid infrastructure requirements.

Developers have claimed that the installation of large-scale ground mounted solar is the only way to install solar capacity at the rate the climate emergency demands, however more solar could be installed on new-build house rooftops, more quickly than the development of a project at the physical scale of Tillbridge, with all the associated impacts and environmental considerations that are required.

All of this renders ground mounted solar development at such a large scale unnecessary. This means that should the Tillbridge project not be approved, the UK can still easily meet its ambition to install 70GW of solar capacity, particularly as NESO have reported that there is already an excess of schemes in development.

What is equally important to consider is the publication of major reports that assess the decarbonization of the power sector in the UK and current progress towards delivering on that goal. In doing so, they describe the main challenges and the extent to which solar plays a role. These reports are:

- Delivering a reliable decarbonised power system, by the UK Climate Change Committee (CCC), March 2023
- Decarbonising the power sector, by the National Audit Office (NAO), March 2023
- Decarbonisation of the power sector, by the Business, Energy and Industrial Strategy Committee (BEIS), April 2023 – **Note:** *the energy portfolio of this department is now the responsibility of the Department for Energy and Net Zero (DESNZ)*

Their most pressing findings are:

- The need for overall co-ordination and planning of the energy system
- The resolution of grid connectivity issues – especially to deliver offshore wind generation
- Inadequate pace of deployment of wind and nuclear power generation
- The need to manage energy flexibility and intermittency of renewable energy sources

While solar has its part to play, it features very little in the landscape of key challenges identified by these reports that must be overcome for the UK to make a success of decarbonising the power sector.

Finally, while NESO's recent advice to Government on delivering Clean Power 2030 acknowledges the important role of solar in the future energy system, it also highlights many of the limitations of solar that have been highlighted in this WR.

We are in favour of good solar development:

- Solar should be deployed where there is little else that can be done with the space – such as rooftops. To make that happen, planning should require solar on new-build commercial warehouses and domestic properties as an immediate priority, and a framework should be provided to support retrofitting of solar to existing buildings.
- Where a solar development is considered at scale, it should be decided upon locally, not nationally – and any development must consider sustainability in its widest sense, including the impacts on sustainability of food production, sustainability of communities, impact on health and wellbeing.

Section 1: The landscape of UK Climate Change and Energy policies

1.1 Global Decarbonisation:

The need to address climate change is clear, and the UK led the world in 2008 with the Climate Change Act, which committed the country to significant reductions in greenhouse gas emissions by 2050, based upon 1990 as a reference for emission levels.

Since then, the country has made significant progress towards decarbonisation, reducing emissions of Carbon Dioxide from over 800m tonnes of CO_2 in 1990, to below 400m tonnes by the end of 2023[1] (see graph, below) and the UK continues to show leadership on the issue of climate change, for example, by being the first G7 country to end coal fired electricity generation in September 2024.

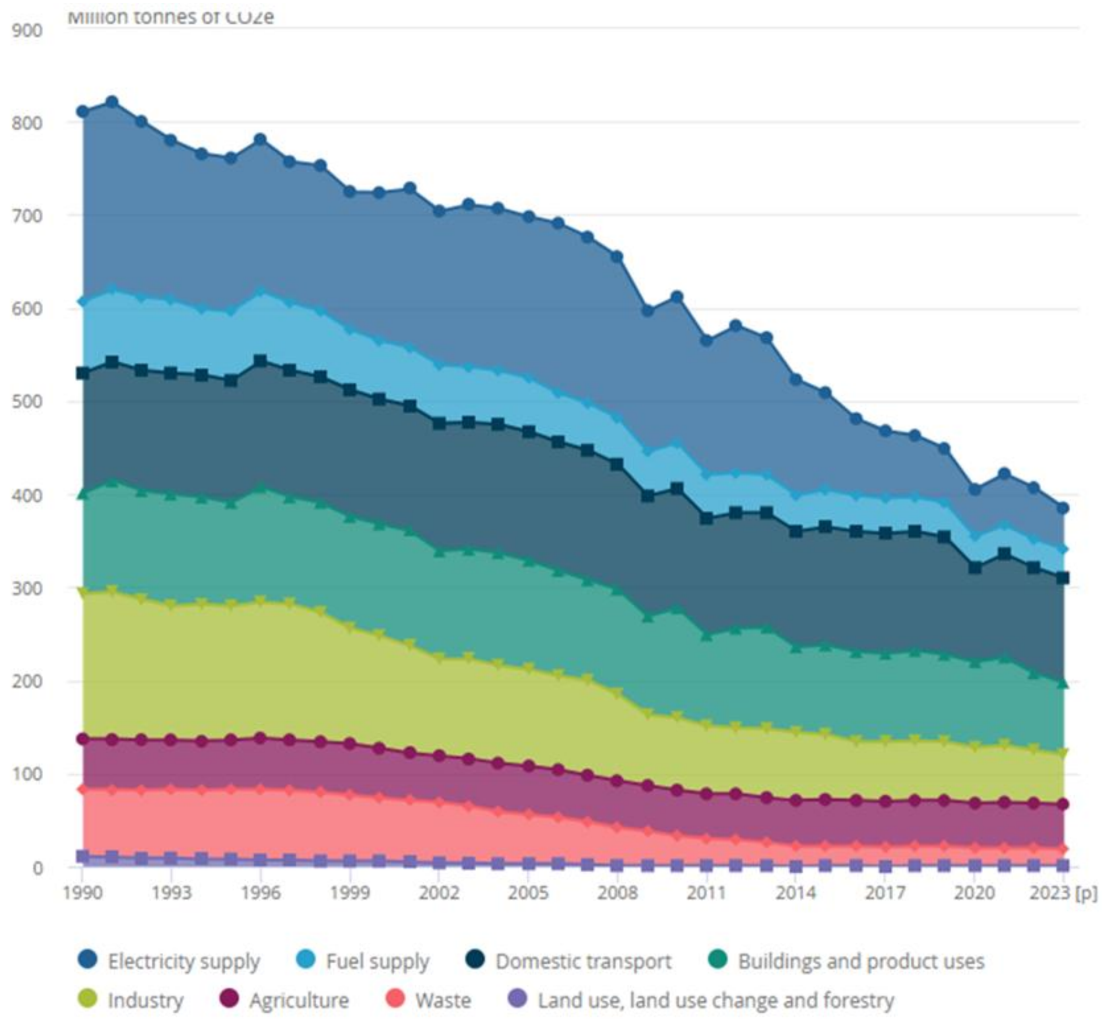
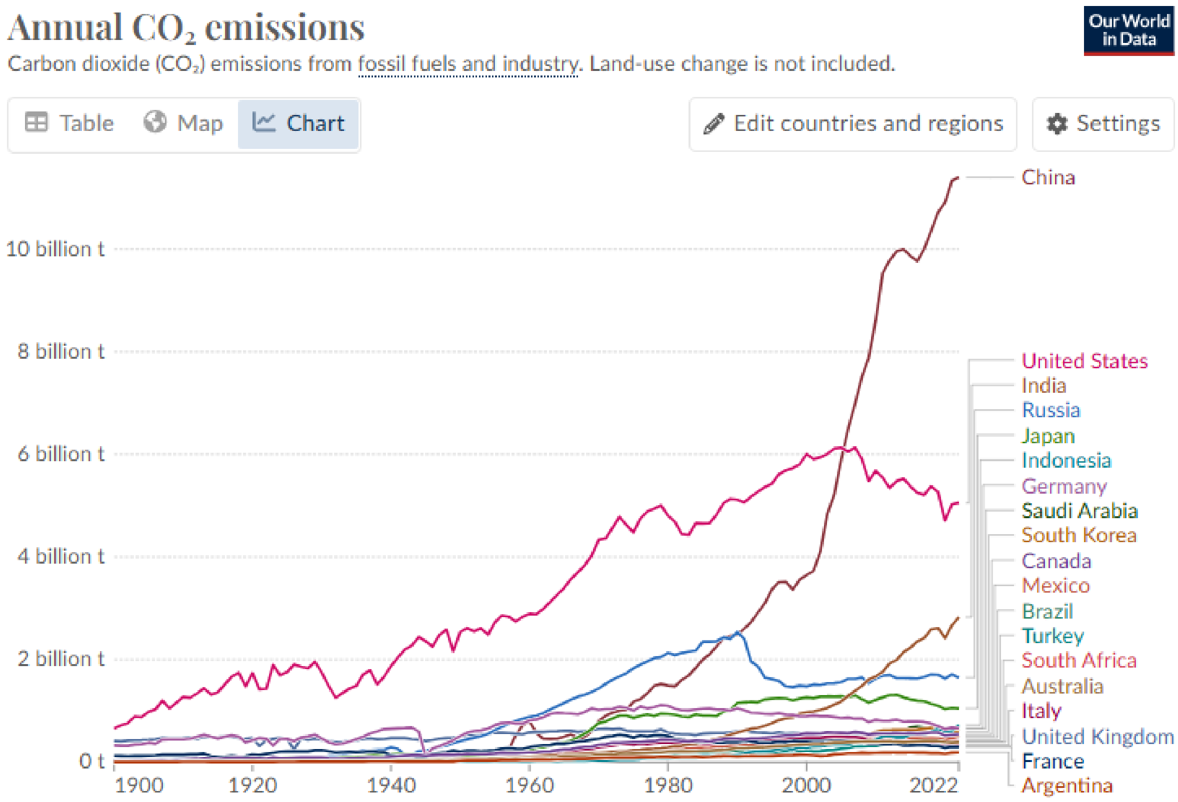


Figure: Territorial CO2 emissions by sector, 1990-2023 (provisional)

[1] Measuring UK greenhouse gas emissions - Office for National Statistics

In global context, however, the marginal impact of further UK emissions on CO2 is limited, with the country producing <1% of 2022 global emissions, according to figures sourced from Our World in Data[2], illustrated on the graph, below of emissions from G20 nations. Furthermore, in stark contrast to the major reductions in CO2 emissions achieved by the UK, many countries continue to increase emissions or are reducing emissions at a much slower rate.



It is therefore impossible for a scheme such as Tillbridge to have a "Beneficial (significant)" impact on Global Climate greenhouse gas emissions, as has been claimed by the Applicant. This global context is important in these key regards:

- Further reduction of UK CO2 emissions will have an extremely limited effect on global decarbonisation, and the contribution the Tillbridge scheme can make to UK decarbonisation will be marginal. The Tillbridge scheme claims to be able to save c. 15mT[3] of CO2 over the project's 60-year lifetime. In the context of the UK producing 400mT of CO2 per year, or China producing over 10bnT of CO2 per year, this can only be considered an insignificant contribution. This tiny global greenhouse gas reduction should be weighed against the intense local harms experienced by locating such large ground mounted solar development as Tillbridge on productive farmland, and close to villages and properties.
- CO2 is a global issue. Therefore it is essential that any benefits claimed by the Applicant do not result in "offshoring" CO2 emissions, i.e. artificially showing a reduction in UK emissions, but resulting in an increase in emissions elsewhere. Such may be the case by displacing food and biofuel crops by using productive UK agricultural land for ground-mounted solar, which then requires imported food or biofuels. The displacement impact has not been considered

[2] United Kingdom: CO2 Country Profile - Our World in Data
[3] EN010142-000399-6.1 Chapter 7 Climate Change.pdf (planninginspectorate.gov.uk)

and therefore the CO_2 savings claimed by the Tillbridge scheme are incomplete and potentially overstated. While Tillbridge solar is large, it is part of a much wider land grab for UK agricultural land, the cumulative consequences of which do not appear to feature in any planning consideration.

- Furthermore, much of the UK's success in reducing CO_2 emissions has been within the electricity sector, primarily through switching from coal to gas fired electricity generation and allowing renewable generation to develop without the need for renewable capacity to guarantee security of supply. Much of the remaining generation to be displaced is the flexible generation needed to balance the electricity system, particularly at times of peak demand, or during periods of renewable production. Given that solar cannot be scheduled to match generation, it cannot meet this need, therefore the comparison made by the Applicant to consider CCGT as a reference in its CO_2 saving calculation is an over-simplification. The energy produced by solar is not directly equivalent in how and when it can be used. Indeed, as flexible generation technology becomes abated or provided through low-carbon technologies, the carbon intensity of flexible generation will be expected to reduce. The Applicant's use of unabated CCGT a reference for CO_2 savings of the scheme over its 60-year operational lifetime will serve to overstate the potential CO_2 savings delivered by the scheme.

The Applicant has therefore described the global challenge of decarbonisation and makes an excellent case for those countries that are failing to reduce, or continuing to grow their CO_2 emissions to take urgent steps as the UK is already doing. However, it is clear that the UK's remaining practical impact on emissions is now very small, and any associated contribution towards decarbonisation considered to be afforded by the Tillbridge scheme must be given very little weight.

1.2 The Sixth Carbon Budget, 2020, UK Climate Change Committee:

Although the work of the Climate Change Committee is not itself a Government Policy, it provides the vital body of work upon which the UK's climate change and energy policies depend. It is important therefore, to consider this dimension first.

Solving climate change is a huge and complex challenge, with many interdependencies, where solving one issue may well compromise another. The Sixth Carbon Budget (6CB) considers the sectors that need action to meet the target of net zero, including Electricity Generation as well as Agriculture and Land Use, which are at the heart of the issue of large-scale ground-mounted solar development in the UK.

Within the 6CB[4], the "Balanced Net Zero Pathway for electricity generation" scenario includes 85GW of solar by 2050. It also indicates a progressive increase in solar generation output (in terms of volume of energy, rather than capacity) "from 10 TWh in 2019 to 60 TWh in 2035", which would imply around 60GW of installed capacity by 2035.

In terms of Agricultural Land Use, the 6CB also expects a 9% loss of agricultural land to reduce emissions and sequester carbon by 2035, and 21% by 2050. The key changes in agricultural land indicated are planting additional mixed woodlands, restoration of peatlands and energy crops grown in the UK. 6CB calls for between 30-70kha of tree planting per year. In addition to this, "around one-third of agricultural land is freed up through reduced output and more efficient farming practices". It

[4] Sixth Carbon Budget - Climate Change Committee (theccc.org.uk)

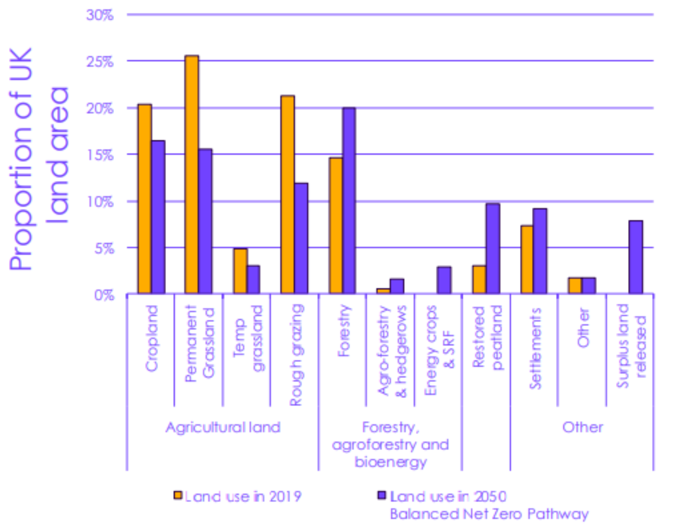
is not clear from the 6CB the extent to which further agricultural land is lost to urban development but demands for new housing and building for economic growth place further pressure on agricultural land. The use of large areas of agricultural land for ground-mounted solar development is not included in the consideration of changing agricultural land use envisaged by the 6CB.

Looking in more detail at what agricultural land is expected to reduce (see Figure 2.10 from 6CB), the land area of cropland is one of those expected to reduce by the least amount (<5%). By contrast, permanent grassland and rough grazing is anticipated to reduce by significantly more (c. 10% each). The net effect of all the changes is to release some “surplus land” by 2050, but this is heavily dependent upon many significant underpinning changes, e.g. increasing crop yields, dietary changes by the population (away from meat and dairy) and reduction in food waste.

The document is silent on how the anticipated increase in solar capacity might be implemented, i.e. how much capacity may be domestic or commercial rooftop solar, or how much might be from ground-mounted solar development. There does not appear to be any specific agricultural land identified for solar development, and the only way such capacity could be achieved would therefore be through far more conservative use of farmland than appears to be the current trajectory, the inference being the majority of capacity would need to be delivered through domestic and commercial rooftop solar.

It is clear therefore, that a radical and challenging change in agricultural land use is envisaged, in which a number of co-dependencies are necessary in order to achieve decarbonisation, and large-scale ground mounted solar has not been explicitly identified as one of these demands on land use. The early release of large areas of agricultural land to ground-mounted solar development at scale, would place additional pressure on agricultural land and potentially undermine the key changes in agricultural land use that are, according to the 6CB, necessary to decarbonise.

Figure 2.10 Land uses in 2019 and under the Balanced Net Zero Pathway in 2050



Source: Centre for Ecology and Hydrology (2020) and CCC analysis.
Notes: Forestry area includes small woodland areas (less than 0.5 ha or less than 20m in width) which are assumed to stay at current area. These areas are not accounted for in the Forestry Commission stats of forest coverage.

1.3 Recent UK Energy Policy Publications:

Underpinning the UK's Energy Policy is the 2008 Climate Change Act, which commits the country to legally binding reductions in CO2 emissions, achieving "net zero" by 2050. After that, a series of strategy documents describe the sector in more detail; the Ten Point Plan for a Green Industrial Revolution (November 2020), the Net Zero Strategy (October 2021), the British Energy Security Strategy (April 2022) and Powering Up Britain (March 2023).

Notably, while the **Ten Point Plan for a Green Industrial Revolution (2020)**[5], explicitly describes the important role of wind, hydrogen, nuclear and Carbon Capture and Storage (CCS), among other transport and financial measures, with clear ambitions for each, *the Ten Point Plan does not include solar*.

In the **Net Zero Strategy (2021)**[6], although solar is mentioned, most references are to new build rooftop and retrofit solar, and the case study is of a community solar scheme (Cuckmere Community Solar) at 4MW capacity.

The **British Energy Security Strategy (2022)**[7], restates the Ten Point Plan, in which solar is again not included. Solar is included in a chapter heading for the first time "Solar and Other Technologies". In this, the ambition for a five-fold increase in solar capacity is first described, i.e. from 14GW currently, to 70GW. There is no reference to where the ambition for 70GW originates from, with significant variation in possible solar capacity pathways to net zero being described by 6CB and FES (see below). There is also little information on how it is envisaged the UK electricity system would accommodate such a high volume of intermittent solar generation, without significant curtailment (also see below).

The document also includes commitments to alter planning rules, although there is a clear tension between strengthening policy "in favour of development on non-protected land" and "ensuring communities continue to have a say and environmental protections remain in place". There is also a clear emphasis on "supporting the effective use of land by encouraging large scale projects to locate on previously developed, or lower value land".

Powering Up Britain (2023)[8], again states the ambition for 70GW of solar by 2035, with the first reference to large-scale solar development "looking for development mainly on brownfield, industrial and low/medium grade agricultural land", in addition to "widespread deployment of rooftop solar in commercial, industrial and domestic properties across the UK".

These publications show how rapidly the policy landscape with regard to solar has shifted in recent years. The ambition for 70GW is relatively recent, with little detail available as to how this may be achieved within the context of overall decarbonisation objectives. It is therefore essential that a holistic view is taken, particularly regarding finite resources, such as land. Nowhere is there an explicit call for large-scale ground-mounted solar.

It is worth noting that the Government has already been criticised for "overpromising" finite land with its multiple ambitions for land use, (BBC article, Land use: Government has overpromised says

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[5] The Ten Point Plan for a Green Industrial Revolution (publishing.service.gov.uk)
[6] net-zero-strategy-beis.pdf (publishing.service.gov.uk)
[7] British Energy Security Strategy (publishing.service.gov.uk)
[8] Powering Up Britain: Energy Security Plan (publishing.service.gov.uk)

Royal Society", 01/02/2023)[9], following a report by the Royal Society on Land Use[10], which concludes that current policies on land use are "disjointed", with the chair of the report's steering group quoted as stating "the UK does not have enough land for any of it to be non-productive."

The Government is developing a Land Use Framework (LUF), which remains overdue. In this situation of flux, it is essential that caution is exercised when making determinations on large areas of land.

1.4 The Skidmore Review:

The **Mission Zero, Independent Review of Net Zero (2023)**[11], also referred to as **"The Skidmore Review"**, looks across Government departments "to ask how the UK can better meet its net zero commitments". Most importantly, this review takes a holistic view of the Net Zero challenge, seeking to make "recommendations both for government, for each sector and industry, for local regions and authorities, indeed for individual households". Solar is frequently mentioned in the review, but the key themes that relate to solar are:

Within Section 2.4 on Energy Supply, Paragraphs 266-268 (and following panel) call for a "Mission for Rooftop Solar", including a "rooftop revolution" (it is notable there is no equivalent call for a ground-mounted solar revolution). The section also states that:

- "solar farms in the countryside should be not be planned piecemeal but in a co-ordinated fashion as part of a Land Use Strategy".
- "where located near communities, the utilisation of a consent process — that could be delivered through Local Area Energy Planning, a 'Net Zero Neighbourhood Plan' or equivalent — should aim to ensure that these projects are not imposed on local communities"

Section 2.5 of the review considers the electricity grid in terms of System Flexibility, opening with "The high penetration of renewable generation within the energy system comes with the challenge of supply side variability". Within this section:

- Paragraphs 287 states "There is a clear and rising need for flexibility in the UK's electricity system", arising from the need to balance energy supply with demand,
- Paragraph 292 states that while plans for short-term storage (intra-day) are comprehensive, the review concluded in Paragraph 293, that "government could provide more clarity on long duration (between day and beyond) solutions for managing so called dunkelflaute events, periods of low wind and low solar generation potential." ("Dunkelflaute" is a German word used to describe dark i.e. low-solar, and still, i.e. low wind periods, which are most challenging for energy systems with high proportions of renewable generation).

Section 3.6 looks at growth and decarbonisation across sectors, recognising the particular interdependency between food, agriculture, nature and land use have with decarbonisation. In this section:

- Paragraph 654 asserts "The transition to net zero and the growing impact of climate change is affecting how we use land" and highlights the need for new uses of land to decarbonise,

[9] Land use: Government has overpromised says Royal Society - BBC News
[10] des7483_multifunctional-landscapes_policy-report-web.pdf (royalsociety.org)
[11] MISSION ZERO - Independent Review of Net Zero (publishing.service.gov.uk)

“Net zero relies on using land to remove carbon from the atmosphere. For example, the UK is planning to plant 30,000 hectares of woodland a year by the end of this parliament. Nature-based solutions (like tree-planting) are expected to provide around 40% of the greenhouse gas removals required by 2050. At the same time, there is growing pressure on our land for other uses – for example, the UK’s housebuilding target of 300,000 new homes per year by the mid-2020s and growing uses linked to net zero, such as biomass, nuclear, solar or wind power.”

- Paragraph 659 asserts “The Government lacks a clear plan for how we will manage these competing and interrelated demands on land”.

1.5 Energy Act 2023:

The Energy Act became law in October 2023, with the Government describing the act as “biggest piece of energy legislation in the UK’s history”[12]. The Act seeks to transform the UK’s energy system by “strengthening energy security, supporting the delivery of net zero and ensuring household bills are affordable in the long-term”. The Act covers a tremendous breadth of topics necessary to achieve these goals, including market reforms, the arrangements for an independent system operator and planner, energy saving opportunities, smart appliances, as well as explicitly covering specific energy technologies, including Carbon Capture Use and Storage (CCUS), hydrogen, wind and nuclear. Within the Act’s 497 pages, solar is not mentioned once, which starkly illustrates the strategic contribution solar can play in meeting the UK’s future energy landscape.

1.6 Ofgem Connections Action Plan, 2023:

In November 2023, Ofgem, the Energy Regulator published its “Connections Action Plan”[13], which is about speeding up connections to the electricity network across the country. Delays to grid connections have become a significant issue in recent years as the system has become increasingly congested. The volume of connection applications has increased tenfold over the last 5 years.

