7000 Acres

7000 Acres Response to the Gate Burton Energy Park Ltd Application on the subject of:

The role of Solar in Energy Provision and Decarbonisation

Deadline 2 Submission – 8 August 2023

Contents:

<u>Executive Summary:</u>

<u>Written Representation: The Role of Solar in Energy Provision and Decarbonisation</u>

This paper considers the need for the Gate Burton Energy Park, 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 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.
3. **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.
4. **The Connection of Solar to the Electricity System**, in particular the power and voltage needs of solar panels.
5. **The Role of Battery Energy Storage Systems** in terms of supporting the solar scheme and their wider role in the energy market.
6. **The Decision on Longfield Solar Farm,** in terms of the key Energy and Decarbonisation points that have and appear to have not been considered in the concluding report.
7. **The Gate Burton Statement of Need,** in which there are notable omissions and sections have been drafted using partial or misleading information.

In doing so, this paper will seek to answer the Examining Authority's written questions and requests for information (ExQ1), Issued on 12 July 2023.

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, providing the impression that the scheme can power 160,000 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 Gate Burton Energy Park 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 existing NPS suite makes little reference to solar other than pointing out the difficulty associated with intermittent generation. Even the revised draft NPS suite from 2023 does not foresee large-scale ground mounted solar of the size proposed for Gate Burton Energy Park.

What is strongly consistent, however throughout all Government energy policy and strategy announcements, as well as the existing and draft 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 case 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 Gate Burton, with all the associated impacts and environmental considerations that are required.

All of this renders large-scale ground mounted solar development unnecessary. This means that should the GBEP not be approved, the UK can still easily meet its ambition to install 70GW of solar capacity.

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 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 basis 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, 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 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 (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, however, with no specific agricultural land identified for solar development, it would be reasonable to infer the majority of this capacity would 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. The early release 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.

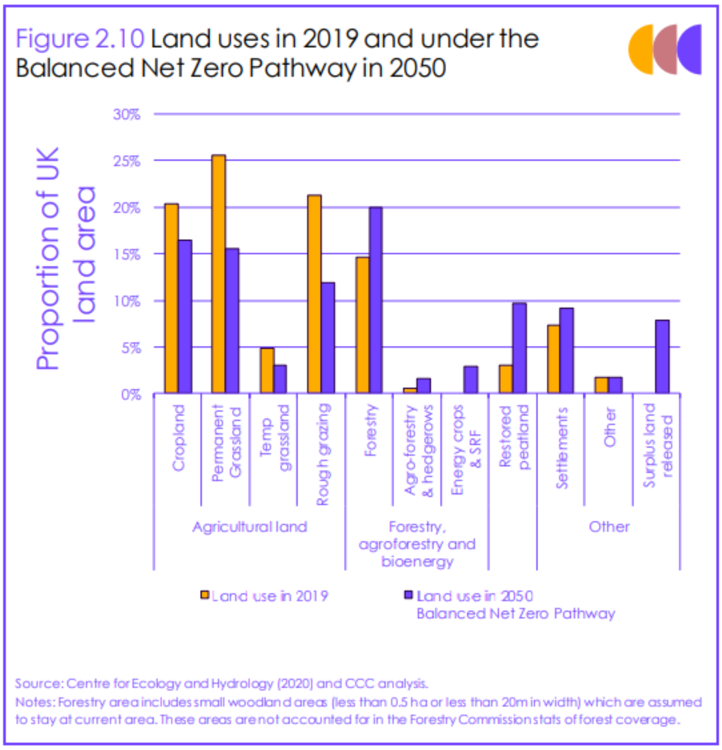


Figure 2.10 Land uses in 2019 and under the Balanced Net Zero Pathway in 2050

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.

1.2 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 (2020)**, 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)**, although solar is mentioned, most references are to new build rooftop and retrofit solar, as well as a case study of a community solar scheme (Cuckmere Community Solar) at 4MW capacity.

The **British Energy Security Strategy (2022)**, 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), 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 is shifting. The ambition for 70GW is just over 1 year old, 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 Royal Society", 01/02/2023), following a report by the Royal Society on Land Use, 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 it has committed to produce this year. In this situation of flux, it is essential that caution is exercised when making determinations on large areas of land.