The document shows that solar is the largest single contributor to this situation of grid constipation, with almost 80GW of applications in the year 2022/23 alone (see Figure 2 from the CAP, below). Much of the problem the Connections Action Plan seeks to address has arisen from the massive recent surge in applications for ground-mounted solar schemes that would oversupply the UK’s 70GW ambition by at least a factor of two (without considering existing installed capacity or any potential rooftop solar). The lack of strategic plan to understand how the Government’s ambition for 70GW of solar is delivered, what proportion should be on rooftops, and what proportion should be ground-mounted has worsened the scale of challenge already faced by National Grid, leading to significant delays in the projects that can make the greatest contribution to decarbonisation or that are essential to grow the economy.

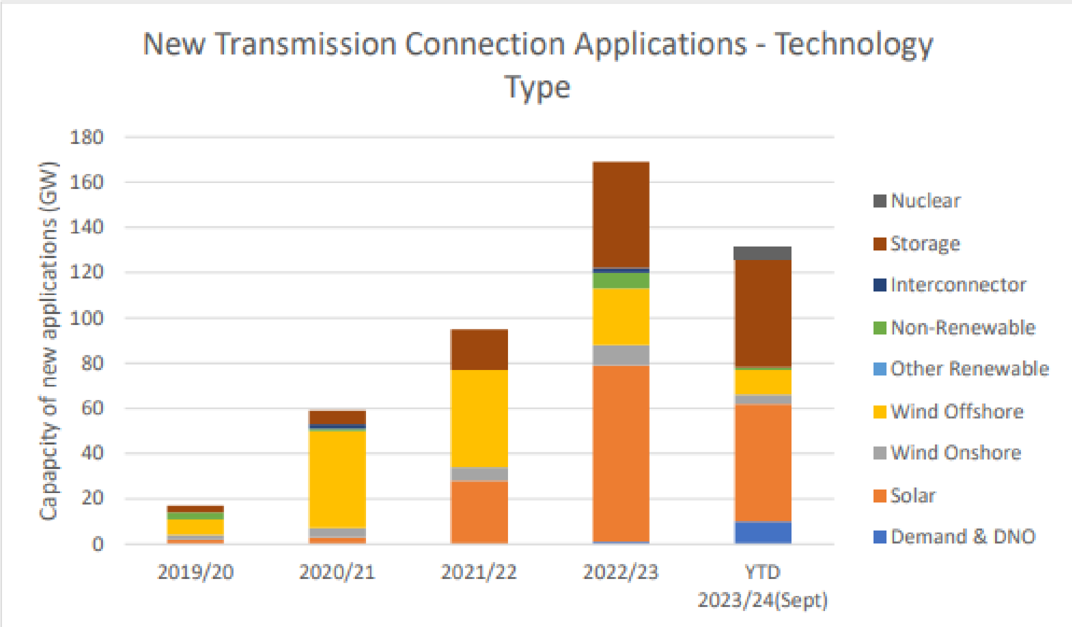
The plan itself seeks to raise entry requirements and remove “stalled” projects, which will address the many speculative connection applications in the queue. Further actions are to improve utilisation and allocation of the network capacity. There remains, however, an absence of any consideration of technology type within the plan, i.e. the strategic capacity required of any technology or any

[12] New laws passed to bolster energy security and deliver net zero - GOV.UK (www.gov.uk)

[13] Connections Action Plan: Speeding up connections to the electricity network across Great Britain (publishing.service.gov.uk)

assessment of contribution it can make to decarbonisation. Therefore, the underlying situation of there being far more solar applications than the country needs remains a key Achilles in the quest to reduce grid connection times.

Figure 2: New connection applications to the transmission network by technology and capacity.



1.7 Further Government announcements and messaging, new Government from July 2024

The key message of the incoming Labour Government with regard to the environment has been to accelerate the decarbonisation of the electricity sector, bringing forward the goal of zero carbon electricity to 2030. A raft of new bodies and structures have been introduced, including the establishment of "Mission Control for Clean Power 2030"[14], to which Chris Stark (former Chief Executive of CCC) has been appointed lead, a Clean Power 2030 Advisory Committee[15] and the establishment of Great British Energy, as a vehicle to co-invest in technologies that will help decarbonise the sector among a range of other priorities for the Department[16], including the establishment of the National Energy System Operator (NESO)[17].

With regard to solar specifically, the incoming Secretary of State had a number of NSIP-scale solar schemes on his desk that were overdue for determination. Against this context of acceleration and the desire for the UK to be seen to be "open for business"[18], the SoS would have been under pressure to approve these schemes. Two of these schemes, Cottam and Gate Burton are in the immediate vicinity of the Tillbridge scheme, and 7000Acres believe that in the time between the SoS

[14] Chris Stark to lead Mission Control to deliver clean power by 2030 - GOV.UK
[15] Energy experts appointed to deliver clean power 2030 mission - GOV.UK
[16] Energy Secretary Ed Miliband sets out his priorities for the department - GOV.UK
[17] Designation of the National Energy System Operator (NESO) - GOV.UK
[18] PM tells US investors "Britain is open for business" as he secured major £10 billion deal to drive growth and create jobs - GOV.UK

taking up his appointment and approving the schemes, it would have not been possible to fully understand the significant cumulative impact on the area.

In parallel with the approval of 3 NSIP-scale solar schemes in July, plans for a delivering the long called-for "rooftop revolution" were signposted, indicating solar-related standards for new-build properties from 2025[19].

In addition, the Government's Solar Taskforce has been relaunched in October 2024[20], to "accelerate the UK's solar energy rollout". In the relaunch press release, there is "focus on ethical supply chains and a skilled workforce to scale up installations" as well as reference to the "rooftop revolution". 7000Acres will watch with interest whether the Solar Taskforce can reconcile the necessary breadth of decarbonisation and commercial interests of organisations represented[21].

1.8 Commission of the Strategic Spatial Energy Plan

In October 2024, the UK, Scottish and Welsh Governments jointly wrote to NESO to commission them to deliver the SSEP[22]. Within this commission is the requirement to deliver optimal "Locations, quantities and types of energy infrastructure that balance all the SSEP's objectives by being resilient, low-carbon, affordable, and taking into account cross-sectoral demands on land and sea"[23]. Further "cross-sectoral" considerations are highlighted in the commission, ensuring that "the SSEP considers wider demands on land and sea, including (but not limited to) food production, transport, water supply, nature recovery, fisheries, tourism and military", furthermore, that "the SSEP does not seek to prioritise energy over competing sectoral demands". If this work can satisfactorily meet these requirements, it will be an important consideration, however 7000Acres fear its conclusions will be too late for the West Linsdey region given the timescales of concentrated development in the region.

Section 1: Summary

In Decarbonisation terms:

- There is need to expand solar capacity to decarbonise – but this is not explicitly by use of ground mounted solar.
- There is pressure to reduce agricultural land to decarbonise, through forestation, peatlands and biofuels; 6CB calls for between 30-70kha of tree planting per year. Large-scale ground-mounted solar would place extra pressure on this land use.

From an Energy Policy perspective:

1. Solar is not part of the of the UK Government's Ten Point decarbonisation plan.
2. The policy framework regarding solar has been a shifting landscape in recent years and continues to evolve.
3. While the ambition for solar development has grown to 70GW of capacity, there is no explicit target for large-scale ground-mounted solar development in the UK.

[19] Labour's 'rooftop revolution' to deliver solar power to millions of UK homes | Solar power | The Guardian
[20] Solar taskforce meets in drive for clean power - GOV.UK
[21] Solar Taskforce - GOV.UK
[22] SSEP joint commission letter
[23] Strategic Spatial Energy Plan: commission to NESO

4. Significant challenges to large-scale ground-mounted solar development are acknowledged, including efficiency of land use, community impacts and environmental impacts. (None of these downsides arise for rooftop solar installations.)
5. Land use is increasingly recognised as being a key challenge and is subject to current Government work to develop a Land Use Framework.

The “Skidmore Review”:

1. Acknowledges the need for a “Mission for Rooftop Solar”,
2. Recognises the increasing importance of managing land use as a part of decarbonisation – and the need for a clear plan on how we manage competing demands on land.
3. Asserts that near communities, solar should not be “imposed on communities”, instead being consented through a process of Local Area Energy Planning.
4. Recognises the increasing importance of managing system flexibility – particularly in periods of low wind and solar.

Section 2 National Policy Statements

2.1 Background - Statement by the Secretary of State and National Planning Policy Framework

Throughout the recent evolution of policy, a number of key features have remained consistent for many years. The Secretary of State for Communities and Local Government stated on 25 March 2015:

> *"Last year, the Coalition Government published a comprehensive solar photovoltaic strategy setting out our ambitions for the technology as an important part of the United Kingdom's energy mix. In doing so, the strategy underlines the importance of focusing growth on domestic and commercial roof space and previously developed land."*

This statement is consistent with the Skidmore Review (Skidmore Review, see above) that calls for a "rooftop revolution". So, in citing the use of domestic and rooftop solar the Government is presenting a long standing and consistent policy. The Secretary of State's Statement then said:

> *"Meeting our energy goals should not be used to justify the wrong development in the wrong location and this includes the unnecessary use of high-quality agricultural land. Protecting the global environment is not an excuse to trash the local environment. When we published our new planning guidance in support of the Framework, we set out the particular factors relating to large scale ground mounted solar photovoltaic farms that a local council will need to consider. These include making effective use of previously developed land and, where a proposal involves agricultural land, being quite clear this is necessary and that poorer quality land is to be used in preference to land of a higher quality".*

These principles are consistent with the National Planning Policy Framework[24] (updated 19th December September 2023) that sets out three requirements:

> *"An economic objective – to help build a strong, responsive and competitive economy, by ensuring that sufficient land of the right types is available in the right places and at the right time to support growth, innovation and improved productivity; and by identifying and coordinating the provision of infrastructure."*
>
> *"A social objective – to support strong, vibrant and healthy communities, by ensuring that a sufficient number and range of homes can be provided to meet the needs of present and future generations; and by fostering well-designed, beautiful and safe places, with accessible services and open spaces that reflect current and future needs and support communities' health, social and cultural well-being;"*
>
> *"An environmental objective – to protect and enhance our natural, built and historic environment; including making effective use of land, improving biodiversity, using natural resources prudently, minimising waste and pollution, and mitigating and adapting to climate change, including moving to a low carbon economy."*

2.2 NPS Suite (2011 – 2023) and Evolution of NPS Suite 2024

The suite of National Policy Statements (NPS) for energy have been revised following a prolonged period of review and feedback. The new suite of NPS documents came into force in January 2024.

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[24] National Planning Policy Framework

Despite this review process, commenting on late draft documents, the Electricity Networks Commissioner report (June 2023)[25] called for several improvements in the coordination and planning of electrical infrastructure projects and has recommended that "the Energy NPS should be updated again urgently after the current round of changes that are currently in consultation, to reflect the recommendations in this report". There is potential, therefore that the currently proposed NPS documents will need to be refreshed relatively quickly, subsequent to their publication.

The previous NPS suite was in force for much of the development of the Tillbridge Solar Project, so the documents provide the context for the policy landscape during this time – as well as the Applicant's choices in terms of what requirements have and have not been followed.

The previous NPS documents were published in 2011, three years after the 2008 Climate Change Act came into force. The documents make little reference to solar. The 2011 version of EN-1[26], which is the Overarching Policy, envisages large scale renewable energy generation from wind (offshore / onshore), Biomass, EfW, Wave and Tidal, citing the UK's abundant national resources in these areas – notably, this does not include solar. Solar is only mentioned once, to highlight the need for back-up capacity to manage intermittent generation.

With regard to land use, the 2011 NPS EN-1 (5.10.8) requires that Applicants "should seek to minimise impacts on the best and most versatile agricultural land (defined as land in grades 1, 2 and 3a of the Agricultural Land Classification) and preferably use land in areas of poorer quality (grades 3b, 4 and 5) except where this would be inconsistent with other sustainability considerations". The Applicant has not considered the wider implications their extensive land use for solar, particularly in terms of the additional pressure on land use, which must also meet other decarbonisation and sustainability demands, such as food security, direct decarbonisation measures or growing biofuels.

The 2011 NPS EN-1 also advises that the Inspector should give little weight to the loss of poor-quality land (including 3b), "except… in areas… where particular agricultural practices may themselves contribute to the quality and character of the environment or the local economy." Notwithstanding the unusually high proportion of land that has been assessed as 3b, within the area of West Lindsey in which the Tillbridge project is proposed, there is a demonstrable link between agriculture, the environment and the local economy, therefore the exception should have been applied.

Within the 2011 NPS EN-3[27], the National Policy Statement for Renewable Energy Infrastructure, solar is not mentioned in 82 pages of guidance, whereas, onshore wind, offshore wind, biomass, waste combustion, wave and tidal are all covered.

2.3 2024 NPS EN-1

The NPS suite has been through two drafts, in September 2021 and in March 2023, both associated with consultation rounds. The Consultation Response, as well as the versions to be adopted were published in November 2023.

Overall, 2024 NPS EN-1[28] reflects the current situation of transition and uncertainty with regard to decarbonisation, in particular the need for co-ordination of energy policy and planning (as widely called for in reports reviewing UK progress towards decarbonisation, see below in this WR), noting

[25] Electricity Networks Commissioner letter to Secretary of State for Energy Security and Net Zero
[26] 1938-overarching-nps-for-energy-en1-withdrawn.pdf
[27] 1940-nps-renewable-energy-en3-withdrawn.pdf
[28] EN-1 Overarching National Policy Statement for Energy

that the "Government has committed to producing a Strategic Spatial Energy Plan (SSEP), to bridge the gap between government policy and infrastructure development plans". The document also notes that many technologies that will be essential to decarbonisation are in their infancy, e.g. how technologies "to provide storage over longer periods of low wind and solar output (e.g. days, weeks or months)… are not yet available at scale", or will require further action to develop business models to incentivise their deployment, e.g. as with Carbon Capture Use and Storage (CCUS) or low carbon hydrogen production.

NPS EN-1 also describes the holistic nature of sustainable development, as being "relevant not just in terms of addressing climate change, but because the way energy infrastructure is deployed affects the well-being of the environment, society and the economy, for both current and future generations".

Specifically, regarding electricity, NPS EN-1 states that "the larger the margin, the more resilient the system", but that "a balance must be struck between a margin which ensures a reliable supply of electricity and building unnecessary additional capacity which increases the overall costs of the system". This underlines the need for overall co-ordination, particularly where the underlying favourable economics could easily deliver an excess of generation capacity associated with specific technologies, and thereby exacerbating issues of inefficiency through curtailment (see Section 4.1.3).

The NPS describes a list of known generation technologies within the scope of the document, and following consultation feedback, has evolved the definition of "a critical national priority (CNP) for the provision of nationally significant low carbon infrastructure", where low carbon infrastructure is defined as "for electricity generation, all onshore and offshore generation that does not involve fossil fuel combustion…". This is an evolution of the 2024 Draft NPS[29], which defined the CNP only "for the provision of nationally significant new offshore wind infrastructure (and supporting onshore and offshore network infrastructure)".

This very recent change follows a very close margin of feedback[30] (with 35 in agreement with the March proposed draft definition of CNP, and 39 in disagreement). It is worth noting that this is from a total of 157 responses, 61 of which were from the categories "Business / Trade Association" or "Commercial Organisation". Many of the names of these organisations are redacted from the consultation feedback report, but of the named respondents, many were bodies with interests in solar development, e.g. Solar Energy UK, Eden Renewables, EDF and Scottish Power Renewables.

The result of this is that is no emphasis within the NPS on any one technology over another, even though not all technologies are able to contribute to decarbonisation in equal measure. For instance, offshore wind is foreseen by National Grid to produce over 70% of the UK's electricity by 2050, which is presumably why it was singled out in the original definition of CNP in the March 2023 draft NPS.

Although the 2024 NPS EN-1 therefore, at one level, equates such diverse contributors as offshore wind, solar, wave and geothermal, apparently without regard for their potential to contribute towards the energy mix and decarbonisation, in weighing impacts and benefits, the Secretary of State is directed to "take into account its potential benefits including its contribution to meeting the need for energy infrastructure". This allows the SoS to consider the actual contribution such technologies can make.

[29] EN-1 Overarching National Policy Statement for Energy

[30] Draft National Policy Statements for energy infrastructure: government response to consultation

The 2024 NPS EN-1 also reinforces two long-standing requirements of planning, namely, applying principles of “good design” and the consideration of alternatives to a proposed development.

“Good design” includes how infrastructure “relates to the landscape it sits within” and that “applying good design to energy projects should produce sustainable infrastructure sensitive to place, including… efficient in the use of natural resources, including land-use”.

Allied to land use, is the subject of the use of agricultural land. The NPS states “Where development of agricultural land is demonstrated to be necessary, areas of poorer quality land should be preferred to those of a higher quality” (this principle of a “hierarchy” of preferred land use is further expanded in emerging NPS EN-3). In the case of Tillbridge, the Applicant has focused entirely on the quality of agricultural land and has not made a case to demonstrate the necessity to use agricultural land.

Also, within “Good Design”, the NPS notes the importance of “the functionality of an object – including fitness for purpose and sustainability”. This WR will describe the constraints around the functional contribution solar can make to energy and decarbonisation, which are limited to the point where the benefits do not outweigh the harms arising from ground mounted solar installation at such a large scale.

From the NPS, in decision-making, the Secretary of State “should be satisfied that the applicant has considered both functionality (including fitness for purpose and sustainability) and aesthetics (including its contribution to the quality of the area in which it would be located, any potential amenity benefits, and visual impacts on the landscape”.

With regard to alternatives the NPS states that the “decision making process of the existence (or alleged existence) of alternatives to the proposed development is, in the first instance, a matter of law”. The NPS recommends that the “Secretary of State should be guided in considering alternative proposals by whether there is a realistic prospect of the alternative delivering the same infrastructure capacity (including energy security, climate change, and other environmental benefits) in the same timescale as the proposed development”.

In the case of Tillbridge, the Applicant has created an extremely narrow envelope of alternatives, starting with grid connection access, then seeking to secure sufficient volume of land to maximise use of the grid connection. On that basis, the discussion of alternative sites by the applicant is superficial, in that rooftop solutions, or use of brownfield sites were never a genuine consideration. On the other hand, in order to decarbonise effectively, even without retrofitting solar to rooftops, the capacity of Tillbridge could be deployed each year by making use of new-build domestic rooftops, thereby providing a much more rapid deployment of the same capacity, with fewer adverse impacts than the Tillbridge scheme.

The NPS also describes the impacts on landscape, stating that effects “arise not only from the sensitivity of the landscape but also the nature and magnitude of change proposed by the development”, noting that “the scale of energy projects means that they will often be visible across a very wide area. The Secretary of State should judge whether any adverse impact on the landscape would be so damaging that it is not offset by the benefits (including need) of the project”. The combination of the colossal scale of ground mounted solar projects such as Tillbridge as well as the height selected of tracking panels at 3.5m to 4.5m, is not sensitive to the landscape.

Related to landscape is the provision of green infrastructure and open space to meet the need of local communities, which are seen as having a vital role in promoting healthy living. Development of a scale that dwarfs the surrounding communities removes such amenity.

2.4 2024 NPS EN-3

Within the 2024 NPS EN-3 (Renewable Energy), solar is now included, although this describes "a typical 50MW solar farm", being between 125 and 200 acres. While it notes the potential for this to vary significantly, it also notes the potential for this to change over time as technology becomes more efficient – implying a reduction, rather than an increase in size.

In addition, there is a clearly defined hierarchy in the list of land that should be used for ground-mounted solar. Section 2.10.29 states: "applicants should, where possible, utilise previously developed land, brownfield land, contaminated land and industrial land. Where the proposed use of any agricultural land has been shown to be necessary, poorer quality land should be preferred to higher quality land avoiding the use of "Best and Most Versatile" agricultural land where possible."

The wording is clear therefore, in that agricultural land should be used after these other land classes have been explored, and only where use of agricultural land has been shown to be necessary. The Applicant has failed to identify any previously developed land, brownfield land, contaminated land or industrial land for any of its proposed development, and the Applicant has failed to make any case that using agricultural land at this scale is at all necessary.

As an aside, there is a clear anomaly in the treatment of different generating technologies within the NPS, by considering "capacity", without consideration of the yield it can deliver. For instance, offshore wind is required to have a capacity of >100MW to be considered a nationally significant electricity generating station. With a load-factor of over 50%, the likely yield of such a plant will be >50MW. By contrast, the threshold for a solar farm is 50MW. With a typical yield of 10% in the UK, the threshold to be nationally significant effectively falls to an average of 5MW.

2.5 NPS EN-5

Much of the focus of EN-5[31] is specifically related to delivering the infrastructure to deliver offshore wind, and the details of offshore/onshore networks. EN-5 makes explicit reference to the need for infrastructure to deliver offshore wind throughout the document, e.g. in sections 1.1.2, 1.1.3, 2.2.3. 2.7.5.

Aside from offshore wind, other generation technologies are bundled together and are understood to fall within the watered-down definition of "Critical National Priority". This definition originally applied to offshore wind (2023 dNPS), but was fatally weakened down in the final draft to refer to any low-carbon generation and therefore renders any effective prioritisation utterly meaningless.

Nevertheless, in practice the prioritisation is clear; despite the focus of EN-5 being Electricity Networks, wind is mentioned 34 times within 47 pages of the document. Solar is not mentioned in EN-5.

The Applicant has selected land areas >2km from substation to deploy solar panels, and because of the distance, a high voltage transmission line is required, and the Applicant may therefore attempt to argue that technically, their associated network infrastructure should in some way be considered to be in line with EN-5. However, the Applicant has effectively "created their own need" through their preference and selection of scheme design, which is not the same as a genuine "need". This should

[31] Electricity Networks National Policy Statement - EN-5

not therefore, carry the same weight as electricity network requirements essential to deliver offshore wind, which are the primary focus of EN-5.

Fundamentally, the requirement to deploy solar at an HV substation is unnecessary, (as described in Section 6 of this WR). Connection of solar at the point of use avoids transmission and distribution losses of typically c. 8% . It is clear therefore, that much of the yield increase the Applicant seeks by deploying large 3.5m to 4.5m high tracking solar panels will simply offset the loss incurred by having selected a 400KV transmission substation as the point of connection.

Of importance when considering EN-5 is the Electricity Networks Commissioner Report (2023), which makes several recommended improvements, notably around creating a Strategic Spatial Energy Plan, i.e. mapping where specific energy provisions will be deployed. The report seeks that the “Energy NPS should be updated again urgently after the current round of changes”. Again, by way of illustration, in the Commissioner’s 12-page covering letter, “wind” is mentioned on 7 occasions. Solar is not mentioned. In the accompanying report, within 15 pages, wind is referred to on 13 occasions, and solar is mentioned once.

EN-5 highlights the requirement for “Good Design”, as laid out in EN-1 (above).

Section 2: Summary

1. The 2024 NPS does not foresee ground mounted solar of the scale proposed by CSP.
2. The NPS advocates “good design”, including the importance of the functionality of the development. This WR will describe the constraints around the functional contribution solar can make to energy and decarbonisation, which are limited to the point where the benefits do not outweigh the harms arising from ground mounted solar installation at such a large scale.

Section 3 Review of Progress Reports on UK Decarbonisation:

3.1 Overview of Review Reports

Three major reports were published in 2023 that assess the decarbonization of the power sector in the UK and current progress towards delivering on that goal. In doing so, they describe the main challenges and the extent to which solar plays a role. These reports are:

- Delivering a reliable decarbonised power system[32], by the UK Climate Change Committee (CCC), March 2023
- Decarbonising the power sector[33], by the National Audit Office (NAO), March 2023
- Decarbonisation of the power sector[34], by the Business, Energy and Industrial Strategy Committee (BEIS), April 2023 – **Note:** *the energy portfolio of this department is now the responsibility of the Department for Energy and Net Zero (DESNZ)*

In addition, the Climate Change Committee produced their annual report to Parliament on overall progress in reducing emissions, considering all sectors of the economy. While this report provides a much broader perspective than the power sector, the document still provides insightful and more recent comments. This report is:

- *Progress in Reducing Emissions 2024 Report to Parliament[35], by the UK Climate Change Committee (CCC), July 2024*

The CCC 2023 report states “the UK Government has committed to decarbonise electricity supply by 2035, in line with the Climate Change Committee’s advice. However, the Government has not yet provided a coherent strategy to achieve its goal”; this is a consistent message across all reports, with the BEIS Committee report stating, “for too long, policies for the power sector have been designed in silos, without adequate consideration of how they all interrelate and fit together”.

All reports call for greater Government involvement, with the NAO report recommending that “Decarbonising power requires government to increase its planning and coordination of the power system”. The BEIS Committee echo this by stating “the Government must become more involved in co-ordinating delivery, including the provision of an overarching delivery plan”, and the CCC 2023 report similarly states “careful system-level and asset-level planning and design is needed from the outset to ensure that a decarbonised system, with a higher degree of weather-dependence, can be made reliable and resilient.”

All reports conclude that delivery of the decarbonisation of the electricity system is under threat because of this uncoordinated approach, with the NAO stating, “the lack of a delivery plan means DESNZ cannot be confident its ambition to decarbonise power by 2035 is achievable”, and going on to assert that “without a delivery plan DESNZ cannot fully understand when costs could be highest and the potential effect on taxpayers and consumers.”

The BEIS Committee identifies notable omissions in the Government’s strategy to decarbonise the power sector, “these include, but are not limited to, policy to deploy onshore wind, measures to

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[32] Delivering a reliable decarbonised power system March 2023
[33] Decarbonising the power sector - NAO report
[34] Decarbonisation of the power sector
[35] Progress in reducing emissions: 2024 Report to Parliament

reduce energy demand, support for long-duration energy storage, a decision on the use of hydrogen across the economy and clarity on where private finance for nuclear energy projects will come from."

The BEIS Committee report goes on to highlight points from the CCC, echoing concerns that the Government's 2035 goal will not be met without "urgent reform", their key issues being:

- a lack of an overarching delivery plan and focus on whole system costs;
- network constraints and delays in securing grid connections;
- an outdated planning regime;
- economic headwinds that have increased costs for developers of low-carbon projects, and a global race to secure investment in the energy transition;
- bottlenecks across supply chains;
- a wholesale electricity market that is in need of reform;
- a lack of focus on ensuring a route to market for flexible assets; and
- limited progress in reducing energy demand.

In all of the above, while there are clear concerns raised regarding the UK's current path to decarbonization, within the details, it is notable that *solar is not central to any key recommendations to address the situation in any of the reports*.

In the Government's response to the BEIS Committee Report on progress towards decarbonisation, the word "Solar" does even not feature once in 33 pages of discussion.

The 2024 CCC progress report identifies 10 priority actions for the remainder of the year, to make up lost ground. These measures advocate the policy landscape to encourage the use of heat pumps, improvements to energy efficiency, measures to decarbonize buildings, increase the rate of electrification for industrial heat, as well as explicit support for on and off-shore wind. There is also a call for a ramp up of tree planting and peatland restoration, stating "There must be no more delays to addressing the barriers to delivery". Solar does feature in these 10 priority actions.

For the electricity supply, the sector-specific priority recommendations in the 2024 CCC report relate to ensuring CfD auctions support offshore wind, removing planning barriers for onshore wind, managing flexibility through low-carbon options, ensuring sufficient network capacity, and urging the Government to publish the Strategic Spatial Energy Plan. Again, solar does not feature in the sector-specific priority recommendations.

Some of the key themes from reports are described in more detail, below.

3.2 Call for Overall Co-ordination

The BEIS committee state that "The level of coordination and pace of delivery needed requires the Government to operate in a different way than it has in the past" and call for an "overarching delivery plan for the decarbonisation of power, with clear milestones and contingencies". This aligns well with the CCC recommending the publication of "a comprehensive long-term strategy for the delivery of a decarbonised, resilient, power system by 2035"

According to the NAO report, the Government has committed to create a new organisation to co-ordinate the power system, called the Future System Operator, which would "advise government on policy decisions that balance decarbonisation with maintaining a secure supply of electricity and ensuring the system runs efficiently. This might include, for example, advice on the best location to build new wind farms".

This indicates the high level of intervention such a body would be required to play in the co-ordinated development of the future energy system, in order to effectively and efficiently decarbonise the power system.

3.3 Issues with Network infrastructure

Delays in availability of grid connections are widely reported in the press. The BEIS committee asserts that "The UK's 'first come first served' approach to grid connections is failing to deliver the volume of connections required. Projects which may be speculative or slow-moving risk being prioritised over those that are more viable".

The nature of the challenge lies in the observation made by the BEIS committee that "The expansion of renewables, especially offshore wind, will mean that more generation is located on the periphery of the network (for instance in Scotland or East Anglia or Cornwall), situated at greater distances from large centres of demand (such as South East England)".

The CCC 2023 report quotes National Grid which stated that "in order to support the Government target of up to 50 GW of offshore wind by 2030, in the next seven years it will have to install more than five times the amount of transmission infrastructure in England and Wales than has been built in the last 30 years".

This highlights the scale of the challenge, and given offshore wind is expected to play such a dominant role in the future UK energy mix, failing to deliver grid connectivity to offshore wind would have a seriously impair decarbonisation.

The BEIS committee noted that "In May 2022, the Government appointed Tim Pick as the UK Offshore Wind Champion—an independent advisor to government on the development of the UK's offshore wind sector". Tim Pick was quoted as saying that if Ministers "take just one message… it should be the urgent need to upgrade our national grid".

As an indication of the scale of change, the BEIS committee reported that "Between 2018 and 2022, the volume of new application offers provided per year by National Grid ESO to generators wanting to connect to the grid grew tenfold, and the volume of offers that will be sent out in the first quarter of 2023 alone will exceed the total volume in 2022".

What is unhelpful are the high volume of speculative or unnecessary schemes that are in the queue for National Grid connections. The BEIS Committee report reports that "Future Energy Scenarios modelling by National Grid ESO shows that Great Britain needs between 123 and 147 GW of low-carbon transmission generation by 2030 to be on a net zero compliant pathway. In February 2023, Great Britain had 257 GW of low-carbon electricity generation with contracts for future connection to the transmission network. Combined with the 83 GW already connected to the grid, that is almost three times as much than is needed. However, National Grid ESO expects just 30–40% of projects in the queue to come to fruition, with many pipeline connections likely to be speculative".

There are now over 150GW of solar schemes in the National Grid connection register. Such schemes do not include the potential for rooftop solar schemes. This is a clear area where greater coordination is required as the current scramble for potential solar schemes and strategic holding of grid connections serve to exacerbate the existing circumstance of congestion.

BEIS recommend that "Ofgem allows National Grid ESO to require projects already in the queue to meet strengthened milestones. If projects are unable to meet these, network operators should be able to prioritise other more viable projects in the queue".

It is worth noting that network infrastructure extends beyond the electricity network. The CCC 2023 report notes "The network and storage infrastructure needed to support a decarbonised system will also be very significant, with build required for the transport and storage of electricity, hydrogen and CO2". Such infrastructure for electricity storage (particularly medium to long-term), hydrogen and CO2 is in its infancy, again underlining the scale of network infrastructure challenges that must be overcome to decarbonise the UK power sector.

The CCC 2024 report echoes this, with a sector-specific priority recommendation to ensure capacity meets growing demand – and fully implementing improvement plans.

3.4 Need to address the shortfall in low carbon generation:

To meet the decarbonisation target, the bulk of future energy volume will be produced by low carbon generation. In this space, there is real concern expressed by the CCC and NAO that installation of wind and nuclear generation are not being progressed sufficiently quickly.

With regard to wind, the NAO notes that "Achieving DESNZ's ambition of up to 50GW of offshore wind by 2030 requires more than 37GW to be deployed in eight years. By comparison, as of January 2023, 12.6GW has been deployed since the first offshore wind farm started operating in 2000".

The BEIS committee also notes that "No offshore wind project has been recommended for approval by the Planning Inspectorate since 2017". Wind is also highlighted as a key priority area of action by the CCC 2024 report.

BEIS states that "The UK is a world leader in offshore wind, with the largest fleet of turbines outside China. Offshore wind is widely expected to provide the bulk of the UK's electricity in future. The CCC 2023 report suggested that by 2050 the UK may have between 65 and 125 GW of offshore wind capacity, up from 13 GW today."

Crucially, with a yield (load-factor) of over 50% for offshore wind, that capacity will deliver 280-560TWh of power – and provide the foundation for the future energy system.

With regard to nuclear, NAO notes that "DESNZ has an ambition for up to 24GW of nuclear power by 2050 and to make progress on up to eight more reactors by 2030", but highlights "a gap of nearly 18GW for the government to achieve its 2050 ambition of up to 24GW. Only one project (3.2GW at Hinkley Point C) has entered construction in the past 20 years".

The NAO makes the explicit recommendation that the Government "within 12 months, review plans for achieving its ambitions for offshore wind and nuclear power expansion".

For Solar, the CCC 2023 report notes that build rates for solar remain "close to historical peak". It describes the estimated installation rates to meet the 70GW ambition by 2035 as requiring 4.3 GW per year of solar and "4.1 GW of solar having been achieved historically", however the CCC's 2024 report noted a significant shortfall in PV installation. This shortfall was not of sufficient concern to be included in its "ten priority actions". Nowhere does the CCC call for extensive ground mounted installation, which would no doubt interfere with the delivery of tree planting and peatland restoration, both of which require land for direct decarbonisation measures.

Furthermore, in evidence given to the BEIS Committee it was noted that “there have been double the installations of rooftop solar this year compared to last year. That is entirely driven by the energy price crisis. Those in the warehousing sector have said that they think we could put 15 GW of solar on their sector alone. There is an awful lot we can do there, which has not really been looked at yet.” It was also noted that “local planning system is working quite well”, and reflecting that “Local democracy is working” in this regard.

The BEIS Committee reflected on the Review of Net Zero by Chris Skidmore MP which “recommended that the Government establish a taskforce and publish a roadmap to help achieve its 70 GW ambition” and that “in March 2023, the Government accepted this recommendation, with plans to establish a joint government industry taskforce and publish a solar roadmap in 2024”.

A final aspect that is raised by in both the CCC 2023 and 2024 Reports and the BEIS Committee is that of skills, there is pressure in particular sectors, where gaps and shortages have the potential to pose a delivery risk to offshore wind, new nuclear and carbon capture projects. It is therefore essential that these skills are not “diverted” into projects that are of limited value to the decarbonisation of the power sector.

All reports call for urgent action to ensure sufficiency of wind and nuclear delivery programmes, and while one report highlights the shortfall in PV deployment, none call for large-scale ground mounted solar schemes, as proposed by the Applicant.

As an aside, the CCC 2023 report explores the possibility of importing renewable energy from outside the UK, “especially from countries with abundant potential for low-cost generation (e.g. from solar in sunny regions)”. Implicit in this is the acknowledgement that the UK is not an abundant source of solar energy.

3.5 The increasing importance of generation flexibility to manage intermittency of renewable generation.

To be able to balance the electricity system in the future, it is acknowledged that there is the need to manage this energy flexibility through energy storage and carbon free dispatchable power generation. Apart from the historical variability of demand, this is increasingly important as electricity supply is increasingly sourced from intermittent renewable sources.

The CCC 2023 report notes that “Careful system-level and asset-level planning and design is needed from the outset to ensure that a decarbonised system, with a higher degree of weather-dependence, can be made reliable and resilient”. Similarly, the NAO recommends that the Government should “establish how it will ensure the system is resilient to prolonged periods of low generation from renewables”. The CCC states that “The Government must give equal focus to low-carbon flexible solutions as to the full delivery of its existing renewables and nuclear commitment”.

The CCC 2023 report describes “a typical year” where “a balanced supply mix could comprise around 70% of annual generation from variable renewables (primarily offshore wind), complemented by around 20% from relatively inflexible generation such as nuclear and bioenergy with carbon capture and storage (BECCS). The remaining generation will need to come from low-carbon back-up generation (e.g. hydrogen-fired turbines and fossil gas plants with carbon capture and storage – CCS) alongside other forms of flexibility”. It is notable that solar does not feature as a material element of the CCC’s description of a future typical year.

The CCC 2024 report also calls for the development of low-carbon flexibility options within one of its 5 sector-specific priority recommendations, calling for an overall strategy for the delivery of a decarbonised, resilient energy system.

The BEIS Committee reports that “Traditionally, meeting security of supply has been most challenging during times of peak demand, with gas-fired power stations providing the required flexibility. In the future energy system, stress will be driven as much by peaks and troughs of electricity supply”. However, the BEIS Committee also reports that “Oversupply will also be problematic as, at periods of high renewable generation and low demand, additional energy will need to be consumed (either by increasing demand or using storage) or generators will need to be paid to reduce output, which would add to customers’ bills. Modelling by the CCC suggests that the power available from renewables will exceed demand in around one-third of hours in 2035”.

The BEIS Committee reported that “The total cost of balancing the system for 2022/2023 was £4.2 billion. To manage constraints (when there is more electricity in a part of the network than the network can safely handle), National Grid ESO paid out £1.38 billion in 2022 to reduce the supply of cheap renewable energy on the periphery of the network and increase supply from gas plants closer to demand instead”.

The BEIS Committee report described “The average cost to turn down a wind farm generator is around £50 per MWh, while the average cost to turn up a combined cycle gas turbine (CCGT) plant is around £200 per MWh”. The report also quoted Will Mezzullo, Head of Hydrogen at Centrica, who said “some studies estimate that by 2035, around 30 terawatt hours of electricity, equivalent to powering 8 million homes for a whole year, may need to be curtailed”.

This highlights the adverse consequences of uncontrolled, uncoordinated development of infrastructure, such as excessive large-scale ground mounted solar would have on the efficient delivery of a decarbonised energy system, by exacerbating the situation of “curtailment”, where renewable power is required to be reduced during periods of excess generation.

In terms of storage, the BEIS Committee report uses the analogy of frozen food to describe the importance of storage. Before refrigeration we lost 60% of food. Without greater storage capacity, the same would go for excess renewable generation that could not be immediately used. It was commented that this “is the big strategic gap that we have in this decarbonisation system”.

The BEIS Committee report stated that “The deployment of long-duration energy storage is essential to ensuring that a zero-carbon power system can operate 24/7, 365 days a year”.

The Applicant’s proposed development produces large-scale intermittent renewable generation with only very limited, short-term energy storage. The Applicant therefore provides only a partial offering to the decarbonisation of the power system, by failing to address the intermittency and flexibility issues necessary to balance the energy system.

3.6 Local involvement

In common with the Review of Net Zero (Skidmore Review), the BEIS Committee report states that “Local communities who host critical clean energy infrastructure should benefit from doing so”. As with the majority of other content in these reports, the focus is on resolving delivery of wind generation, rather than solar, suggesting “connections between offshore wind farms and transmission networks need to be better co-ordinated to minimise disruption for local communities”.

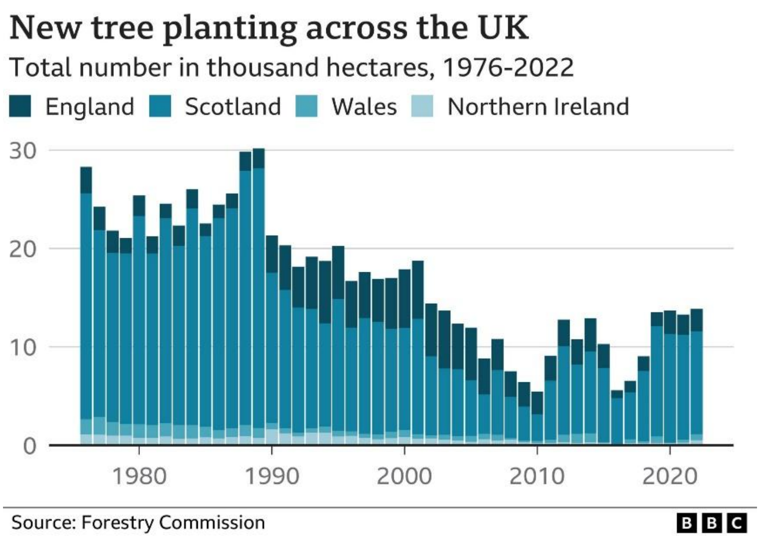
There is no reference to the circumstance of multiple large-scale ground mounted solar schemes being proposed within the same area, but it is clear that no net community benefit that would arise from Cottam, West Burton, Gate Burton and Tillbridge solar being located in such close proximity, quite aside from the compound effect of disruption to local communities through multiple schemes being developed in parallel.

Aside from these reports, the Electricity Network Commissioner report (June 2023) also called recommended that "Government and Ofgem should agree and publish guidelines on benefit sharing for individuals and communities affected by new or upgraded transmission lines". An observation was that "Communities may not see a direct link between connecting low carbon generation and local decarbonisation outcomes. Citizens may respond by strongly opposing projects". Although the Commissioner is primarily concerned with transmission lines associated with the electricity network, the same principle applies to generation infrastructure.

3.7 More broadly – with regard to Land Use

The BBC article Climate change: Is the UK on track to meet its net zero targets?[36] considers many facets of the UK's progress towards decarbonization, and including progress towards the measures necessary for direct decarbonization through tree planting and the restoration of peatlands, as advocated by the UK Climate Change Committee in the 6th Carbon Budget.

This is an important factor, particularly when considering the use of land at scale for ground-mounted solar. Trees and peatlands play important roles in removing carbon dioxide from the atmosphere. The article states that "UK forest cover is 13%, among the lowest in Europe."



It states that the "Government has a target to plant 30,000 hectares of trees a year by 2025. However, annual UK tree planting has not risen above 15,000 hectares since 2001". The article quotes the UK forestry body as warning that there is "zero chance" of the UK meeting its target."

The BBC article reports that "it is estimated that only around 20% of UK peatlands are in a near-natural state, including only 1.3% in England. These damaged peatlands are responsible for around

[36] Climate change: Is the UK on track to meet its net zero targets? - BBC News

5% of the UK's greenhouse gas emissions, whereas healthy peatlands would take up carbon dioxide." And reports that the CCC says that peatland restoration is "significantly off track".

Deployment of large-scale ground mounted solar puts additional pressure on land use – already considered to be stretched, at a time when it is clear that plans to deploy direct decarbonization measures through tree-planting and restoration of peatlands are already behind.

Section 3: Summary

It is clear that in order to decarbonise, the UK faces many challenges, among which those most pressing concerns are:

- The need for overall co-ordination and planning of the energy system
- The resolution of grid connectivity issues – especially to deliver offshore wind generation
- Inadequate pace of deployment of wind and nuclear power generation
- The need to manage energy flexibility and intermittency of renewable energy sources

While solar has its part to play, it features very little in the landscape of key challenges to be overcome for the UK to make a success of decarbonising the power sector, and existing rates of deployment do not appear to be a concern, thereby undermining the call by Applicants for extensive acceleration of solar deployment through large-scale ground mounted solar.

However, uncoordinated deployment of solar has the potential to interfere with efficient and effective decarbonisation by:

- Exacerbating issues of excess renewable supply and curtailment, thereby increasing the net cost of a decarbonised energy system.
- Competing for land that will be required for direct decarbonisation measures, through tree planting and restoration of peatlands.
- Providing additional "clutter" to an already overwhelmed queue of grid connection applications.
- Diverting skilled resources away from delivering on the key priority tasks for decarbonisation, e.g. offshore wind, new nuclear, carbon capture.

It is therefore essential that there is a clear plan for the deployment of solar to deliver the Government ambition for 70GW of solar, as has been recommended by Chris Skidmore's report, and as has been accepted by Government.

In the absence of such a plan, the Applicant seeks to gain from the uncoordinated situation in the UK with regard to decarbonization, and in so doing lock in long-term contracts that will back an infrastructure investment that may well be a source of future regret.

In submissions to the Examining Authority, the Applicant repeatedly conflates the urgent need for decarbonization with the urgent need for their large-scale ground mounted solar project. While there is an urgent need to decarbonize, it is clear that solar will play a limited role in resolving the key issues required to decarbonize the UK power sector – something that must be fully considered when weighing up the significant impacts of large-scale ground mounted solar schemes.

Section 4: Solar Capacity and Electricity System Considerations

4.1 Future Energy Scenarios, National Grid

National Grid publish Future Energy Scenarios (FES) each year, as a forward look into the development of the electricity system. Within FES2024[37], there are 4 "pathways", which are described as being "credible outcomes on the route to net zero". In 3 of these pathways, net zero is achieved by 2050, and in a 4th "counterfactual" pathway, net zero is not achieved by 2050, owing to slow decarbonisation and minimal behaviour change.

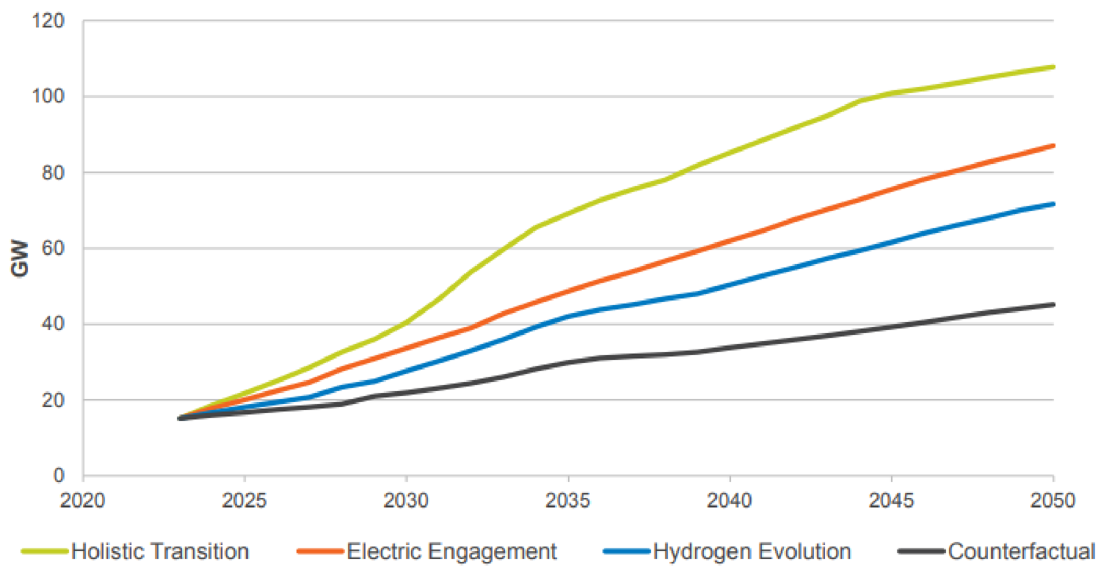
FES2024 highlights 8 key actions required "for a fair, affordable, sustainable and secure net zero energy system by 2050". These cover a strategic approach to network infrastructure, market reform, acceleration of hydrogen and CO2 infrastructure necessary for system flexibility, acceleration of low-carbon heating, delivery of smart technology for consumers, driving energy efficiency, long-duration energy storage and skills investment.

As FES evolves, different data sets are published each year, and some information was not published in FES2024, so FES2022 has been used where such information is not otherwise available. As with FES2024, FES2022 uses 4 different models ("scenarios", rather than "pathways"). Again 3 of these achieve net zero by 2050, and one, "Falling Short", does not.

4.1.1 Solar Capacity

Within the scenarios that meet the net zero target, the installed solar capacity increases from c. 16GW now, to a range from around 65GW to 107GW in 2050. In the "Counterfactual" pathway, only 45GW of solar is installed (Figure ES.14, from FES 2024). Therefore, even across the pathways that do achieve net zero by 2050, there is a wide range of installed solar capacity.