1.3 National Policy Statements

The existing suite of NPS were published in 2011 and make little reference to solar. EN-1, 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. Within 82 pages of the current EN-3, for Renewable Energy Infrastructure, solar is not mentioned at all.

A revised draft of NPS EN-3 (Renewable Energy Infrastructure) was produced in March 2023, which now includes solar. The draft has been revised to include the latest ambition for 70GW of solar capacity, but even this revised draft considers 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.

The evolution of the NPS suite reflects the rapid change in the wider policy landscape, but key elements remain, including the need for "good design", the need to manage impact on landscape and visual impact, efficient land use and to consider community impacts.

1.4 The Skidmore Review

The **Mission Zero, Independent Review of Net Zero (2023)**, also referred to as **"The Skidmore Review"** was published earlier in the year, looking 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 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." ("Dunkelfaute" 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, "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. 469 Nature-based solutions (like tree-planting) are expected to provide around 40% of the greenhouse gas removals required by 2050. 470 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".

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. 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.
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: Solar Capacity and Electricity System Considerations

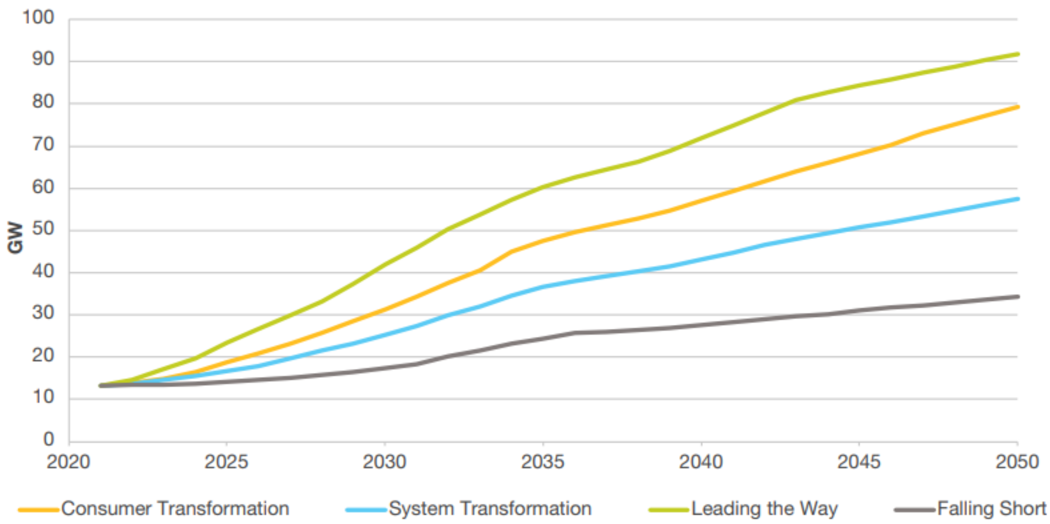
2.1 Future Energy Scenarios, 2022, National Grid

National Grid publish Future Energy Scenarios (FES) each year, as a forward look into the development of the electricity system. Within FES 2022, there are 4 scenarios, which are described as being "credible pathways for the future of energy between now and 2050". In 3 of these scenarios, net zero is achieved by 2050. In the final scenario "Falling Short", net zero is not achieved by 2050, owing to slow decarbonisation and minimal behaviour change.