Figure ES.14: Solar capacity

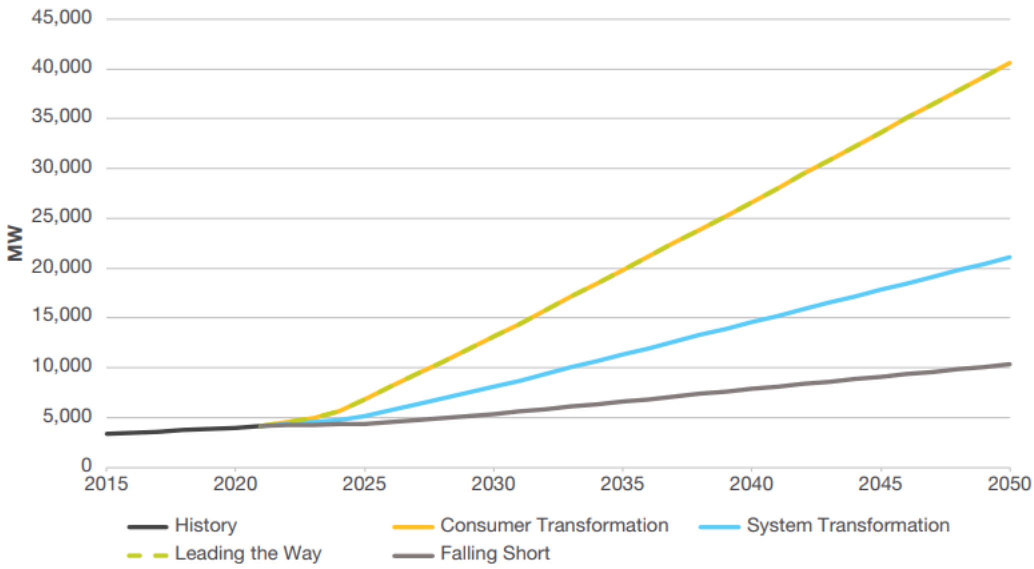


[37] Future Energy Scenarios (FES) | National Energy System Operator

In FES2022, National Grid have modelled the likely development of Domestic solar capacity until 2050, in the 4 scenarios (Figure EC.R.19 from FES2022). In the three scenarios where net zero is achieved, the rooftop solar capacity ranges from just over 20GW to just over 40GW. Part of the work done by National Grid as part of FES 2022 was to engage in consumer research. One concerning point is the degree to which households are "likely" to install solar panels in the next 5 years, which is below 25%.

Overall, the expected solar capacity installed increases between FES2022 to FES2024 and, reading between the two, there is a huge potential range for the contribution of Domestic solar PV, potentially 20% to 50%. Notably, this excludes rooftop solar connected on commercial buildings, so there is clear potential for rooftop solar to play a significant role in future solar capacity – precisely the opposite of the current path in which ground-mounted solar installation is dominant.

Figure EC.R.19: Domestic solar PV installed capacity



4.1.2 Flexibility and Balancing the Electricity System

FES 2022 also highlights the problem created by generation sources that are dependent upon prevailing weather conditions, e.g. wind and solar. This creates the need for flexible generation and storage capacity. To balance the electricity system, the National Grid needs flexible services to be able to match supply (generation) and demand over the short and long term.

In FES2024 "Flexibility is key to a net zero energy system and so this is covered in all chapters". It is a key consideration in each of the 4 "pathways", and features in one of the 8 key actions, as the need for infrastructure to support system flexibility.

To explain the need for flexibility more generally, there is a constant need to balance electricity supply and demand in the moment. The difference between available renewable generation and demand is considered to be the "residual load" requirement. To bridge this gap, the electricity system needs flexible "dispatchable" power, that can be instructed by the system operator to match demand.

For example, in the left-hand graph (below), the solid dark line is the total load required by the electricity system. After accounting for the renewable generation, the remaining generation to be dispatched is the graph on the right. This shows the amount of flexible, dispatchable power required and how quickly it is required to be dispatched. In this example, there is only a peak of 20GW of solar over the period. With up to 70GW of solar, the solar peaks will be much higher but will not be any wider (as this is determined by the length of daylight) and will still be zero overnight.

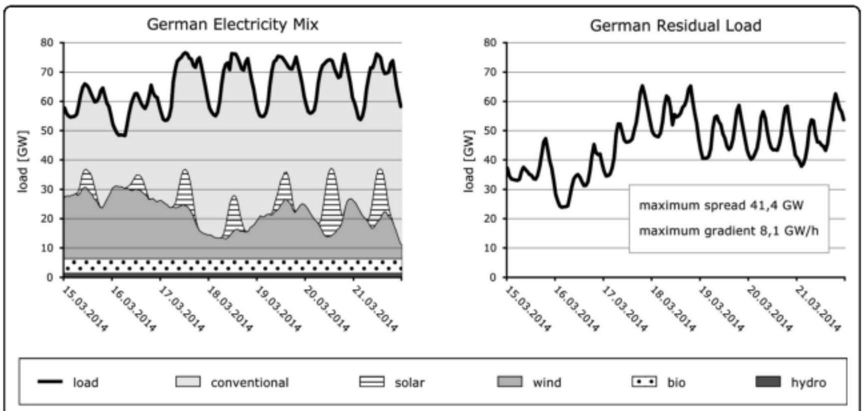


Fig. 2 Recent electricity mix and variation of residual loads (defined as load less wind and solar generation) in Germany, 11th week 2014, own presentation based on [102, 103, 104]

(From Energy, Sustainability & Society, 2015)[38]

This example shows that in this time frame, solar is the key contributor to the volatility of electricity supply by creating spikes in supply. Within the UK, these spikes do not coincide with peaks in demand, therefore high penetration of solar leads to a very challenging and volatile residual load line that dispatchable power needs to be able to meet, i.e. around the presence or absence of up to 70GW of solar.

In the second instance, there is the need to manage energy from season to season. Historically this has been done with coal, oil and gas as well as pumped hydro storage and interconnectors. Removing the carbon impact from this toolkit relies upon the development of hydrogen as a fuel and carbon capture processes to facilitate the continued use of gas (see diagrams Flexibility Requirements in 2020 and 2050 from FES2022).

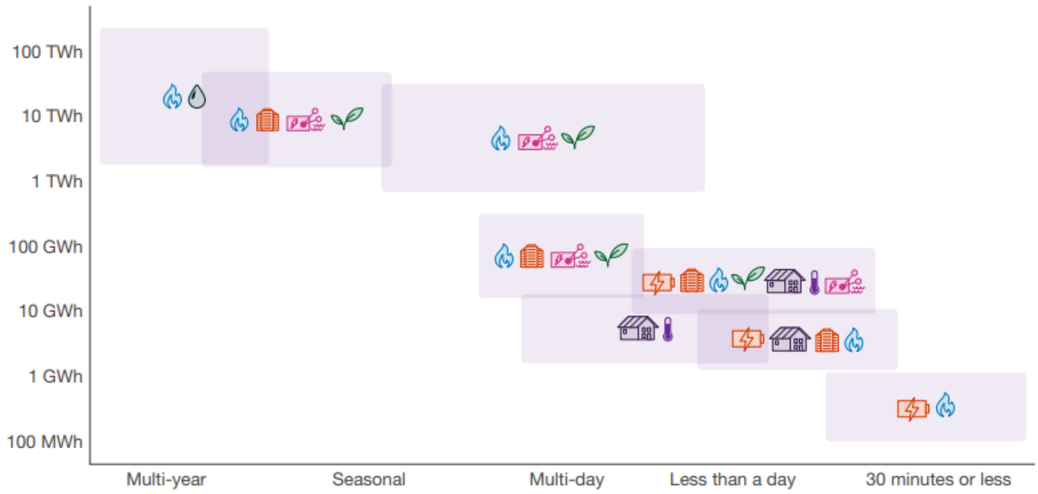
Electrolysers produce hydrogen from water and electricity. They will be essential to help store surplus power produced which is in excess of demand, which typically occurs when there is too much renewable energy, e.g. in the middle of breezy, sunny, summer days, when demand is low. As a result, hydrogen electrolysers are fundamental being able to manage energy between seasons.

FES2022 shows the range of electrolyser build until 2050 (Figure FL.13 from FES2022), ranging from 27GW to 45GW for the FES scenarios that meet net zero target by 2050 (and around 2GW in "Falling Short"). While the technology for electrolysers exists, it has not been deployed at such scale and there is no large-scale energy market for hydrogen in the UK (although its development is being encouraged by Government actions). With very limited opportunities for low-carbon, long duration energy storage, early excess build of intermittent renewable energy will lead to more energy being wasted, or curtailed (see next section).

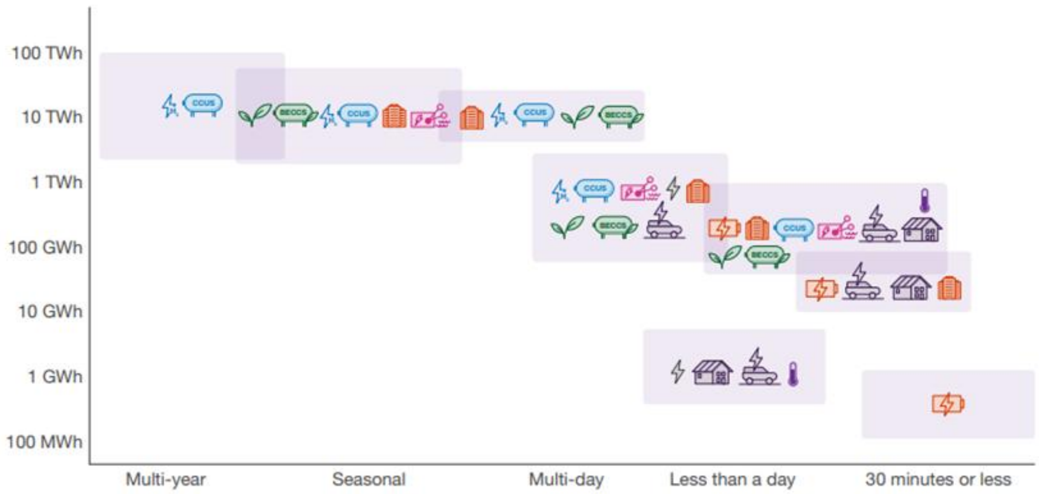
[38] Flexible bioenergy supply for balancing fluctuating renewables in the heat and power sector—a review of technologies and concepts | Energy, Sustainability and Society | Full Text

Although presented differently, FES2024 shows a similar scale growth of hydrogen (within ES.35 From FES2024). Much of this is considered to be electrolytic hydrogen, illustrating the scale of future need for high-power strategic connections to the National Grid to deliver decarbonisation goals.

Flexibility requirements in 2020[6]



Flexibility requirements in 2050



Key:
Electricity storage: Batteries Long duration energy storage (e.g. pumped hydro, compressed air, liquid air) **Interconnectors:**
Electrolysis: **Thermal energy storage:** **Oil:** **Demand side response:** Domestic or industrial EV flexibility
Gas storage: Natural gas Natural gas with CCUS Hydrogen **Bioenergy:** Biomass BECCS

Figure FL.13: Total electrolysis capacity: all network-connected electrolysers (including nuclear)[16]

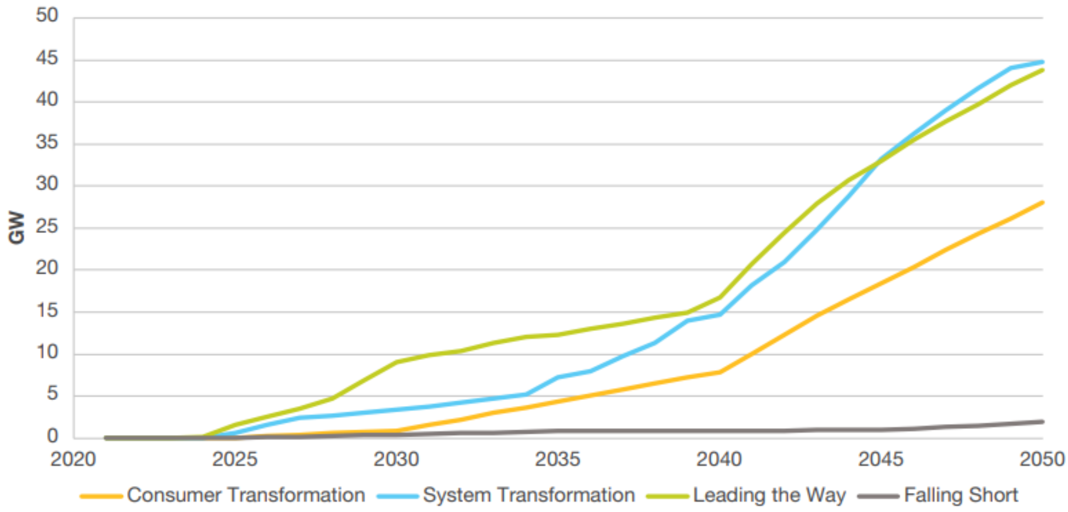
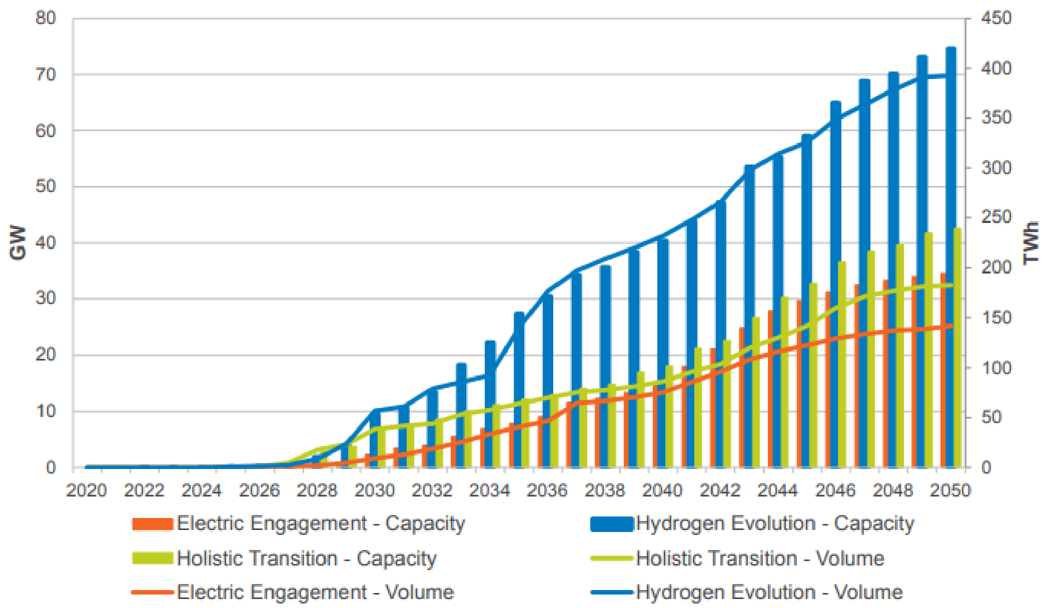


Figure ES.35: Hydrogen capacity and supply by pathway



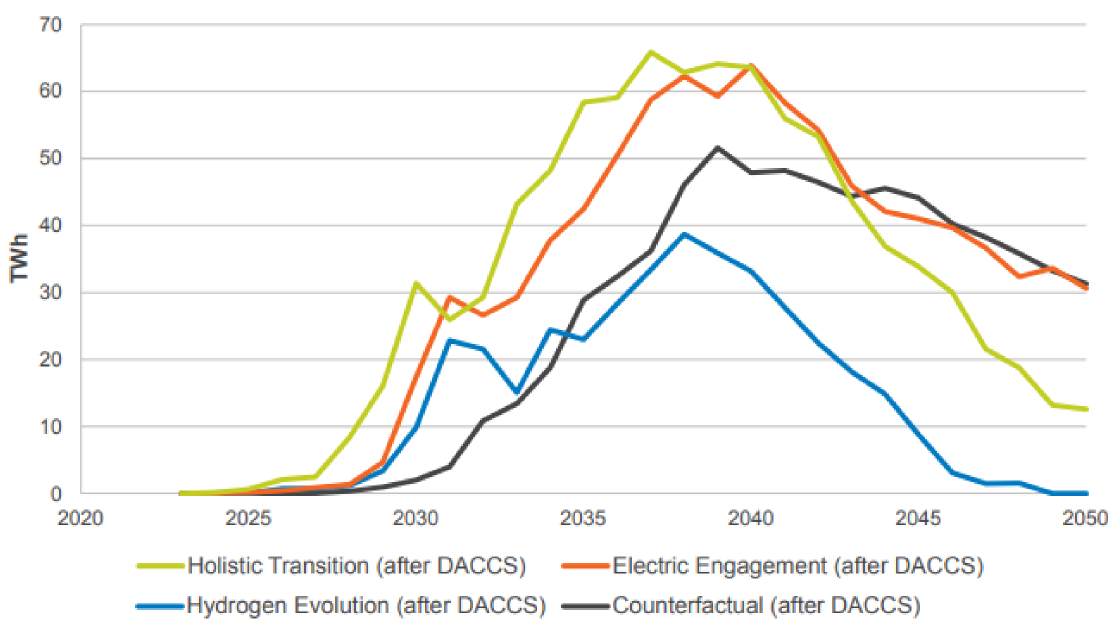
4.1.3 Curtailment

Curtailment is where an energy source is not used because there is simply too much generation for the demand, or through network constraints. In the former case, when there is a surplus of electricity generation, particularly through wind and solar, some generation will be asked to stop generating. It is done through a market mechanism, where the cheapest to turn off is instructed first. This already takes place on particularly breezy, sunny days in the summer, where solar output is at its peak, which then typically coincides with when demand is low. Curtailment is expected to become a growing problem. In the three pathways that meet net zero within FES 2024, in which curtailment peaks at between 40TWh to 65TWh. (See ES.26 from FES 2024). In context, the UK power demand annually is currently around 300TWh. This level of curtailment is between 13% and 22% of the current annual energy requirement and represents a material amount of power for which the producer typically is paid to not generate.

One way to minimise curtailment is by matching the amount of renewable capacity with the ability to manage demand or provide storage, e.g. with batteries or with hydrogen electrolysis. Without such a carefully managed approach, the vast amount of curtailment foreseen by National Grid will come to pass.

It has been reported that curtailment has already cost over £800m over the years 2020-2021 ("Renewable curtailment and the role of long duration storage", Drax LCP, May 2022[39]), when seeing only a fraction of the volume of curtailment anticipated by National Grid in future years. This represents a cost inefficiency passed on to a consumer who is already under significant financial pressure, as well as a poor return on investment in resources deployed with the aim of decarbonisation.

Figure ES.26: Annual curtailment



[39] Drax-LCP - Renewable curtailment report

4.2 Practical implications of high solar capacity on the National Grid

4.2.1 Balancing the electricity grid

A key feature of the electricity system is that the volume generated must match the demand at all times, in order to maintain system stability, otherwise the voltage and frequency would quickly fall outside permitted tolerances, and protection intervenes to disconnect the affected areas of the grid.

There are significant variations in demand across the day and between seasons. Historically, electricity generation has been scheduled and instructed to operate and vary its output to match the demand. Many renewable sources of electricity, in particular wind and solar, are "intermittent", in that they are dependent upon the prevailing weather conditions, rather than being able to be scheduled. See the following pages for information on the demand shape and generation mix across typical winter and summer days.

As an illustration, peak demand on the system can be as high as 45-50GW in the UK, depending upon the severity of winter weather. Such peaks are usually on winter evenings. By contrast, demand through the summer is much reduced, with demand often below 25GW through the daytime.

4.2.2 Need for flexible electricity generation

High levels of renewable generation are already posing a challenge to National Grid problems in balancing the system, often because there is too much, or too little wind and solar energy for the demand. The Grid needs plant with particular characteristics to help manage the stability of the system, as well as flexible generation to meet variability in demand. In this circumstance, the balancing market is used to determine which generation ceases or reduces production, and how much they will be paid to do so. This "balancing action" means that National Grid, and ultimately the consumer, pay for the inefficiency of having more power at certain times of the day than the system can handle.

In the pandemic year of 2020, with demand reduced as a result of lockdown, in order to accommodate renewable energy, National Grid are reported to have paid EdF around £50m to switch off the nuclear Sizewell Power Station[40]. Although the pandemic is an extreme circumstance, the situation was widely believed to be something of a "look into the future", as the growing capacity of renewable energy supply has the potential to cover periods of low demand many times over.

Through most summers now, the balancing market already pays renewable energy companies not to generate when there are periods of insufficient demand (curtailment). Domestic suppliers are already looking to address the topic of surplus power. For example, British Gas has introduced a tariff that encourages energy use between 11am and 4pm on Sundays in the summer[41], when solar demand is at its highest, and demand is typically very low.

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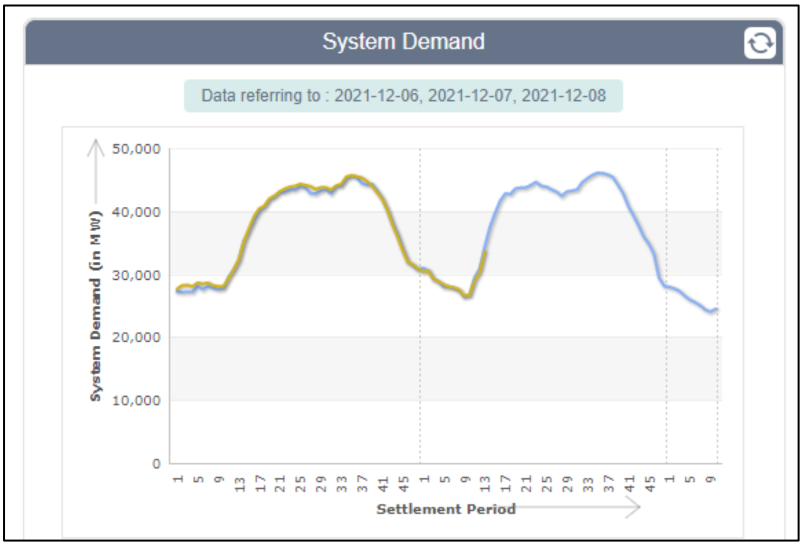
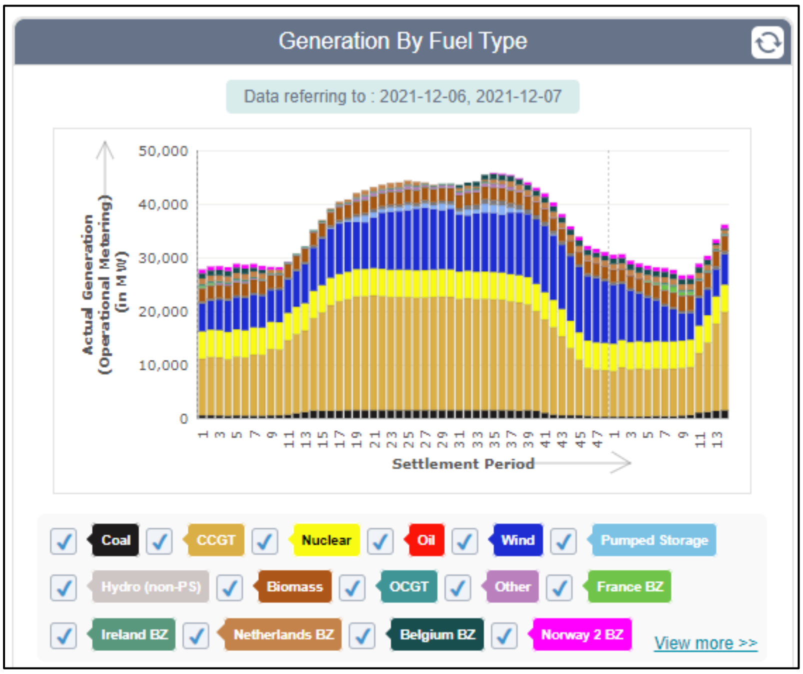
[40] Big is not so beautiful in Grid talks to power down (thetimes.com)
[41] PeakSave - rewarding better energy use | British Gas

Typical Winter Day – Electricity System (graphs from Elexon website, BMREPORTS.COM)

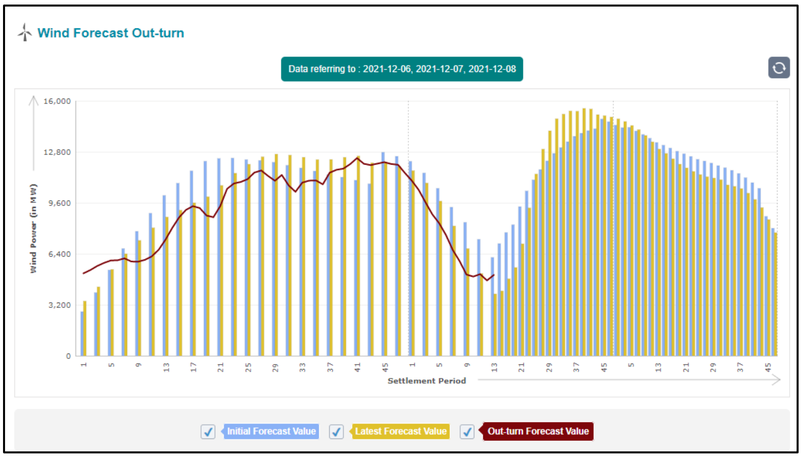


Typical winter demand from 25GW overnight, to 45GW at "peak"; settlement periods 37-38 (around 5-6pm)

(The electricity market day is split into 48 half-hour settlement periods, from midnight to midnight)

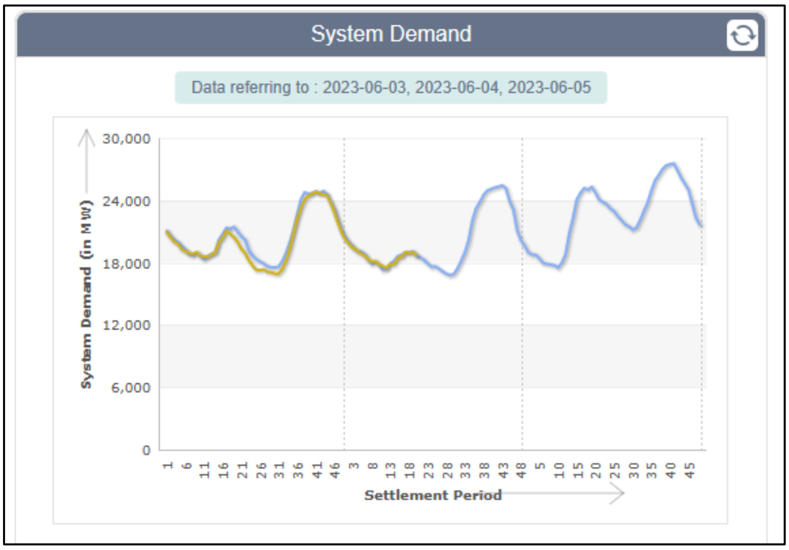


Generation type to meet the demand curve. Significant variable volume (blue) is wind. CCGT (gold) makes up the majority of the flexible generation (gas fired generation) needed to match the demand shape.



Graph shows the variability of wind over this period, from around 5GW to 16GW. The shaded bars show the difference in near-time forecasts versus the actual wind output (red line) – illustrating the uncertainty around forecasting renewable generation.

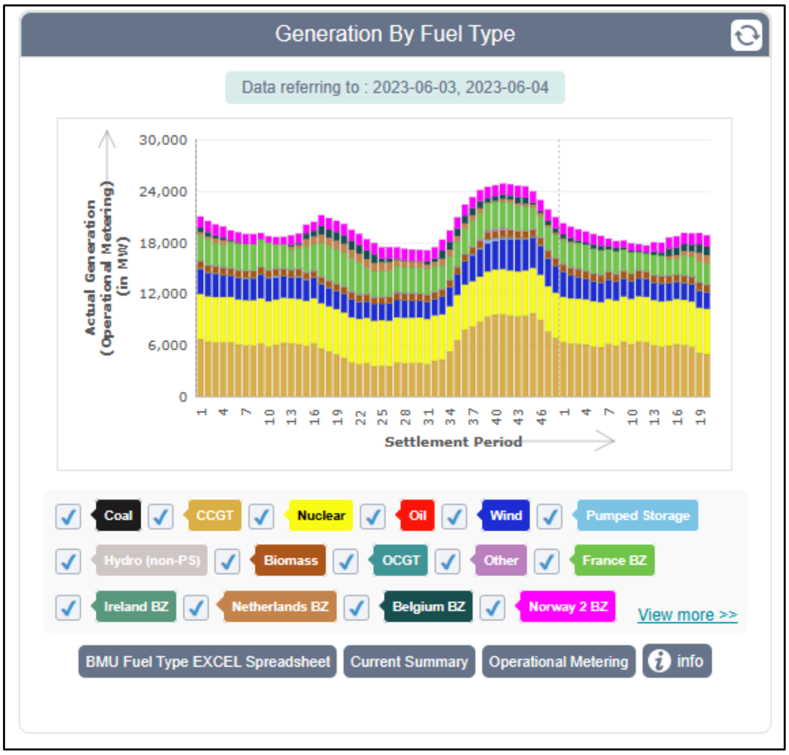
Typical Summer Day – Electricity System (graphs from Elexon website, BMREPORTS.COM)



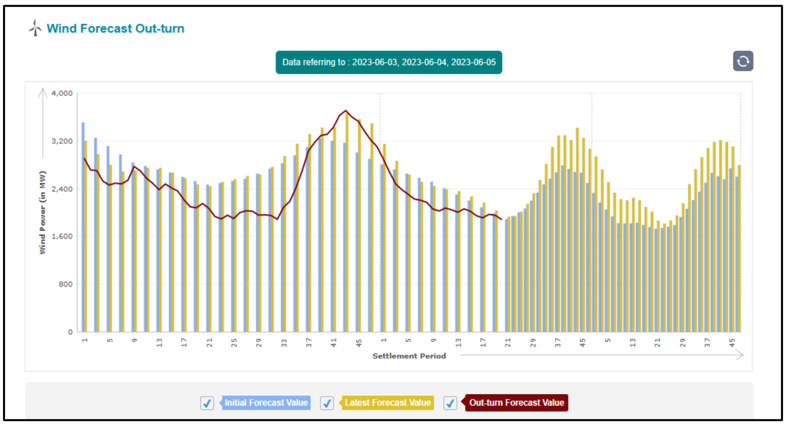
Typical summer demand from 18GW overnight, to 26GW at "peak"; settlement periods 40-41. (around 8pm)

Demand is effectively suppressed by solar during the middle of the day, e.g. periods 20 to 36.

(The electricity market day is split into 48 half-hour settlement periods, from midnight to midnight)



Generation type to meet the demand curve. CCGT (gold) makes up the majority of the flexible generation (gas fired generation)



Graph shows typically lower wind generation in the summer, as well as the variability of wind, from around 1.8GW to 3.7GW, in this case. The shaded bars show the difference in near-time forecasts versus the actual wind output (red line) – illustrating the uncertainty around forecasting renewable generation.

4.3 Solar Generation Capability

Solar power output is proportional to the amount of sunlight available. This means that solar power output peaks at a predictable time, usually between 11am and 3pm, even if the output itself is variable, dependent upon cloud cover. In the summer, when days are longer, and the sun is stronger the output is significantly higher than during the winter. (See next page, Indicative Solar Output in the UK).

In the UK, the average yield from solar generation is between 9% and 11% of its rated capacity (according to the Digest of UK Energy Statistics, DUKES[42]). Therefore, a scheme rated at 500MW, would, on average produce the equivalent of around 50MW for the year. This output however, would naturally vary, such that the power output would deliver its peak rated capacity during summer day-time periods, when demand is low. In this time, the scheme would produce the bulk of its power, reaching an average yield of around 16% of its capacity, i.e. around 80MW. In December, when days are shortest, the scheme would only yield an average of around 3% of its capacity, i.e. around 15MW. Noting this is an average figure, on the most overcast or foggy days, the yield could be as low as 0.5%, i.e. an average of 2.5MW, and in every case, the scheme will produce zero at peak winter demand. (Figures derived from Solar Power Calculator[43], which align with National Energy Action data[44])

While wind power is similarly intermittent, the average yield from a wind turbine is significantly higher. An offshore turbine can average around 45% of its capacity, while an onshore wind turbine can deliver around 28% (again from DUKES). Solar has the lowest average yield, and highest range of intermittency.

Increasing any intermittent renewable capacity, without the ability to manage demand, or store the power, means that there is a greater risk of curtailment, i.e. restricting the generation contribution of wind and solar generation because it is surplus to requirements. In turn, this will reduce the yield figures for the technology type. The yield figures for solar in the UK of between 9-11% are low, in global terms. They will be reduced by curtailment.

Much of this issue is because there is very limited storage capacity on the grid at present. Battery Energy Storage Systems (BESS) can only store an hour or two of their rated capacity, which facilitates the shift of some power between day and night, but it doesn't facilitate energy storage between seasons, therefore their role is critically limited. By contrast, the use of electrolysers to produce hydrogen has the capacity to use surplus power and create hydrogen, and store energy for use at a later time, but market scale development is in its infancy. Even in the more ambitious scenarios within FES 2022, there is only between 10 to 15GW of electrolyser capacity until 2040.

With solar capacity of 70GW, and offshore wind between 50GW to 100GW, the 2050's could regularly see between 100GW and 150GW of intermittent generation available to the grid, and that is before considering any onshore wind, nuclear or any remaining flexible generation necessary to stabilise the electricity grid. For a summer day today, of around 25GW of demand, there are already instances of curtailment.

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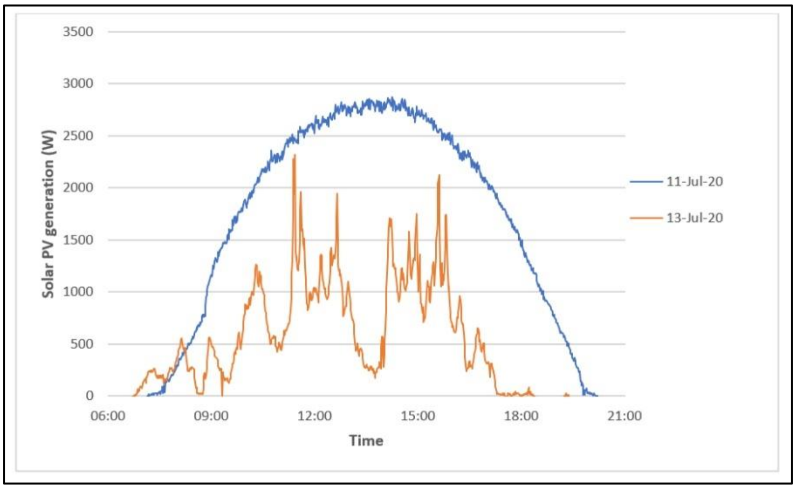
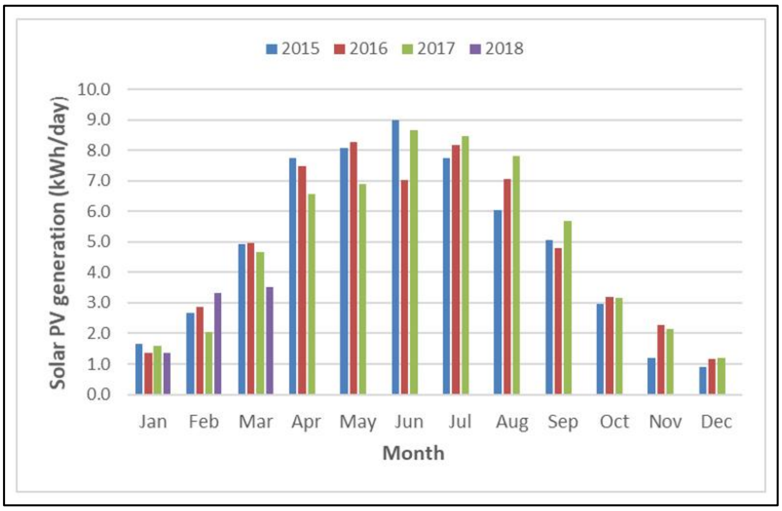
[42] DUKES 2021 Chapters 1 to 7 (publishing.service.gov.uk)
[43] Solar Power Calculator breakdown by month (in2gr8tedsolutions.co.uk)
[44] How much electricity do solar panels produce? - National Energy Action (NEA)

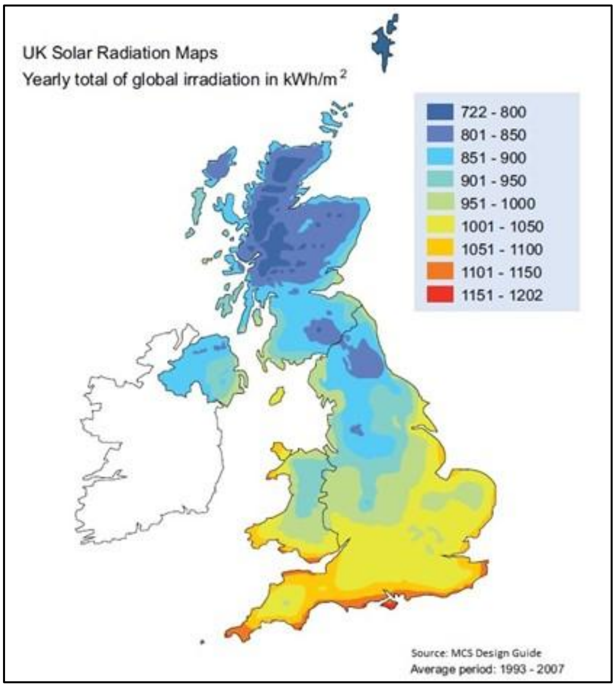
Indicative solar output in UK (Data from National Energy Action)



The curves show the output of panels on two July days, one is a sunny day (blue), the other is a day with patchy cloud (orange).



The curves show the output of panels over the year, with peak output being in May, June and July. The lowest output is in December and January.



Solar radiation maps show the amount of energy available to panels over a year.

Much of the UK yields around 1000kWh per m^2 or less.

The largest solar farm in Europe is in Spain, where each panel produces more than double this at 2130kWh per m^2.

The success of further expansion of renewable energy is therefore critically reliant upon the development of storage. Without this, the curtailment problem will worsen, the yield of schemes will reduce – and the net contribution to carbon reduction will diminish.

Large-scale ground-mounted large-scale solar is simple and cheap to install but given the mismatch between when it produces power and when power is needed, without sufficient storage, much of the energy available in the summer will simply be wasted.

4.3.1 How much power do solar panels produce? Solar to Power Households

The Tillbridge Solar Project describes the generation capacity of 500MW as being able to "Provide equivalent energy needs for around 300,000 households"[45].

This type of assertion is frequently made by developers. The calculation is based upon an annual total of power produced by the development divided by the average energy used by a household per year, but averaging in this way fails to take into account the need to match supply with demand, with solar production being out of phase with the demand curve.

Demonstrating the calculation for Tillbridge Solar Project:

> 500MW x 365 days x 24 hours x 11% yield factor, the average annual production = 481,800MWh
>
> The average household electricity use is dependent upon many variables, but Ofgem use 2900kWh as an average[46]:

Energy Use	Example – home type and number of residents	Typical annual electricity use (kWh)
Low	Flat or 1-bedroom house; 1-2 people	1,800
Medium	2-3 bedroom house; 2-3 people	2,900
High	4+ bedroom home; 4-5 people	4,300

> In terms of output, 481,800 MWh is 481,800 x 1000 kWh, therefore
>
> Equivalent number of homes powered = (481,800 x 1000) / 2900 = 166,137 households

For the Heckington Fen scheme, Ecotricity demonstrate their calculation[47], including using a higher average electricity use per household, based upon their evidence of higher than average electricity use locally in Lincolnshire, 3877kWh. Based on this assumption, the equivalent number of homes Gate Burton scheme could claim to power would fall to 124,271.

It is unclear therefore, how Tillbridge can claim to provide the energy needs of 300,000 households. This typical approach shows the sensitivity of any claimed number of houses supplied to the

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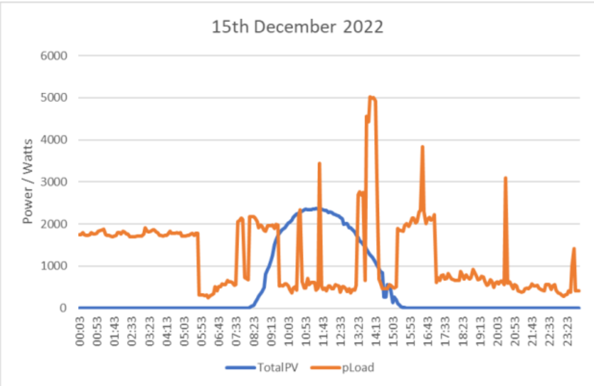
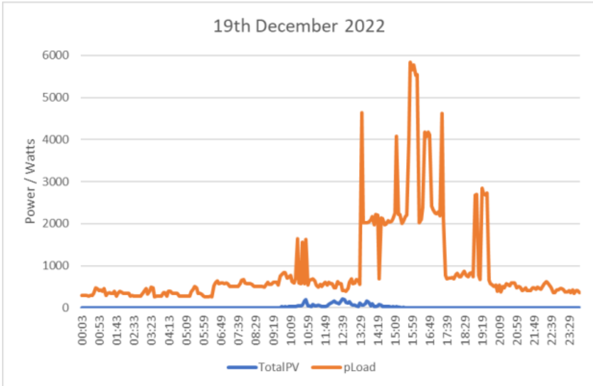
[45] The Scheme - Tillbridge Solar
[46] Average gas and electricity usage | Ofgem
[47] Heckington Fen Solar Park | Ecotricity

assumptions made, but more importantly, it is when the power is produced that matters in being able to genuinely power homes.

In the example graphs below, a 4kW domestic solar installation in Lincolnshire is used to demonstrate both the variability in household demand (orange), and the variability in solar output (blue) across a particularly sunny day and a particularly cloudy day in December 2022. Consumption is higher than the Ofgem average, notably owing periods of EV charging, with daily load totalling 22kWh to 29kWh. The 15th December was a clear and sunny, with solar production for the day of 11kWh, which for a 4kW scheme, represents around 11.5% of rated capacity. On the 19th December, weather was heavily overcast, and the daily production was only 0.5kWh, which represents 0.52% of rated capacity. For a 500MW scheme, the equivalent capacity yield on the day would be an average of only 2.6MW.





Visually, the graphs show the stark mismatch between the periods of solar production (blue) and the sharp variability of domestic demand (orange). On the bright, sunny day, the solar production even has the capacity to outstrip the immediate demand for a short period, but for the most part, the bulk of demand is away from the period of highest solar output. On the cloudy day, the graph starkly demonstrates the minimal contribution solar can make to power a household.

As has been demonstrated, solar production over the year is variable, on average, between 16% in the summer, to 3% in winter, when domestic demand is typically 36% higher than in the summer.

The seasonal as well as daily variations in supply render the concept of solar being able to power 300,000 homes as a meaningless, oversimplified and overstated claim, that is being used to mislead the public, particularly in the absence of both intra-day and inter-seasonal energy storage.

4.3.2 Impact of Solar on Market Price

The cost of solar panels has reduced significantly, meaning that solar is one of the cheapest forms of electricity generation to deploy, however, the role it can play on market price is limited, particularly without storage:

- Solar produces most power in the summer, at times demand is lower – this is reflected in the market price, where an excess of production pushes the price of power down during these periods – and in extreme circumstances, the market price can become negative, e.g.

("European Power Prices Go Below Zero Again as Solar Output Surges", Bloomberg 04/07/2023[48]). In short, solar provides most power when the market price is already cheap.

- Also, because solar produces no power in the winter, at times when demand is at its highest, then the entire demand needs to be met by other means, either through alternative generation sources or from energy storage. When market prices are high, as the market bids for power sources to meet peak demand, solar can do nothing to mitigate price peaks. For instance, in a December 2022 cold spell, with day-ahead prices at £675/MWhr, in the darkness of 5-6pm (peak demand), the price spiked to £2,586/MWhr ("UK power prices hit record high amid cold snap and lack of wind power", Guardian article, 11/12/2022[49]).

The Applicant has claimed the electricity generated will be low cost or reduce costs (e.g. Statement of Need 1.2.11), but this is only a partial picture. Under the Contract for Differences (CfD) Scheme[50] the Applicant will be paid an agreed strike price. The recent Contracts for Difference Allocation Round 5 resulted in a typical solar cost of £50. per MWh (CfD scheme prices are quoted in 2012 prices, with the latest indexation[51] this is £61 per MWh). The peak generation of all solar will be around the middle of a sunny day in summer, when the typical grid price is frequently much lower, and already sometimes negative.

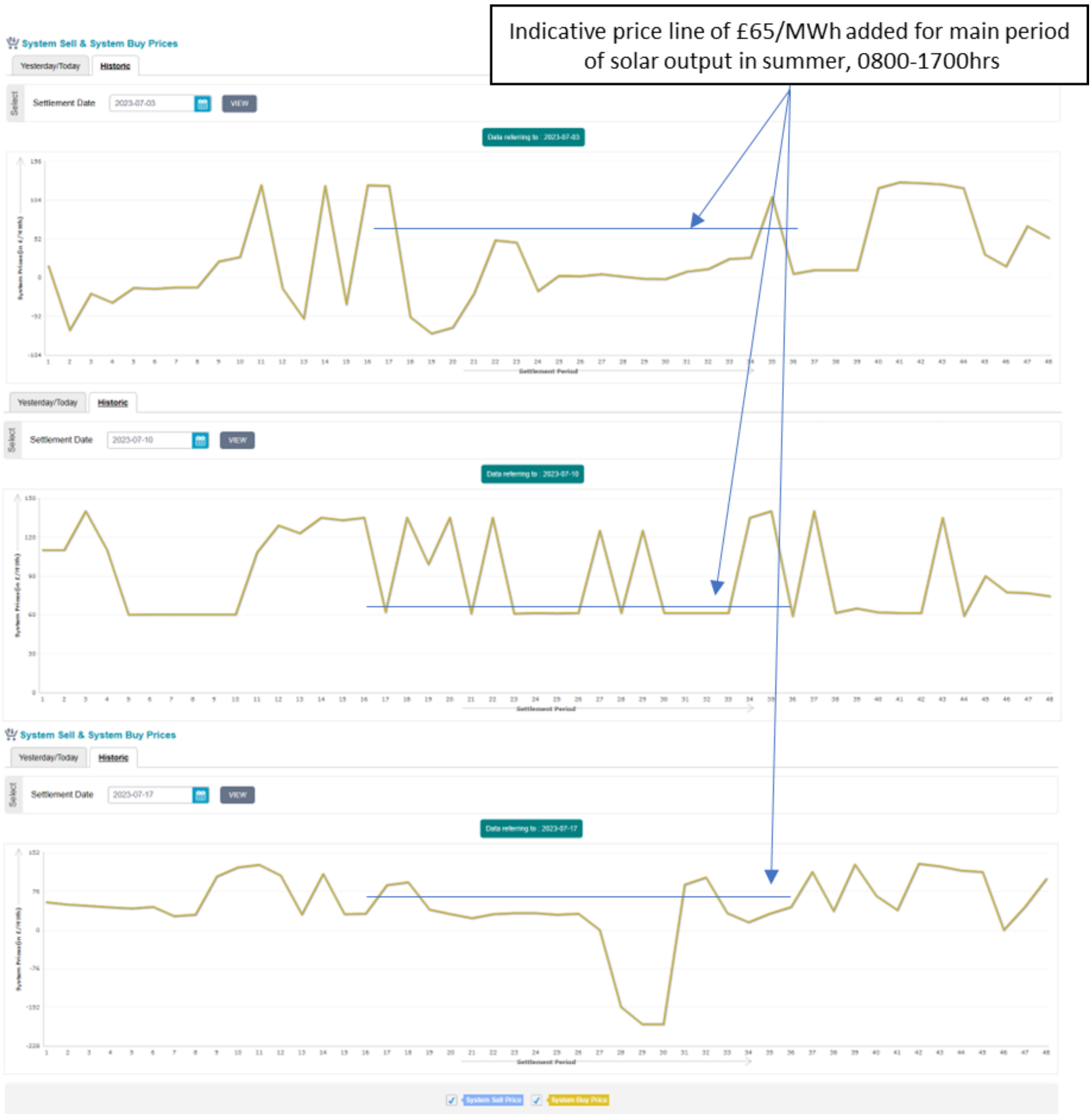
The graphs below are taken from BMReports[52] (website of the UK Electricity balancing and settlement market) and show the first three Mondays of July 2023 (Monday is chosen as this is frequently the highest demand day of the week) and show that system prices are frequently significantly lower than the indexed strike price. For 03/07, the price falls to £-75 per MWh, but hovers around zero for much of the peak solar output period. For 17/07, the price plummets to £-185 per MWh, and is around £22 per MWh for much of the peak solar output period. These figures demonstrate the relatively low spot market prices of electricity during periods when solar output is at its greatest, and the relatively high price solar will be paid during these periods, through CfD prices.

Over the same period, the weekly average prices ranged from £115 per MWHr to £125 per MWhr (Electricity Prices: Forward Delivery Contracts, Weekly Average, from Ofgem) [53] , which provides an indication of the much higher cost of energy during periods at other times of the day, typically when solar is not able to contribute to the electricity system.