2.1.1 Solar Capacity

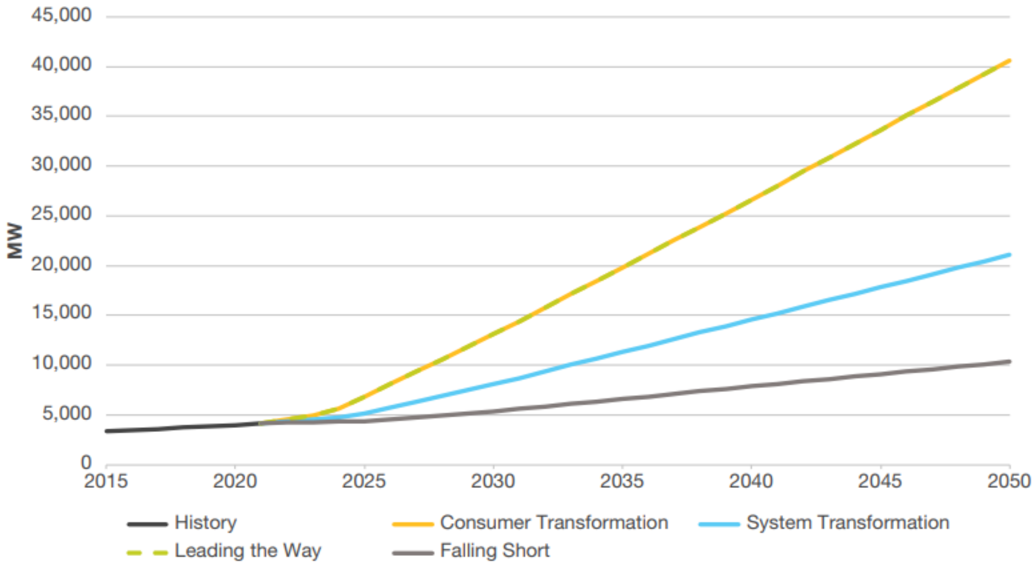
Within the scenarios that meet the net zero target, the installed solar capacity increases from c. 14GW now, to a range from around 58GW to just over 90GW in 2050. In the "Falling Short" scenario, only 35GW of solar is installed (Figure ES.E.16, from FES 2022).

Figure ES.E.16: Installed solar generation capacity (GW)



National Grid have modelled the likely development of Domestic solar capacity until 2050, in the 4 scenarios (Figure EC.R.19 from FES). 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%.

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



2.1.2 Flexibility

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 the short term, there is a key need to balance 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.

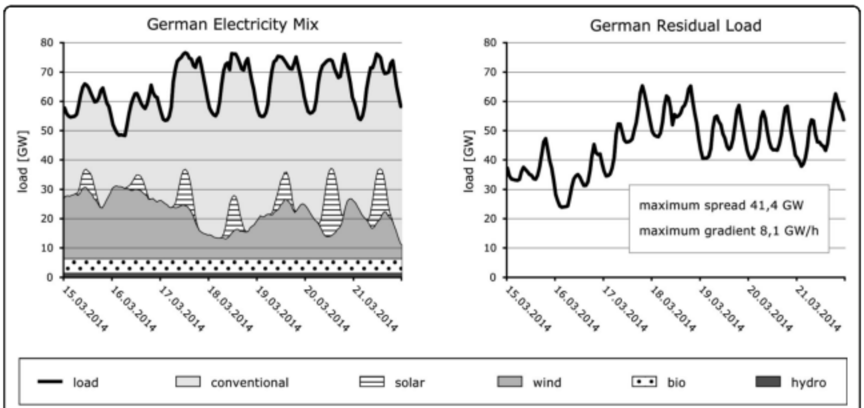


Fig. 2 Recent electricity mix and variation of residual loads (defined as load less wind and solar generation) in Germany, 11th week 2014, own presentation based on [102, 103, 104]

(From Energy, Sustainability & Society, 2015)

For example, in the left-hand graph above, the solid dark line is the total load required. 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 the rate at which 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.