This demonstrates that, while the Applicant may argue the cost of deploying solar is low, *the value of when the bulk of solar energy is produced in the UK, is already when prices are among their lowest, and therefore this must be considered when weighing the benefits and impacts of large-scale ground-mounted solar installation.*

Suppliers are already identifying ways to encourage energy usage during periods where it is anticipated that solar generation will be high, by offering half-price tariffs during this time. *Therefore, in the context of when the energy is available and how it can be used, paying £50 per MWh (indexed to £61 per MWh in 2024 prices) is not low cost.*

[48] European Power Prices Go Below Zero Again as Solar Output Surges - Bloomberg
[49] UK power prices hit record high amid cold snap and lack of wind power | Energy industry | The Guardian
[50] https://assets.publishing.service.gov.uk/media/64fa0473fdc5d10014fce820/cfd-ar5-results.pdf
[51] AR6 Core Parameters (publishing.service.gov.uk)
[52] Electricity Data Summary | BMRS (bmreports.com)
[53] Wholesale market indicators | Ofgem



4.3.3 Solar gain and Energy Density

As a source of energy, solar has an extremely low "energy density", which is defined as the amount of energy for a given space. The table below from "A Comparison Of Energy Densities Of Prevalent Energy Sources In Units Of Joules Per Cubic Meter"[54], International Journal of Green Energy, 2008, which also makes the point that "wind energy on a moderately windy day is over a million times more energy-dense than solar energy". This is referenced, not to undermine the need for solar generation, but to put in context during the consideration of need, benefit and harms associated with large-scale solar development, particularly in terms of how much land it has the potential to consume.

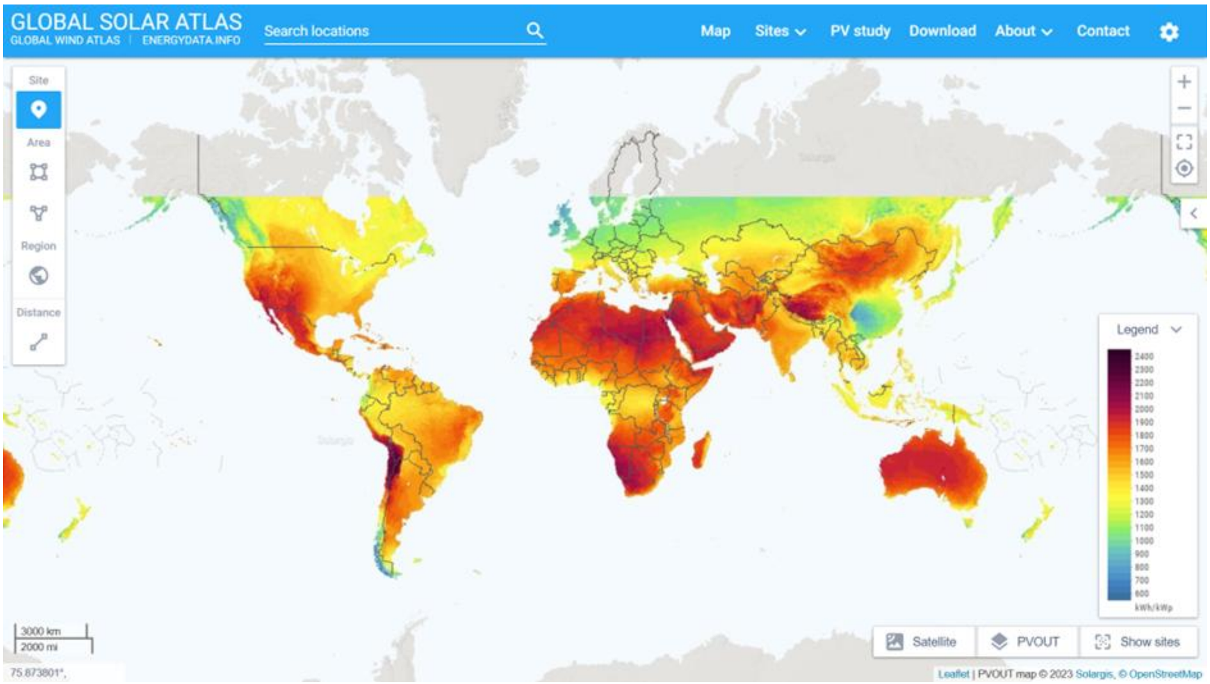
[54] https://drexel.edu/~/media/Files/greatworks/pdf_sum10/WK8_Layton_EnergyDensities.ashx

Table 1 Energy density

Source	Joules per cubic meter
Solar	0.0000015
Geothermal	0.05
Wind at 10 mph (5m/s)	7
Tidal water	0.5–50
Human	1,000
Oil	45,000,000,000
Gasoline	10,000,000,000
Automobile occupied (5800 lbs)	40,000,000
Automobile unoccupied (5000 lbs)	40,000,000
Natural gas	40,000,000
Fat (food)	30,000,000

Where solar is currently deployed at scale, globally, this is typically where there are globally high levels of solar gain, that is the energy available per square metre of land. These developments are currently in locations such as India, China, Egypt and the USA (see graphic below, from theecoexperts.co.uk[55]). As well as having high solar gain, these areas have much less competition for land use.

[55] The 15 largest solar farms in the world 2024 | Eco Experts



In the graphic above (from Global Solar Atlas[56]), the solar gain is shown to range from the highest values of up to 2605kWh/m^2 to around 900kWh/m^2 across the world. Typically, the UK is in the range of 1100-1200kW/m^2, and is in one of the lowest areas of solar gain.

It means that a solar panel deployed in the UK will produce some of the lowest yield in comparison to a solar panel placed almost any other location on earth (before being further reduced by curtailment). To deploy large scale ground mounted solar in such circumstances, the UK must first have clarity that it can afford to use land at scale in this way.

4.3.4 Solar and Decarbonisation

The decarbonisation benefits of the scheme are overstated in a number of ways:

Firstly, the Applicant does not appear to have considered the degree to which the development may be curtailed at periods of excess renewable generation. Such curtailment will reduce the contribution of the scheme and therefore the potential benefit it will be able to make for the CO2 investment made in manufacture, construction and installation. It does not appear that the Applicant has considered this dimension in its lifetime assessment of the carbon intensity of the scheme, with the only reduction modelled being an age degradation factor.

Secondly, the farms covered by this proposal currently produce crops that are used for renewable energy production as well as food. The overall assessment of decarbonisation benefit calculations currently fail to consider the negative impact of displacing one renewable energy source (crops for biofuels) with another (solar energy), or for additional "food miles".

When considering comparisons of carbon intensity, Chapter 7 of the Applicant's Environmental Statement[57] compares solar to current UK grid carbon intensity and Combined Cycle Gas Turbine

[56] Global Solar Atlas
[57] EN010142-000399-6.1 Chapter 7 Climate Change.pdf

(CCGT) plant, noting the much lower carbon emissions of solar. While the absolute figures are correct, because of the need to balance the electricity system supply and demand in the moment, the CO2 intensity will vary according to the prevailing constitution of the electricity supply. Therefore, while solar has a very low incremental CO2 intensity per MWhr, each additional MW produced by solar will contribute at a time when CO2 intensity is already at its lowest. By contrast, when demand is at its highest, in winter evenings – or at other times of low renewable production, the solar panels produce nothing, so cannot serve to reduce the CO2 intensity, without other storage technologies. Energy from solar is not directly comparable with flexible, dispatchable energy, and therefore the example is over-simplified.

Section 4: Summary

From National Grid Future Energy Scenarios (2024 and 2022):

- There is a wide range of scenarios for deployment of solar in which the country meets its Net Zero target by 2050, ranging from 65GW to 107GW.
- There is a wide range of potential implementation of rooftop solar, from 20GW to 40GW – to meet Net Zero.
- Balancing, i.e. matching supply with demand, is an essential requirement of managing the electricity grid; flexibility of supply and demand are a key future requirement. Large scale implementation of electrolysis is a key underpinning requirement to manage the future energy system.
- Curtailment will become an increasingly significant action by the grid operator; i.e. turning off excess renewable power that the grid cannot consume.

In terms of output:

- In the UK, solar schemes will typically yield between 9 and 11% of their rated capacity – much lower than other renewable sources.
- The intermittency of solar causes the grid problems in particular, because of the high degree of intermittency and the fact that solar production is at its peak when demand is at its lowest, and is zero at peak demand.
- Without the capacity of seasonal energy storage, intermittent renewable generation – and solar in particular, exacerbate the need for curtailment, i.e. turning off excess renewable power the grid cannot consume.
- Curtailment is a system inefficiency that costs consumers and will serve to reduce the current solar yield of 9 to 11% - thereby further reducing their already limited contribution.
- Solar has least impact on overall market price, as it produces most of its power when demand is already low, as is the electricity price. Similarly, when the demand and price are at their peak, no solar power is available to reduce the price.
- Claims that the solar scheme can power 300,000 homes are based upon oversimplified claims by developers and are misleading to the public.
- Globally, the UK is in one of the lowest areas for solar gain, meaning that a solar panel deployed in the UK will produce some of the lowest yield in comparison to a panel located almost any other location on earth.

Section 5: Potential for Rooftop Solar to meet UK Solar Capacity Targets

5.1 Reports on the potential for commercial and domestic solar capacity

One of the great mysteries of the moment surrounding the urgent need for decarbonisation, which drives the need for a huge increase in solar power, is that domestic and commercial buildings continue to be built with no planning requirements for solar power to be mandated, or at least considered, as part of their construction. On the face of it, this would seem to be a straightforward "win" in terms of increasing solar capacity.

Two reports have highlighted the potential for domestic and commercial solar to contribute to the increased solar capacity.

The UK Warehouse Association published "The Investment Case for Rooftop Solar in Warehousing"[58] in September 2022. It asserted that using only the largest 20% of current UK warehouses could provide around 14GW of additional solar capacity (see diagram below). The report outlines many attractions of rooftop solar to developers, including return on investment, ability to attract business and supporting local area net-zero planning targets. Four key barriers are identified that are acting to inhibit this development, three of these relate to the complexity of energy and warehouse markets. The fourth is the grid connection constraint – currently an issue for any major development that will take demand from or supply to the grid and distribution systems.

Rooftop solar power could transform the UK warehouse sector into a net producer of renewable electricity

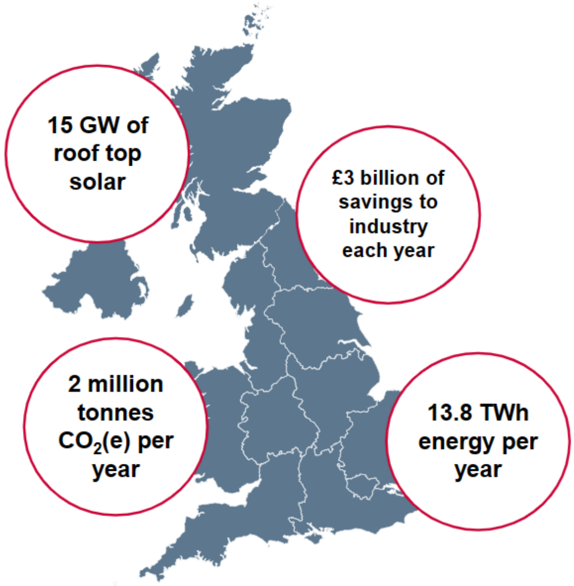
With **only the largest 20%** of warehouses there is enough roof space to **double the UK's solar generation capacity** from 14 to 28 GW

National Grid's future energy scenarios[1] consider 12-29 GW of additional solar is required by 2030; warehousing could play a major role in the next decade.

With 15 GW of solar fitted, the warehouse sector could **generate ~13.8 TWh** of renewable electricity per year – transforming the sector from **net consumers to net producers.**

This could save the logistics business **£3 billon per year**, through energy savings and additional income from energy sales.

This could avoid emissions for up to **2 million tonnes of CO_2(e) per year** by reducing reliance on grid electricity, which is still heavily supported by natural gas.



In May 2023, Ecotricity published "The Rooftop Revolution We Need"[59] and advocated a "national rooftop solar program", highlighting that only 3.9% of houses in the UK have rooftop solar panels. Their approach classifies UK housing stock by suitability for solar installation, finding that 50% are "suitable" and a further 17% are "feasible". The national impact of solar installation on all "suitable"

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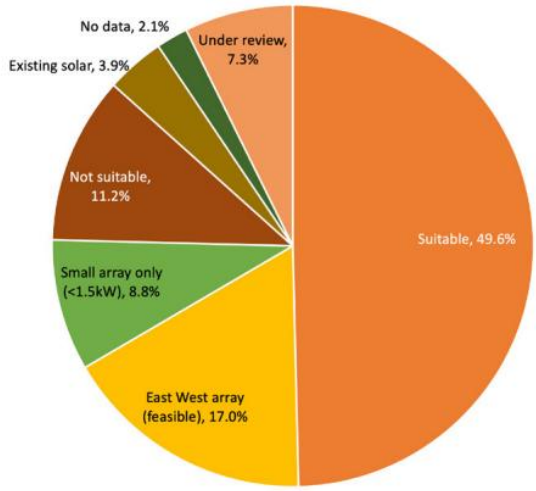
[58] Delta-EE Publications

[59] GBF-Report-Solar-v14.pdf

housing was estimated to be a staggering 37.7GW. (See the following diagrams from the Ecotricity report). There is potential for a further 12.5GW of capacity from those “feasible” properties. Crucially, the small-scale installation of domestic solar (4-5kW per installation), needs no grid-scale infrastructure adjustments, and typically needs little or no adjustments to local distribution networks.

Results overview



49.6%

Houses among the sample are found to be suitable for solar PV, whilst an additional 17.0% could be added to this list for buildings only having suitable east or west facing roof. 11.2% of houses are found to be not suitable due to insufficient roof space, inadequate solar radiation, shading, and sub-optimal orientation.

3.9%

Houses in the sample are found to have already had solar PV system installed.

National impact for ‘suitable’ housing

	Number of buildings	Proportion of suitable	Average capacity, kW	Total capacity, GW	Generation, GWh/year
Detached	5,893,301	50.4%	4.3 kW	12.9	12,019
Semi-detached	7,464,764	50.3%	3.3 kW	12.4	11,428
Terraced	7,751,359	48.8%	3.3 kW	12.4	11,398
National	**21,109,424**			**37.7**	**34,845**

Given there is an existing solar capacity installed in the UK of 16GW, with a potential for an additional 14GW from the largest 20% of existing warehouses, plus 37.7GW from “suitable” domestic properties, this already reaches over 67GW of capacity. This would cover around 95% of the solar capacity in one of National Grid’s pathways to meet net zero by 2050 (i.e. the “Hydrogen Evolution” pathway, which requires 71.8GW[60]). It is also very close to achieving the UK Government's current "ambition" of 70GW, and illustrates what could be delivered without any further ground-mounted solar development – thereby avoiding the adverse consequences on land use.

5.2 Potential for rooftop development to be delivered rapidly

Aside from the COVID impacted years, the recent actual build has been around 230,000 homes per year in the UK (Tackling the under-supply of housing in England, House of Commons Library, May 2023[61]). Up to 81% of these can be houses, rather than flats ("Home building stats show continued increase in starts and completions despite pandemic"[62], Press Release from Robert Jenrick, Minister for Housing, Communities and Local Government 01/07/2021), meaning that these would have the opportunity for rooftop solar. Taking a more conservative assumption that 75% of a year's 230,000 homes are houses, and 50% of these have rooftops that are suitable for solar (as per the Ecotricity assessment), which are then fitted with a 4kW domestic solar installation, then this would deliver the equivalent of a 345MW solar farm each year, with none of the downsides of large-scale ground mounted solar. The UK Government has a target of building 300,000 new homes per year, with some estimates suggesting the need for 340,000 homes per year. Should this higher figure be delivered, the same assumptions of domestic solar installation would deliver a 500MW scheme each year. These figures do not include the potential additional capacity that could be installed each year through the retrofit of solar to existing households, as advocated by Ecotricity.

During the last two years of work on the Tillbridge Solar Project planning process, houses continue to have been built without solar; in this time, far more solar capacity could have been installed than will be delivered by the capacity of the Tillbridge Solar Project. In short, with the right planning incentives, solar could have been deployed faster on rooftops than through large-scale ground-mounted schemes with all the associated impacts and environmental considerations that are required.

There is a massive contradiction between stating the urgent need to deploy solar to decarbonise and continuing to forego the opportunity to install solar at scale, with minimal demands on infrastructure, planning processes (like NSIP) and minimal adverse impacts.

5.3 The current glut of ground-mounted solar projects

According to the UK Government's Renewable Energy Planning Database[63] (REPD) April July 2024, there are currently over 1000 ground-mounted solar projects registered as either being in development through to construction, with a capacity of over 26GW. Of this figure, 22 projects are of NSIP-scale (i.e. above 50MW capacity), with an aggregate capacity of 5.9GW. The database does not include NSIP-scale developments that are in the very early stages of consultation, such as Steeple Renewables Project[64] (RES), One Earth Solar Farm[65] (Orsted), Springwell Solar Farm[66] (EdF), or Fosse

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[60] Future Energy Scenarios 2024 Data Workbook_V003.xlsx
[61] CBP-7671.pdf
[62] Home building stats show continued increase in starts and completions despite pandemic - GOV.UK
[63] Renewable Energy Planning Database: quarterly extract - GOV.UK
[64] Steeple Renewables Project
[65] Home - One Earth Solar Farm
[66] Springwell Solar Farm

Green Energy[67] (Windell Energy), Great North Road Solar[68] (Elements Green) which alone would create in excess of a further 3GW of capacity.

This development, on top of that achievable from roof top solar reaches almost 100GW of solar capacity, some 30GW beyond the UK Government's "ambition" – reflecting the "Wild-West" style rush for development that has the potential to provide way more solar capacity than is needed or is useful, exacerbating the future energy curtailment (wastage) issues.

Aside from the REPD, another source of potential projects is the National Grid TEC register. According to National Grid's "A Grid Guide to Accelerating UK Connections"[69], they have a queue of almost 150,000MW of solar connection capacity (based upon solar accounting for 40% of the 340,000MW Transmission connection pipeline, and 30% of the 46,000MW of Distribution connection pipeline), none of which is rooftop or domestic solar. This capacity pipeline alone is sufficient to more than doubly-achieve the Government's ambition for 70GW of solar, without any rooftop solar. It is clearly a situation that is grossly out of control, with excess schemes clogging up the planning and grid connection application processes.

Of this development, large-scale ground mounted solar has the greatest adverse impact, because of its staggering size and land use. Such schemes will take up land that is needed to progress direct decarbonisation (forestation, peatlands and biofuels), take up productive farmland, destroy existing habitats, as well as transform the character and landscape of the areas affected – and create most harm to communities. In addition, should large scale ground mounted solar development go ahead, it will further undermine the case for rooftop solar, meaning that valuable land will be used, while roof space goes unused, a situation the country may well look on with regret in future years.

Just considering the REPD pipeline, stripping out the monstrous NSIP-scale projects would still leave 20GW of schemes currently in stages from development through to construction, and could still deliver almost 90GW of solar capacity, when combined with existing solar and achievable rooftop solar. This is more than sufficient to exceed the UK Government ambition for solar and would have the additional advantage that the planning determination would be local, rather than national, which is more in line with the recommendations of the Skidmore Review.

Given the available roof space of the largest commercial warehouses and the most suitable houses, sufficient solar capacity can be installed to exceed the requirement for net zero. Smaller ground-mounted schemes are much more able to fit into landscape and be screened, having significantly fewer adverse impacts. On this basis, there is no case for large-scale ground-mounted solar projects.

5.4 Excessive ground-mounted solar will kill the "Rooftop Revolution"

The 2023 Skidmore Review called for a "mission for Rooftop Solar", something echoed by the incoming UK Government in July 2024[70]. Objectively, it is recognised that rooftop solar can play a significant role in delivering solar capacity, with few of the adverse impacts associated with extensive ground-mounted development.

Unfortunately, the current trajectory for solar capacity installation in the UK is for ground-mounted solar, which has the potential to kill a rooftop revolution before there is any momentum, by having

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[67] Overview - Fosse Green
[68] GNR Solar Park
[69] PowerPoint Presentation (nationalgrid.com)
[70] Labour's 'rooftop revolution' to deliver solar power to millions of UK homes | Solar power | The Guardian

already installed so much capacity, the need for further solar on rooftops will be eliminated. This will leave rooftops forever bare, and fields forever full of panels.

Section 5 Summary:

- The Government's 70GW solar capacity target can be achieved without large scale ground mounted solar.
- There is a massive untapped potential for rooftop solar in the UK; using the largest 20% of warehouse rooftops and the 50% of "suitable" housing would yield 51GW on top of the existing 16GW of capacity, i.e. 67GW – almost reaching the UK Government ambition of 70GW of solar without further ground-mounted solar development.
- Houses continue to be built without solar – so there is a tremendous contradiction in stating there is an urgent need to deploy solar and foregoing the opportunity to install solar on every rooftop.
- In the 2 years of development work to date, more solar could have been deployed more quickly on rooftops than Tillbridge Solar Project will produce.
- There is already over 26GW of ground-mounted solar projects currently in development through to construction (notwithstanding further capacity in early consultation), which could already lead to excess solar capacity – of this, some 6GW are large NSIP-scale ground mounted solar projects.
- There is no logical case for further development of large-scale ground mounted solar, particularly given the capacity can be deployed on rooftops, or at smaller scale, with far fewer adverse effects.

Section 6: Connection of Solar to the Electricity System

6.1 The Challenge of Rewiring Britain

The UK National Grid was originally developed to facilitate the connection of a network of large-scale coal fired power stations, located near UK coal fields. Given that over 70% of the country's future electricity will come from offshore wind (According to National Grid FES), one of the key challenges is to provide the network infrastructure to connect offshore wind farms to deliver their power (See Section 3, Review of Progress Reports on UK Decarbonisation).

The Electricity Networks Commissioner's Report[71] (June 2023) sought investigate and report on "how to accelerate the deployment of strategic electricity transmission infrastructure in Great Britain". Within the 12-page "Principle Areas of Recommendation"[72], the Commissioner celebrates the successful deployment of offshore wind, and describes the challenges of delivering strategic transmission infrastructure necessary to continue the deployment of wind generation at pace. Delivering 50GW of wind and 24GW of new nuclear are described as being "a major step towards decarbonising our economy". Notably, solar is not mentioned at all in the document.

The Commissioner recommends the production of a "Strategic Spatial Energy Plan" for the country, "to bridge the gap between Government policy and Network Development Plans", where "Government targets across the whole energy system would be spatially mapped across GB and over a time period of several years. For example, green hydrogen production targets would be translated into volumes in specific locations. This plan would create an overarching reference for many energy network plans". This call for greater coordination in approach echoes the findings of reports described in Section 8.

The Commissioner also highlights the "extremely stretched" global supply chain for high voltage transformers, cables and inverter technology, as well as shortages of UK skills (engineers and technicians) to support the transition. All this underlines the need to focus resources on projects that have the most decarbonisation benefit.

The electricity network challenge is further complicated by a massive backlog of applications for new connections and modifications to the National Grid, threatening the progress of renewable developments (e.g. "Grid connection delays for low-carbon projects 'unacceptable', says Ofgem", The Guardian, 16/05/2023[73]). Many connections are now being quoted connection dates in the mid 2030's, and it is noted that many NSIP solar developments have connection dates beyond those they aspire to in their publicity material.

What is unhelpful are the high volume of speculative or unnecessary schemes that are in the queue for National Grid connections. The report "Decarbonisation of the power sector", by the Business, Energy and Industrial Strategy Committee (BEIS), April 2023, states that "Future Energy Scenarios modelling by National Grid ESO shows that Great Britain needs between 123 and 147 GW of low-carbon transmission generation by 2030 to be on a net zero compliant pathway. In February 2023, Great Britain had 257 GW of low-carbon electricity generation with contracts for future connection to the transmission network. Combined with the 83 GW already connected to the grid, that is almost

[71] Electricity Networks Commissioner report - Energy Systems Catapult
[72] Electricity-Networks-Commissioner-report-to-SoS.pdf
[73] Grid connection delays for low-carbon projects 'unacceptable', says Ofgem | Energy industry | The Guardian

three times as much than is needed. However, National Grid ESO expects just 30–40% of projects in the queue to come to fruition, with many pipeline connections likely to be speculative".

As of summer 2024, there were over 150GW of solar schemes in the National Grid connection register. Such schemes do not include the potential for rooftop solar schemes. This is a clear area where greater coordination is required as the current scramble for potential solar schemes and strategic holding of grid connections serve to exacerbate the existing circumstance of congestion.

Furthermore, by occupying connection applications in the National Grid queue, for solar projects that do not really need 400kV connections (see below) solar developers are actively worsening the grid connection backlog situation faced by National Grid, as well as occupying skilled labour and using key components unnecessarily, thereby potentially delaying other, more effective means of decarbonisation.

6.2 Connection of Solar to Grid

Solar developers (Gate Burton, Cottam, West Burton and Tillbridge) have selected connections at the Cottam and West Burton 400kV National Grid substations, which are the locations of two former coal-fired power stations, each with 4x 500MW generators. These substations are often cited during consultation events as "ideal" and "available" connection points for their projects, particularly given the apparent high-power needs of their schemes.

In practice, solar power is generated at very low voltages (typically <100volts DC) and can easily be connected more readily and more efficiently to lower voltage distribution systems. This is why solar is frequently installed on domestic rooftops with little or no modifications to the underlying electricity system.

To connect solar to the Cottam and West Burton National Grid substations, developers propose to step the low-voltage solar power up to 400kV, using a series of transformers, for connection to the National Grid, for onward distribution, before being stepped down to domestic voltages for consumption.

Technical details within the Tillbridge Environmental Statement confirm that, as is typical, their individual solar panels produce low quantities of power, e.g. between 400 and 1000W per panel[74] (para 3.4.7). For a capacity of 500MW (e.g. West Burton Solar Project), this would therefore require between half a million and 1.25 million solar panels. Hence, it is only where solar panels are combined in such numbers, that a high-power, 400kV connection would need to be used. The direct consequence of this number of panels is the colossal scale of each development. However, fundamentally, there is no need for solar to use 400kV, 500MW connections when connections can be made at much lower voltages and at much smaller power ratings.

Many ground-mounted solar farms are connected to the local Distribution Network. For instance, the proposed Stow Park Solar Farm[75] (Luminous Energy) would be a relatively large solar farm by existing UK standards (at 35MW) and would lie between Gate Burton Energy Park and West Burton Solar Farm. The Stow Park project is planned to connect directly to a 132kV distribution system power line, to a pylon that is sited within the development area. This approach also serves to avoid the need for additional high voltage transmission connections to the substations away from the panels.

[74] EN010142-000395-6.1 Chapter 3 Scheme Description.pdf
[75] Stow Park | Luminous Energy

(Incidentally, Stow Park Solar Farm also has proposed panels at c. 2m height, significantly less than half that of the panels proposed for the Tillbridge Solar Project, showing much greater sensitivity to the receptor landscape).

Gate Burton, Cottam, West Burton and Tillbridge locations appear to have been selected on the basis of making use of high-power (e.g. 500MW) 400kV grid connections as a starting point for their projects, and then aggregating enough land to place sufficient solar panels to fill the capacity. That developers have cited the connection to the National Grid at the Cottam and West Burton substations as a starting point for the site location undermines the breadth of alternatives considered as part of the development. Furthermore, explaining to the public that choice of location was necessary owing to the available National Grid connections was therefore misleading, as solar can be installed at much smaller capacity schemes where such high voltage connections are unnecessary.

The net effect of this selection strategy has secured available parcels of land away from the grid substations – hence the subsequent need for miles of additional high voltage power lines to connect parcels of solar development back to the substations. More careful selection of land and a broader approach in terms of solar scale and connection selection would have therefore avoided the need for additional transmission connections (as per Stow Park).

The result of this approach is that the power from the solar panels sited on land that surrounds the villages where the developments (Cottam, West Burton, Gate Burton and Tillbridge) would be located, would be connected directly to the National Grid for onward transmission – and will not power the local communities that are directly affected.

6.3 Rooftop Solar

Installation of many low-capacity solar schemes, such as on domestic rooftops often does not require any modification to the underlying electricity system – therefore quite apart from the efficiency of land use, this approach takes pressure off the National Grid connection backlog. It is only where solar panels are aggregated into larger schemes that electricity system modifications (to Transmission and / or Distribution networks) are required.

Pursuit of rooftop solar therefore has the potential to deploy solar sooner (and enable earlier decarbonisation) than many schemes that require grid and distribution connections that can only be made many years into the future.

6.4 Future Use of strategic grid connections

Apart from the obvious technical inefficiency of stepping voltages up and down, using connections to the National Grid at Cottam and West Burton sub stations for solar would sterilise the use of those high voltage substation connections, and preclude their use by future high-power applications.

While future requirements are difficult to gauge, the British Energy Security Strategy (April 2022) includes significant volumes of new nuclear and hydrogen production capacity.

With regard to nuclear, the ambition is to provide up to 25% of power from nuclear by 2050. While "conventional" new nuclear plant, like Hinkley Point C, at over 3000MW, would most likely be sited at existing nuclear sites, small modular reactors (SMR's), at 300-500MW capacity would potentially be suitable for connection at Cottam or West Burton substations. In addition, although experimental in nature, West Burton has been selected as the location for the UK Atomic Energy Authority's prototype fusion project "STEP" (Spherical Tokamak for Energy Production), targeting operation by 2040[76].

In nearer time horizons, the British Energy Security Strategy (April 2022) also included an ambition for 10GW of hydrogen production by 2030, with at least half of this from electrolytic hydrogen. This 5GW of capacity required by 2030, this would need 10x 500MW grid connections, such as those available at Cottam and West Burton (of which there are 8). Such high-voltage, high power connections are scarce, nationally and their use must be considered strategically. Looking ahead, the Impact Assessment for CB6 shows an illustrative range for low carbon hydrogen of 85-125TWh in 2035 and 250-460TWh in 2050, which would require many more times this number of connections.

There is a real risk therefore, that occupying these grid connections for solar projects over the next 40-60 years will use these grid connections unnecessarily and require additional grid infrastructure investments to connect such technologies in the future.

Section 6 Summary:

- Solar is connected more efficiently to low-voltage systems, like households.
- Small, low-capacity systems installed on domestic rooftops often avoid the need for electricity system network modifications.
- Where ground-mounted solar farms are installed, they can be connected directly to the electricity distribution grid pylons (without the need for further networks of high voltage connections).
- There is no need to use 500MW, 400kV connections at Cottam and West Burton National Grid substations for solar development.
- It is only the massive aggregation of panels that the developers have pursued to match an unnecessary 500MW, 400kV grid connection capacity, that has driven the colossal use of land.
- By selecting grid connection points and then identifying areas of land away from the substations, developers subsequently need additional High Voltage transmission connections – which could have been avoided with more careful selection of connection points and capacity.

[76] Home - STEP

Section 7: Role of Battery Energy Storage Systems

As has already been described, the most significant challenge to making the deployment of large solar capacity a success is the potential to be able to store the excess energy from the summer, thereby avoiding curtailment, for use in the winter. The proposed Battery Energy Storage System (BESS) cannot deliver this.

Technical details of the BESS are limited in Tillbridge application, although the Tllibridge Statement of Need provides and example of a 200MWh battery, with 100MW of import and export capacity, therefore being able to export or import at a maximum rate of 100MW for up to 2 hours. In this case, the BESS could store less than 30 minutes of output from the Tillbridge solar farm, for later use.

As an example, even with other local schemes with larger BESS, where such information is available, such as the local Gate Burton[77], the proposed storage capacity would be 500MWh, with a grid import capacity of 140MW and an export capacity of 250MW. In simple terms, that means the BESS would the overall capacity to store one full hour of output from the 500MW solar farm, and it could therefore supply power at a maximum rate of 250MW for 2 hours.

These examples show the contribution that BESS may make within-day, to balance the system, but they clearly show that they do not begin to address the primary flaw, that solar produces most of its power in the summer, and this cannot be stored for use in the winter, or for extended periods with low wind or solar output.

As has already been described, the output of the solar scheme will vary over the year, from a peak of around 16.5% per day in July, to 3% in December. The implications of this are:

- In July, the solar scheme would produce, on average, around 1980MWh per day. In theory, therefore, a 200MWh battery would be able to store a maximum of around 10% of the day's output to be able to provide power at periods of no-solar, or to potentially reduce curtailment.
- In December, the scheme would produce, on average, around 360MWh per day, which would be sufficient to charge the battery, but not much else.

What is more typical, is that BESS is be used for intra-day balancing, where the BESS can take advantage of any grid import capability, which would charge the battery, taking advantage of low-priced electricity, and selling this back to the grid at higher-priced periods. Tillbridge do not appear to have disclosed the grid import / export capacities, but other local solar schemes have high grid import (demand) capacity, which would typically be used to charge the BESS from the grid when electricity is cheap. It is not clear what other purpose the solar farm would have for a high-capacity import facility, as the demand to feed the development's auxiliary services (e.g. lighting, CCTV, security systems and offices) when the solar panels are not producing power would be negligible by comparison to the scheme's 140MW import capacity, given the 10kW demand according to the Gate Burton ES (Chapter 6)[78].

To illustrate the potential value of using BESS in this "trading" mode, some example days are chosen to describe the operation. Using the previous examples of sunny and cloudy winter days in December 2022 (using indicative price Data from BMReports, see graphs on next page), using BESS to buy at

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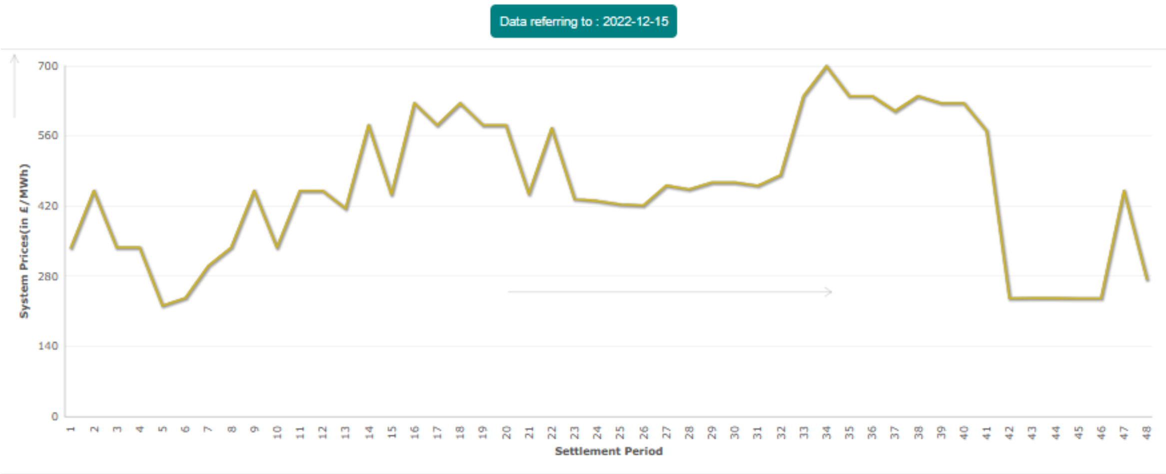
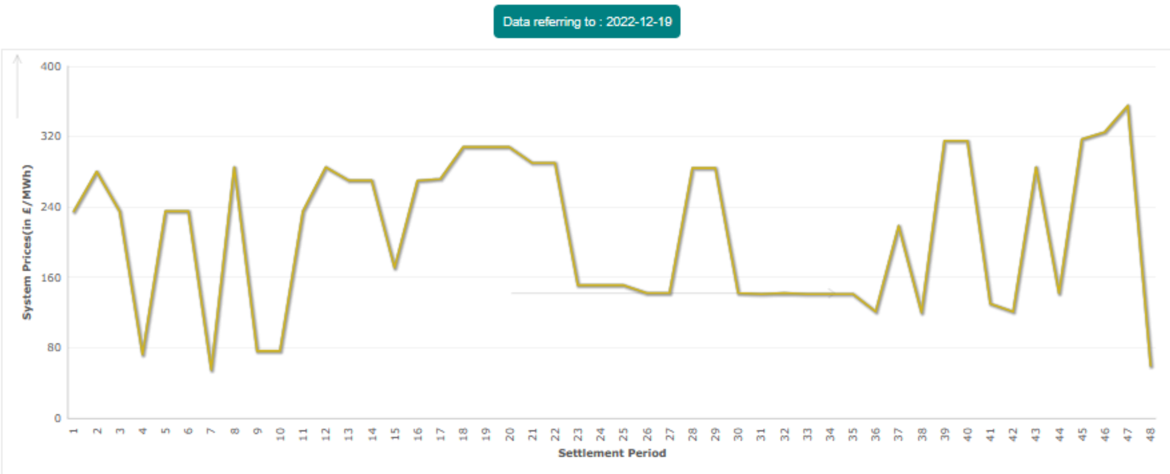
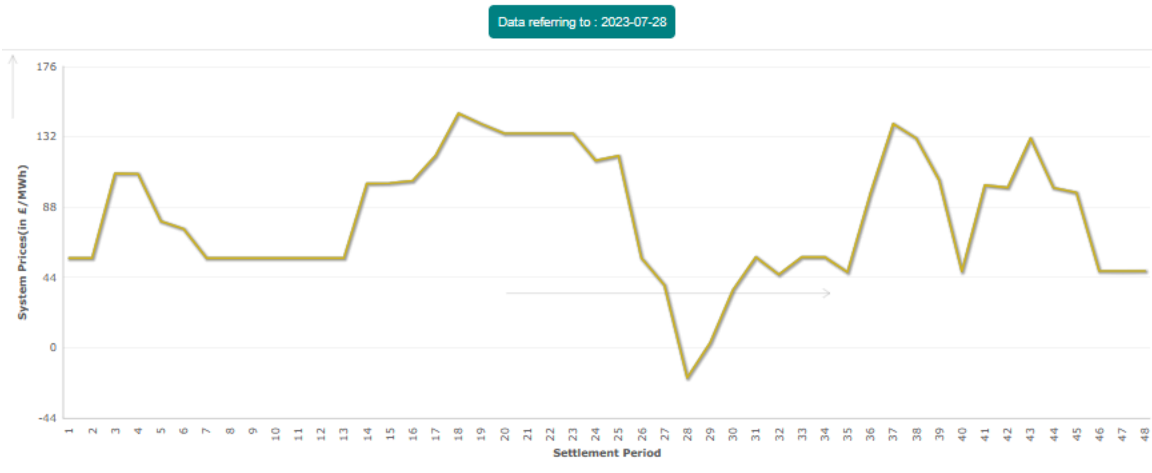
[77] Gate Burton ES Appendix 2-A

[78] Gate Burton ES Chapter 6: Climate Change

low price periods and sell high could yield a spread of £150/MWhr (for 19/12) to £400/MWhr for (15/12). For 200MWhrs, these would be worth £30,000 to £80,000 per day respectively.







Graphs of daily UK Electricity system settlement prices

Each day has 48 half-hourly settlement periods
2022-12-15 – sunny winter day, 2022-12-19 – overcast winter day, 2023-07-28 – typical summer day

Spreads of this nature are not uncommon and such economics can make BESS a lucrative trading instrument, but by being used for within-day system balancing the BESS is operating in a separate segment of the energy market, rather than strictly as associated development for the solar farm.

Even using a relatively unremarkable summer weekday, Friday 28/07/2023, using BESS to import electricity overnight and export back before the solar begins to generate could yield over £40/MWhr, and so £8,000 for the day.

The UK has a Contracts for Difference (CfD) scheme which is the Government’s main mechanism for supporting low-carbon electricity generation. The CfD provides financial certainty for investors by providing a fixed supply price over a 15-year period. In CfD Allocation Round (5), solar capacity secured contracts at a strike price of around £50/MWh. Given the capacity of the Tillbridge Solar Project, will be 500MW with an 11% load factor, this would mean the income of the scheme would be c. £24m per annum. Given that from this, the operating costs and cost of the capital investment must be offset, it is easy to understand the attraction BESS would have to increase the financial return of the scheme, independently of any genuine need for associated development.

Section 7 Summary:

- Tillbridge solar provide limited information about the technical capacity of the proposed BESS and how it may be used in the electricity market.
- With only 1-2 hours of storage capacity, BESS cannot contribute to solving the season-to-season storage issues that limit the useful energy contribution solar can make.
- The BESS can make a limited contribution to reducing summer curtailment.
- The BESS has potential to be a valuable trading tool, in balancing the electricity system, but this is not associated development for the CfD-based solar scheme.

Section 8: Tillbridge Statement of Need

The SoN provides a very detailed and thorough treatment of many areas of Energy and Decarbonisation, however there are notable omissions, and sections have been drafted using partial or misleading information in favour of large-scale ground mounted solar.

We agree with many key areas within the Statement of Need[79], for instance:

- The need for decarbonisation, which requires a growth in renewable energy and the expansion of solar power.
- The foreseen increase in electricity demand to decarbonise other sectors.
- Concerns about timescales for delivery of nuclear and carbon capture and storage (CCS)
- The need for energy storage and flexibility (of electricity supply and demand)

However, the key areas of omission or partial information within the SoN are:

1. Output of solar in the UK
2. Security of Supply
3. Curtailment
4. Alternative Solar Schemes
5. Land Use
6. Government Policy and National Policy Statements

8.1 Output of Solar in UK

In almost 150 pages of detail, the SoN provides only a very simple description of solar output in the UK. The limited load factor of solar is noted, in that it will return between 9% and 11% of the installed capacity given the low solar gain in the UK. By contrast, wind will provide significantly greater yield, on average, given the locational advantages the country has – particularly with access to offshore wind, which can see load factors of up to 65%. Notably, the SoN also omits any reference to the scale of seasonal output difference of panels in the UK from summer to winter, or between variations in weather between days. These aspects are largely covered in Section 4 of this WR and will not be repeated.

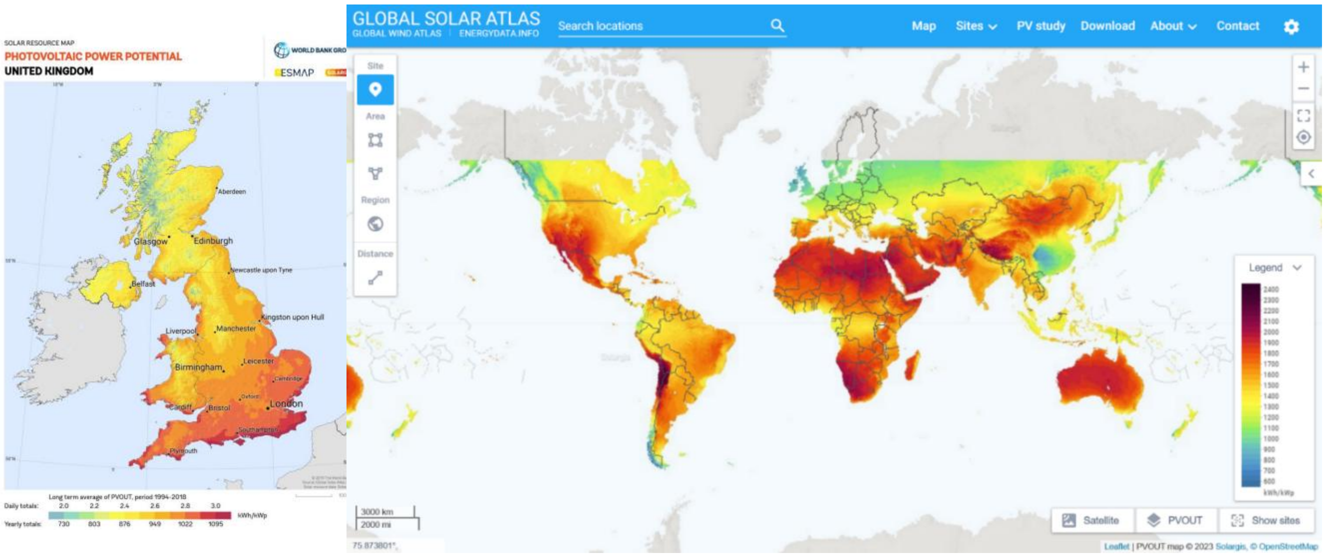
Within the SoN, the Figure 8.1 makes an attempt to illustrate the complementary nature of wind and solar combined on the electricity system. While these averages provide part of the story, in more detail, the actual variation in generation will vary significantly, as solar falls from its peak output at the middle of each day to zero overnight, and as wind and cloud vary each day. Since generation supply must match demand, moment by moment, the impression of a combined dependability is misleading. The author's monthly resolution model is oversimplified and insufficient to capture these variations, and the SoN later notes that the model "does not take into account the requirement to balance supply and demand on a short-term basis", which renders it largely useless for the purpose of the SoN.

In practice, once a combined wind and solar generation picture is formed, the shape of "residual load" required to meet demand must be produced by some form flexible generating capacity (or flexible demand) and is extremely variable. For all the benefit of solar complementing a lack of wind, the sharp variations in solar production make also conspire to make meeting this shape more

[79] EN010142-000206-7.1 Statement of Need.pdf

challenging, particularly on windy days. For the SoN to assert that “solar will help smooth out seasonal variations in total GB renewable generation”, without being honest about the significant challenges solar creates through its highly variable output is disingenuous.

The SoN highlights the locational advantage of Tillbridge, with the potential for 10% higher yield than the UK average. Given that the UK map used by in the SoN reaches as far north as the Orkneys, that is hardly surprising. What the SoN fails to point out, however, is that solar yield in the UK is globally extremely low. A solar irradiation map of the UK is used to create the impression that there are attractive levels of solar irradiation across the UK. Zooming out from this map, shows a very different picture (see images below). On the global map (right), the colour ranges from blue (low solar gain) to deep red (for the highest solar gain), shows the UK as one of the lowest areas for solar gain globally. Also, the variation in solar gain across the UK is relatively modest in comparison to global variations. In fact, where solar is developed elsewhere in the world at the scale being proposed by Tillbridge and others, the solar gain is vastly higher than anywhere in the UK – as you might expect. This means the amount of electricity produced by panels in these areas will be significantly higher – and their contribution vastly more, than panels in the UK. Objectively, therefore, Lincolnshire does not receive high levels of solar radiation, and from a global perspective, the UK would logically be a poor choice for using land at this scale for ground mounted solar.



Map of *solar* irradiation for UK, as shown in SoN (left), vs global picture (right)

Example Location	Global tilted irradiation at optimum angle	% difference from Lincolnshire as a reference
South of UK (Land’s End)	1284.5 kwh/m^2	+11%
Lincolnshire (Gate Burton)	1155.9 kwh/m^2	
North of UK (John O’Groats)	998.7 kwh/m^2	-14%
Extremadura, Spain (Largest European solar, 590MW)	2071.2 kwh/m^2	+79%
Bhadla, India (Largest Worldwide solar, 2245MW)	2242.8 kwh/m^2	+94%

Given the vast differences in yields. schemes such as those in Spain or India would use somewhere in the region of half the land area to produce the same amount of power.

It is also worth noting that typically where solar is ground mounted at such scale, there is much less pressure on land use – or there are fewer alternative uses for the land). Bhadla, for instance, makes use of land in India's desert state of Rajasthan to produce its solar power.

Between Lincoln to Gainsborough, the 4 proposed NSIP solar schemes would have a similar peak capacity and similar physical size to Bhadla. The combined schemes would make Lincolnshire one of the largest areas of solar energy production, worldwide. Given the differences in solar gain, the scheme in Bhadla would produce almost twice the energy over a year (MWhrs) to the combined schemes in West Lindsey. By any objective measure – from a global perspective, it is hard to argue this could ever be described as being a rational outcome.

8.2 Security of Supply

The SoN describes where solar contributes to security of supply by providing diversification of energy source. While diversification is a valuable strategy for creating security of supply, at its most basic level, security of supply is about making sure there is enough electricity for when it is needed, i.e. the fundamental requirement to provide sufficient power to meet demand, the SoN describes the challenge of maintaining system adequacy, but fails to describe the limited role of solar.