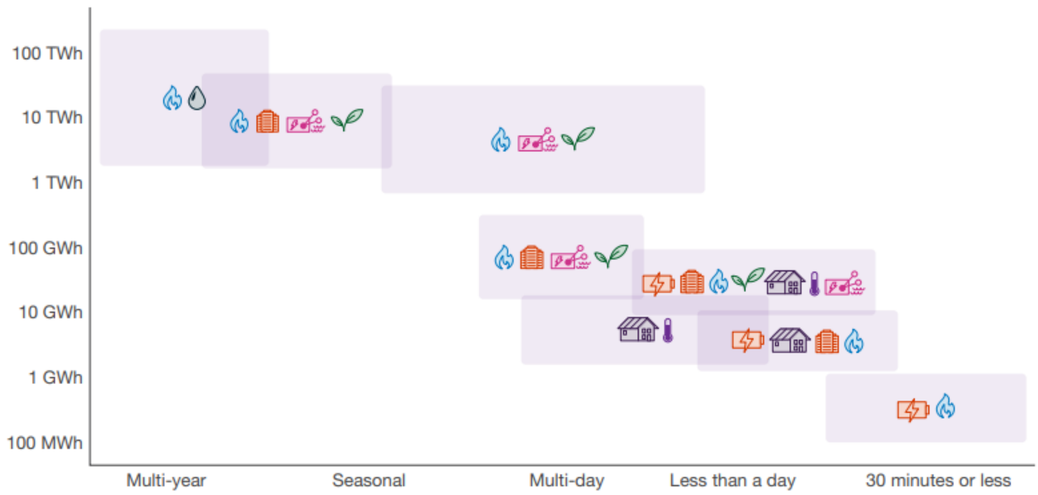
This shows that in this time frame, that solar is the key contributor to the volatility of electricity supply by creating spikes in supply. Within the UK, these spikes do not coincide with peaks in demand, therefore high penetration of solar leads to a very challenging and volatile residual load line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

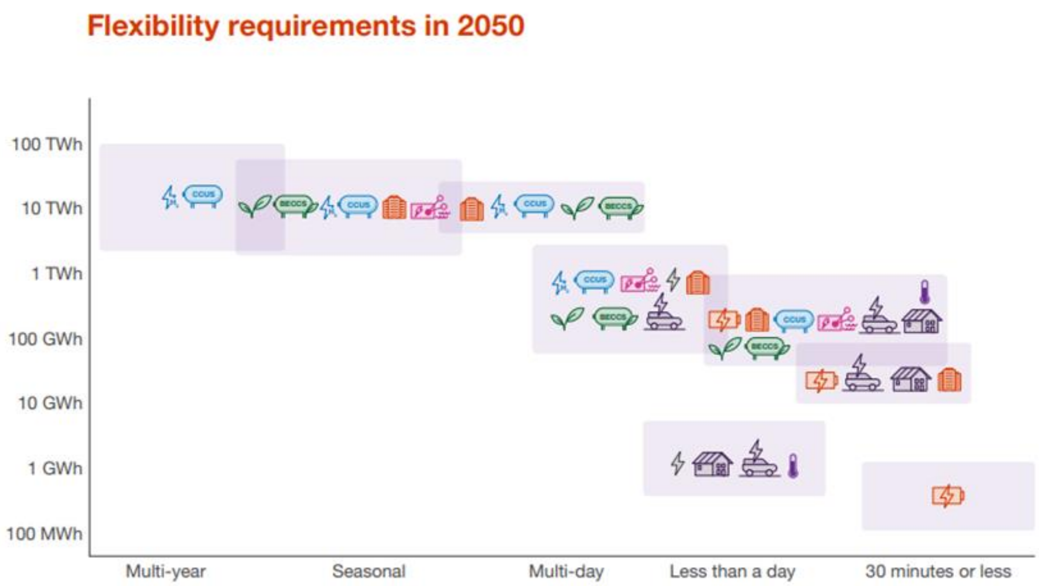
In the second instance, there is the need to manage energy from season to season. Historically this has been done with coal, oil and gas as well as pumped hydro storage and interconnectors. Removing the carbon impact from this toolkit relies upon the development of hydrogen as a fuel and carbon capture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

Electrolysers produce hydrogen from water and electricity. They will be essential to 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.

FES 2022 shows the range of electrolyser build until 2050 (Figure FL.13 from FES), 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).

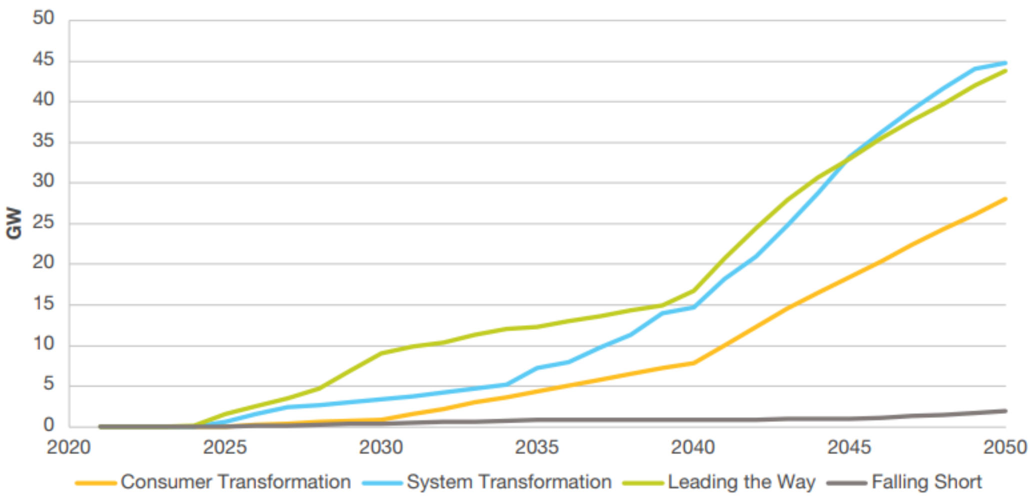
Flexibility requirements in 2020[6]





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]



2.1.3 Curtailment

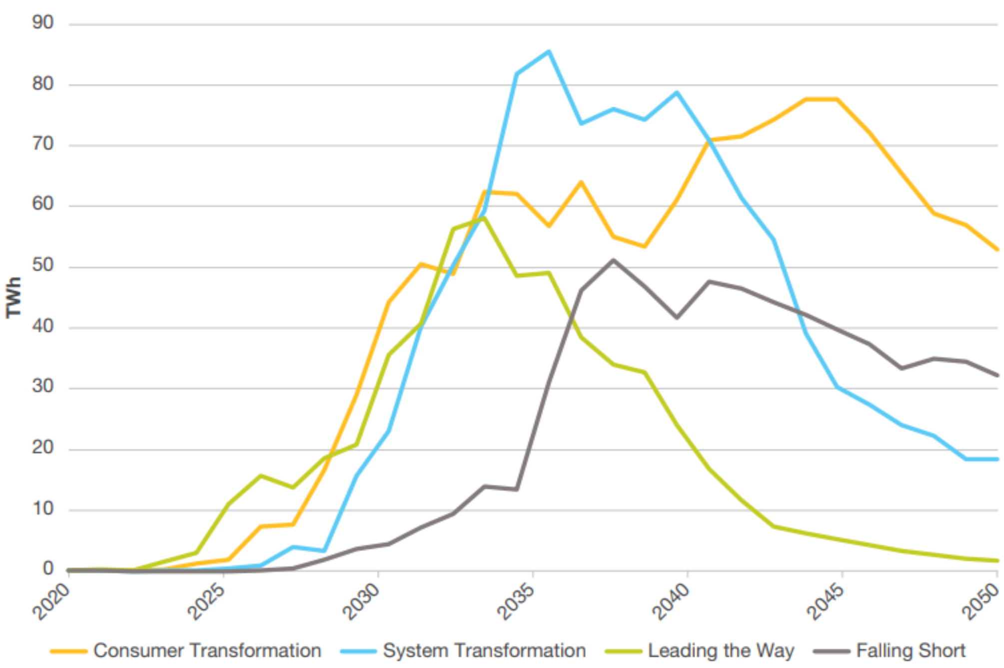
When there is a surplus of electricity generation, particularly through wind and solar, some generation will be asked to stop generating, known as "curtailment". This is done through a market, where the cheapest to turn off is instructed first. This already takes place, particularly on breezy, sunny days in the summer, during the period where solar is at its peak which coincides with when demand is usually lower. Curtailment is expected to become a growing problem. In the three scenarios that meet net zero within FES 2022, there curtailment peaks at between 55TWh to 85TWh. (See FL21 from FES 2022). In context, the UK power demand annually is currently around 300TWh. This level of curtailment is between 15% and 30% of the current annual energy requirement and represents a material amount of power for which the producer is paid to not generate.