Most obviously, electricity demand peaks in the UK fall in winter evenings, typically in January weekdays, between 5pm and 8pm. At this time, the entire capacity of solar output will be zero – so for one scheme at 500MW, or the whole 70,000 capacity ambition the Government seeks, this capacity will not be able to contribute to meeting peak demand. Despite the wide-ranging discussion therein, the SoN omits to describe how demand peaks will be met and how the scheme would be able to contribute without significant additional investment and infrastructure associated with long-term storage (i.e. not BESS).

What is particularly misleading is how the SoN implies a significant role for solar in the UK Capacity Mechanism, which is the primary market tool for ensuring sufficient electricity capacity is available to National Grid (system adequacy). The SoN explains that technology-specific "de-rating factors" are used within the Capacity Mechanism to reflect the likelihood of being able to deliver when needed. The SoN highlights that the de-rating factor for solar has increased to 6.35%. The SoN fails to state highlight this is the lowest of renewable technologies, with offshore wind being rising above 11%, but fundamental to the need of underpinning Security of Supply is the need for reliable delivery, so dispatchable technologies provide the backbone for delivering capacity. Such technologies have de-rating factors of 85% to 95%[80] - meaning that far more of the capacity is expected to be relied upon.

In practice, this means that Tillbridge would potentially be expected to provide only 6.35% of 500MW, about 32MW. Against a peak national demand of 48,000MW, this represents a contribution of 0.066% hardly a significant contribution to warrant the text in the SoN, when the "elephant in the room", i.e. how solar can contribute to security of supply when it's dark, is ignored.

For the SoN to conclude that solar can play an important role in the resilience of the electricity system is at best partial, and potentially misleading.

[80] Electricity Capacity Report 2023.pdf

8.3 Curtailment:

The SoN describes curtailment as arising from two primary routes; through grid transmission constraints and having excess renewable generation than needed for demand. The SoN identifies that currently, curtailment occurs more frequently as a result of network constraints, however the SoN does not consider how this may change through the evolution of the energy system, and how much more frequently curtailment is likely to occur arising from having excess renewable electricity generation.

The SoN highlights the need for “whole system thinking” but fails to include some of the main points that relate to curtailment.

As has been described in Section 3 of this WR, excess renewable power is expected to be switched off, “curtailed” as there will be significant periods where renewable generation supply outstrips demand. National Grid foresees 40TWh to 60TWh of curtailment annually. This represents a colossal cost to the consumer, as the generator is frequently compensated for being switched off, thereby adding to consumer bills.

It is foreseeable that the main time when curtailment events will occur is during the middle of the day in summer – coinciding with highest solar output and relatively low levels of demand. Given solar has such a variable range of output – and is so predictably out-of-phase with demand curves, seeking to achieve 70GW of solar capacity, in an electricity system where the summer day-time demand is typically less than half this, would seem to “hard wire” curtailment into the future without confidence in the delivery of long-term storage infrastructure, undermining the claimed contribution the scheme can make. It is notable the wording in the SoN is chosen carefully, when it states that “transmission constraints are unlikely to cause curtailment at the Scheme and during its operational life”. The SoN is silent on the potential for their scheme to be curtailed owing to generation exceeding demand. It would be interesting to explore with the developer the extent to which they foresee their scheme being curtailed, in the event of the annual curtailment volumes indicated by National Grid in FES 2024.

Treatment of curtailment in the SoN focuses solely on the potential for network constraints to impact curtailment, failing to point out that the oversupply of solar is likely to be a key cause of excess generation and curtailment, or acknowledging self-curtailment in the context of “overplanting”.

Notably, within NPS-EN3, overplanting of solar is foreseen, but only in terms of how “installed generating capacity of a solar farm will decline over time in correlation with the reduction in panel array efficiency”. The Applicant has clearly set out the economic objective of maximising utilisation of grid capacity, rather than to address foreseeable panel degradation.

By “overplanting”, the author refers to installing more solar panels than are needed to meet the rated capacity of the system. The inference being that the proposed development would live with a certain volume of “self-curtailment” by design, to be able to operate at the peak rated capacity of the grid infrastructure for longer periods in the day, by deliberately planning to not use a proportion of the solar capacity that has been installed.

By admitting this, the developer implies the short duration of peak output capacity is in some way insufficient, or an inefficient use of the grid infrastructure – and therefore overplanting allows a higher number of MWHr’s overall to be produced by the scheme, albeit at a lower overall load factor than the typical 9-11% experienced in the UK.

For example, where the SoN describes the "optimum" overplanting ratio of between 1.3 and 1.5, for the Tillbridge scheme, this may result in 650MW or 700MW of panels, to be constrained to 500MW of output at the grid connection. This excess capacity would need to be funded by the developer – so there is a clear requirement for a commercial assessment to be undertaken by the developer in the design phase to assure themselves the overplanting would be worthwhile.

At a macro scale, however, this takes solar panels which would already be located in some of the lowest solar gain areas worldwide, and deliberately reduces their yield. Overall, therefore, between grid curtailment and overplanting, the assumed 10% to 11% load factor would seem optimistic.

The SoN concludes with the assertion that solar provides the opportunity for "lower curtailment" – but without having described the issue fully, or the extent to which excess solar can exacerbate the issue. In this respect, the SoN is misleading in its treatment of the topic.

8.4 Alternative solar schemes

The SoN states that large-scale solar must be considered "as additional to, as opposed to instead of" other forms of solar development, but the SoN does not explain how it arrives at this conclusion. Given the relatively recent emergence of a Government target of 70GW for capacity, there is a case for a strategy to be developed as to how this capacity should be best achieved, taking into account the overall needs of decarbonisation, including efficient land use, and ensuring the right overall market drivers are in place to deliver this. Otherwise, there is real potential that, given the favourable commercial landscape "of the moment" in favour of large-scale ground mounted solar (i.e. high energy prices, uncertain economics of farming, little or no incentive to encourage tree planting to decarbonise, complex economics of rooftop solar), land will be used inefficiently and be a source of future regret.

As has been explored in this WR, there is tremendous potential for rooftop solar to deliver the overwhelming proportion of remaining solar the country may need, with very few of the adverse consequences of using large areas of land, as is the case with large scale ground mounted solar.

8.5 Land Use

In Land Use terms, the Tillbridge development appears to fall outside the "typical" range of between 2 to 4 acres per MW of output (NPS EN-3). The NPS also states that this is "expected to change over time as the technology continues to evolve to become more efficient", implying a reduction in land take per MW. A rough calculation of 1400Ha (3459 acres), for 500MW suggests Tillbridge is proposing to use just over 6.9 acres per MW. Therefore, apart from being significantly larger than a "typical 50MW" solar farm, Tillbridge is potentially seeking to require more land than indicated in the NPS – perhaps to create sufficient envelope for overplanting.

Fundamentally, the SoN fails to consider that there is a clear alternative to the extensive use of land for solar, by deploying on rooftops.

The SoN also limits the extent of comparison between different generation technologies. While offshore wind clearly is not "on land", offshore wind has a significantly higher load factor than solar, and this must be a key consideration when deciding upon effective decarbonisation solutions and any assertion on land use.

The SoN also uses the example of Biogas to provide an example of where a large area of land is needed to produce a relatively small volume of energy. The treatment of the subject in the SoN is superficial, and should warrant much deeper analysis to assess the relative merits of bio-fuels. A key "miss" in the SoN is that biofuels can typically be stored and used as necessary, which gives a distinct advantage over solar. Such fuels are frequently used for transport, so directly act to decarbonise that sector.

Finally, the SoN also fails to consider the direct land use requirements identified by the UK Climate Change Committee for decarbonisation through planting trees and the development of peatlands and does not consider any of the adverse impacts of extensive land use by large scale ground mounted solar.

8.6 Installation cost / energy cost of large-scale ground mounted solar

There are three main aspects of cost relating to solar development where the SoN is weak or incomplete:

How cost of energy is considered: The SoN references the "Levelised Cost of Energy (LCOE)" as an important metric to demonstrate the low cost of solar energy. LCOE, however, presents a very simple view of energy cost, neglecting to consider the time value of energy, which becomes increasingly important in systems with more intermittent, renewable volumes of capacity deployed. Several articles explore the shortcomings of LCOE, with one such abstract stating "The inherent intermittency of wind and solar energy challenges the relevance of Levelized Cost of Energy (LCOE) for their future design since LCOE neglects the time-varying price of electricity"[81]. This means that although solar is low cost, it is not necessarily the cheapest generation source once the challenge of meeting generation with demand in the moment is considered, as is necessary to maintain a stable energy system.

Differential costs of installation: The SoN also highlights the potential cost difference between the deployment of large scale solar and small scale solar, highlighting a significant margin between the two in favour of large scale solar. 7000Acres have not been able to verify the accuracy of these figures. It is unclear the extent to which the two costs genuinely compare "apples with apples". For instance, the cost of NSIP-scale planning will be in the order of tens of millions of pounds per scheme, where no such cost exists for a small scheme. In addition, the calculation probably excludes the opportunity cost of having displaced farming, with all the associated implications, whereas on a rooftop there is no such cost.

Similarly, the SoN references a Solar Energy UK document[82] as its source to assert that new build solar was only 10% more expensive than retrofitting solar. Again, it is unclear how such figures can be verified, particularly as many costs would be avoided in a new build situation, when considering the potential cost breakdown of installation. For instance, as an example[83], several cost elements would not need to be included for houses on a new estate, e.g. scaffolding for roof access would be included in the build, bespoke design and structural surveys would be unnecessary, and many electrical accessories could be supplied and installed more efficiently than by being added later. The cost analysis within the SoN appears to be

[81] Why we must move beyond LCOE for renewable energy design - ScienceDirect
[82] Value-of-New-Build_Report.pdf
[83] How Much Does Solar Panel Installation Cost In 2024? | Checkatrade

Overall energy price impact: The price of electricity is dependent upon many factors required to keep a balanced electricity system, not simply the installation cost. The fact that solar produces its power is essentially out of phase with demand means solar can contribute little to reducing power prices at times of peak demand. Furthermore, given that wind is likely to provide 70% of UK electricity by 2050, any variation on the cost of delivery will have a far greater impact on energy prices than solar, which may only deliver between 7%-10% of electricity. It may be therefore, that overall, once the adverse impacts of large-scale ground mounted solar are more broadly considered, it may be worth paying a slightly higher price in terms of LCOE or installation cost, simply to mitigate these impacts.

8.7 Energy Policy Landscape and National Policy Statements:

The SoN selects elements from the landscape of policy and strategy announcements to support large scale solar development, however the SoN fails to mention:

a) Solar is not part of the UK Government's 10 Point Plan for a Green Industrial Revolution (2020) – nor in updates since.
b) Solar is primarily referenced in terms of rooftop solar in the Net Zero Strategy (2021).
c) The British Energy Security Strategy (2022) was the first reference to an ambition for 70GW of solar.
d) Powering Up Britain (2023) makes the first reference to large-scale solar development "looking for development mainly on brownfield, industrial and low/medium grade agricultural land", in addition to "widespread deployment of rooftop solar in commercial, industrial and domestic properties across the UK".

The SoN considers the National Policy Statements, however:

a) The 2024 NPS EN-3 (Renewable Energy Infrastructure) considers typical example solar farm being 50MW, and being between 2-4 acres per MW. The size of the Tillbridge scheme and the 6.9 acres per MW it potentially takes, are foreseen by NPS EN-3.
b) The NPS clearly requires alternatives to be considered, and the SoN has not done this, for example with options for rooftop solar or for smaller schemes that connect directly to pylons, and the failure to make use of any brownfield sites at the redundant power stations in the area.
c) Good design criteria include sensitivity to place, which the scale of the Tillbridge development fails to address, given the scale of development against the size of communities impacted.

From this, it is clear that:

a) The policy landscape demonstrates that thinking evolving over time, rather than being a settled position.
b) Rooftop solar is clearly advocated in the policy landscape, much more and much earlier than ground mounted solar.
c) The SoN fails to adequately consider place, land use, alternatives.
d) There is no clear policy target for ground mounted solar development at the scale of Tillbridge solar project.

Section 8 Summary:

The Statement of Need contains key areas of omission or partial information, in particular:

- The energy contribution of solar in the UK is not adequately described, and the SoN attempts to illustrate the region as being one of high solar gain, when it is clear the UK is one of the lowest areas of solar gain, globally.
- The security of supply benefit derived from "energy diversification" has been overstated, and the fundamentals of how to meet demand with intermittent supply from the scheme have been omitted from the treatment of Security of Supply in the SoN.
- The SoN chooses to state that solar is included in the UK's Capacity Mechanism, designed to provide sufficient electricity capacity to meet security of supply, but omits the context as to what limited value this means in practice; an expected contribution of 0.06% of peak capacity, but more likely to be zero.
- The SoN does not consider the extent to which the scheme may contribute to creating situations of curtailment on the electricity grid, or the extent to which the scheme will be curtailed.
- The SoN does not thoroughly consider alternatives to the use of large-scale ground mounted solar, e.g. rooftop.
- The SoN does not consider other pressures on land use and the extent to which large scale ground mounted solar will exacerbate this pressure, and potentially have adverse consequences for other direct decarbonisation requirements, for which there is no alternative.
- The SoN selects elements of the UK Energy Policy landscape that suit solar development, and omits many less convenient elements, such as that solar is not part of the UK Government's 10 point plan for a green industrial revolution, or the extent to which there are more references to a push for rooftop development than ground mounted solar.
- Even in the new NPS framework, solar schemes at the scale of Tillbridge are not envisaged.

Section 9: Advice on achieving clean power for Great Britain by 2030

The Energy Act 2023 laid the legal groundwork for the creation of a National Energy System Operator (NESO), which was launched on 1st October 2024. NESO takes its foundations from the UK National Grid Electricity System Operator. Following the 2024 General Election, and the pledge to accelerate decarbonisation of the energy sector, the new Government wrote to ESO / NESO commissioning them to "provide practical advice on achieving clean power by 2030 for Great Britain"[84].

NESO published their advice on 5th November 2024[85]. The advice acknowledges that, "Great Britain can reach a clean power system by 2030", although it is considered "a huge challenge", and it is clear that "offshore wind must be the bedrock of that system".

Within the document, there are some key points that may be relevant to the examination:

Clean Power Plan

The advice includes 5 priorities to achieve clean power. For the purposes of their advice, NESO have considered this to be a system where "unabated gas" should provide less than 5% of the country's energy in a "typical weather year". The plan priorities are:

- Unlock flexibility of demand and supply: this recognises that flexibility is essential in a system with more variable renewables.
- Backing offshore wind and renewables: Onshore wind and solar are included in this priority – but the overwhelming emphasis is on delivery of offshore wind.
- Recognising the value of dispatchable low carbon plants: This highlights the technology necessary to manage the electricity system other than weather dependent renewable energy and "firm" low carbon plants (like nuclear).
- Delivering network plans in full and faster: Highlighting the need to overcome barriers to delivering transmission network needs.
- Keeping options open: The ability to manage uncertainties and delivery risk.

Enablers for clean power

NESO also describe the "enablers" across delivery chains, these include:

- Markets and Investment – arrangements to deliver clean power and operate the system efficiently, in a competitive market.
- Planning and consenting – the ability to manage significant volumes of projects and speed up the process.
- Connections – Ensuring the connection queue is formed of ready-to-connect projects that align with the plan for clean power – and the (forthcoming) Strategic Spatial Energy Plan.
- Supply chain and workforce – recognising the current challenges across generation, storage and network projects.
- Digitalisation and innovation – harnessing the power of sector-wide data and accelerated adoption of AI.
- NESO acting to co-ordinate "action across the energy industry and its institutions"

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[84] SoS and Chris Stark letter to ESO providing advice on achieving clean power by 2030 for Great Britain
[85] Clean Power 2030 | National Energy System Operator

Weather dependent renewables

The advice states that “Access to suitable offshore locations and favourable wind conditions provide ideal geographic and natural resources for offshore wind, making it a highly effective option for generating clean energy for Great Britain. The clean power system must be based on offshore wind”. The advice also references load factors as high as 63% for offshore wind.

While solar is acknowledged to be one of cheapest clean power options, its contribution is significantly less. NESO noted the lower load factor for installed solar capacity of around 11%, but also highlighted that solar “generation is focused over the summer months and does not, therefore, align with Great Britain’s annual demand profile”.

NESO advocate that the distribution network will play an important role in the deployment of renewable generation, with “90% of solar capacities connected to the distribution network in our pathways” (the future scenarios considered in their advice). As referenced earlier in Section 5.3 of this WR, this is at odds with the make up of the current connection queue, which includes an overwhelming proportion of transmission, rather than distribution connections (according to National Grid’s “A Grid Guide to Accelerating UK Connections”). NESO also state that 2Accelerating additional solar and wind generation in the distribution network pipeline is critical to reaching clean power at pace and reducing the risk of under delivery of renewables.”

NESO also noted that “The 2030 connection queue has higher capacities of solar and onshore wind than is required”.

For solar in particular, NESO noted that “high-quality engagement was needed to avoid residents feeling projects are imposed on them”, and that some stakeholders “raised concerns that the cumulative impacts of siting high concentration of renewable generation in certain areas will make it challenging to obtain consent and could alienate communities. For example, some land use representatives and planning experts advised that support for solar would be stronger if it was dispersed at distribution level”. Stakeholder views also included the belief “that it would be possible to deploy 28 GW of domestic rooftop solar PV alongside commercial and industrial rooftops”. Such rooftop deployment would alleviate many of the concerns raised – and be distribution connected as foreseen by NESO.

Insights from clean power sensitivities

NESO explore the potential to further reduce unabated gas (below 5%) post-203 and how this becomes more difficult by building clean power alone. NESO state that “Adding clean power capacity can reduce use of unabated gas, but only by a fraction of its generating potential. This implies that, at the margin, more deployment of clean power sources, particularly variable and inflexible ones, will tend to add to system costs”. They also state “more renewables at the margin will tend to push up costs, unless accompanied with more demand that is flexible enough to take advantage of these times of excess power”. The NESO advice to Government reinforces many of the key points made in this WR, in particular the importance of balancing supply with demand, managing flexibility, avoiding curtailment and how uncontrolled solar development can fail to deliver a low-cost energy system.

Curtailment

NESO identify that clean power pathways involve higher levels of curtailment involve “higher levels of curtailment”, therefore “pushing up the average cost of meeting demand”. NESO estimates that curtailment will add £5/MWh (and reference contract prices for wind and solar at £71-£83 in recent auctions).

Reflections on NESO Advice

Many of the key points raised within this WR are echoed within this recent advice from NESO, including:

- Acknowledging that solar has an important role to play, but its load factor of 11% is low.
- Acknowledging there are tensions in how solar might be best deployed,
- The need to manage system flexibility – and how the intermittency of solar presents a particular challenge in this regard, because when it produces power is out of phase with UK demand.
- The cost of curtailment – and the potential for inefficient / excess renewable energy exacerbating curtailment and increasing the overall cost.
- There is already more solar capacity in the grid connection pipeline than required.
- Advocating for distribution-connected solar, to reduce the scale of individual schemes and reduce the community impact.

Overall, therefore the landscape around solar development remains in transition, and although solar is seen as an important contributor, the limitations, implications and impacts of solar have been transparently stated in advice to the UK Government by its newly-formed National Energy System Operator.

Section 10 Conclusion:

We recognise the need to decarbonise and that solar has a role to play, however, the energy benefits it delivers are limited, owing to:

- The low load-factor of solar in the UK, between 9-11%, because the UK is one of the lowest areas of solar gain, globally.
- The mismatch between when solar produces the bulk of its power (summer days) and when it is needed.
- Periods with excess solar energy, leading to significant curtailment (wastage) from having insufficient capability to store solar energy from the summer for use in the winter.
- The resultant need for the full capacity of solar to be covered by other forms of generation to meet peak winter demand.

In terms of those benefits, the developer has persisted in providing over simplistic and misleading information as part of its application, regarding the role solar power can play in the future of electricity supply, for instance by stating that the UK has high areas of solar gain when it has globally low levels of solar gain, providing the impression that the scheme can power 300,000 homes, and overstating the role solar can play in security of supply.

It is crucial that the limitations to benefits are fully understood, particularly when weighing up the harms arising from ground mounted solar development at such a scale. This harm stems from the fact that solar has an extremely low power density, which means that a solar scheme of the capacity proposed by the Tillbridge Solar Project uses a colossal amount of space.

Using so much land has a tremendous, concentrated impact on the immediate area and its people, but consuming such huge areas of land also puts a wider pressure on land use which may serve to impede decarbonisation by competing for land needed for direct decarbonisation. The UK Climate Change Committee asserts we will need to lose some of this land to plant trees (6CB calls for between 30-70kha of tree planting per year) and develop peatland to sequester carbon. Land will also be needed for energy crops, there are fears that climate change will change the yields of UK farmland and rising sea levels have the potential to further impact farmland. All of which is before any further expansion of urban development is considered.

Quite simply, over committing agricultural land to such inefficient land use as ground mounted solar could very quickly become a cause for regret.

With regard to energy policy, the landscape with regard to solar is evolving. While solar is not part of the UK Government's Ten Point Plan for Decarbonisation, the ambition for solar has grown considerably between 2022 and 2023, now seeking to achieving 70GW of installed capacity by 2035. Similarly, the National Policy Statements for energy are in transition. The new NPS suite for 2024 does not foresee large-scale ground mounted solar of the size proposed for Tillbridge Solar Project.

The NPS EN-1 advocates "good design", including the importance of the functionality of the development. This WR describes the constraints around the functional contribution solar can make to energy and decarbonisation, which are limited to the point where the benefits do not outweigh the harms arising from ground mounted solar installation at such a large scale.

What is strongly consistent, however throughout all Government energy policy and strategy announcements, as well as the most recent and new NPS suite, is the important principle of efficient land use, something that is increasingly recognised as being vital as UK land faces tremendous pressures from all quarters. The “Skidmore Review” also echoes this with a call for a “Mission for Rooftop Solar”, recognising the increasing importance of managing land use as a part of decarbonisation, and the need for a clear plan on how we manage competing demands on land.

Therefore, there is no explicit policy for such large-scale ground mounted solar development in the UK. Quite apart from this, there is growing evidence that the UK can meet its 70GW solar capacity ambition from sufficient available rooftop solar capacity on suitable commercial and domestic buildings, with none of the same adverse consequences of ground mounted solar, and fewer implications on National Grid infrastructure requirements.

Developers have claimed that the installation of large-scale ground mounted solar is the only way to install solar capacity at the rate the climate emergency demands, however more solar could be installed on new-build house rooftops, more quickly than the development of a project at the physical scale of the Tillbridge project, with all the associated impacts and environmental considerations that are required.

All of this renders ground mounted solar development at such a large scale unnecessary. This means that should the Tillbridge scheme not be approved, the UK can still easily meet its ambition to install 70GW of solar capacity, particularly as NESO have reported that there is already an excess of schemes in development.

What is equally important to consider is the publication of major reports that have assessed the decarbonization of the power sector in the UK and current progress towards delivering on that goal. In doing so, they described the main challenges and the extent to which solar plays a role. These reports are:

- Delivering a reliable decarbonised power system, by the UK Climate Change Committee (CCC), March 2023
- Decarbonising the power sector, by the National Audit Office (NAO), March 2023
- Decarbonisation of the power sector, by the Business, Energy and Industrial Strategy Committee (BEIS), April 2023 – **Note:** *the energy portfolio of this department is now the responsibility of the Department for Energy and Net Zero (DESNZ)*

Their most pressing findings are:

- The need for overall co-ordination and planning of the energy system
- The resolution of grid connectivity issues – especially to deliver offshore wind generation
- Inadequate pace of deployment of wind and nuclear power generation
- The need to manage energy flexibility and intermittency of renewable energy sources

While solar has its part to play, it features very little in the landscape of key challenges identified by these reports, that must be overcome for the UK to make a success of decarbonising the power sector.

Finally, while NESO’s recent advice to Government on delivering Clean Power 2030 acknowledges the important role of solar in the future energy system, it also highlights many of the limitations of solar that have been highlighted in this WR.

We are in favour of good solar development:

- Solar should be deployed where there is little else that can be done with the space – such as rooftops. To make that happen, planning should require solar on new-build commercial warehouses and domestic properties as an immediate priority, and a framework should be provided to support retrofitting of solar to existing buildings.
- Where a solar development is considered at scale, it should be decided upon locally, not nationally – and any development must consider sustainability in its widest sense, including the impacts on sustainability of food production, sustainability of communities, impact on health and wellbeing.