The way to avoid curtailment it 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), 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 FL.21: Annual Curtailment



2.2 Practical implications of high solar capacity on the National Grid

2.2.1 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.

Peak demand on the system can be as high as 45-50GW, 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.

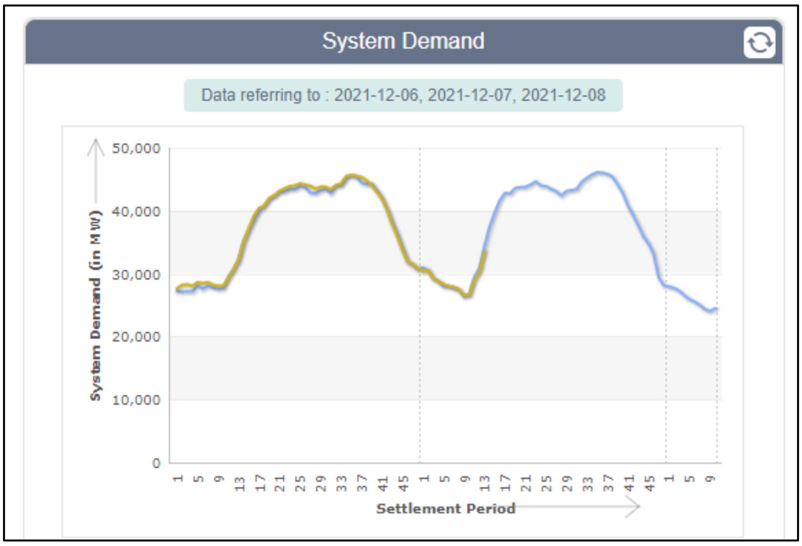
2.2.2 Need for flexible electricity generation

High levels of renewable generation are already causing National Grid problems, often because there is too much wind and solar energy to meet 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 Sizewell Power Station. 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.

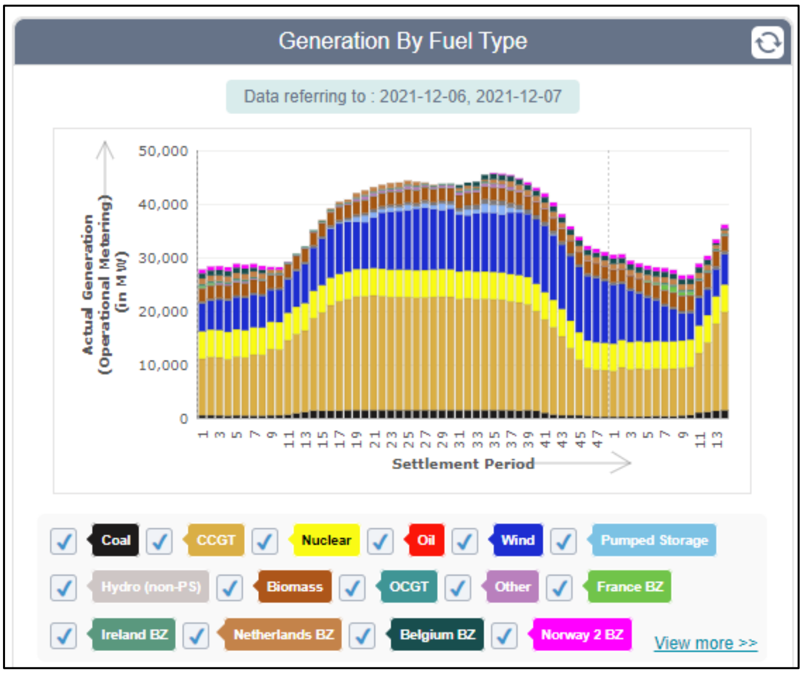
Through most summers now, the balancing market already pays renewable energy companies not to generate when there are periods of insufficient demand (curtailment). Domestic suppliers are already looking to address the topic of surplus power. For example, British Gas has introduced a tariff that encourages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

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

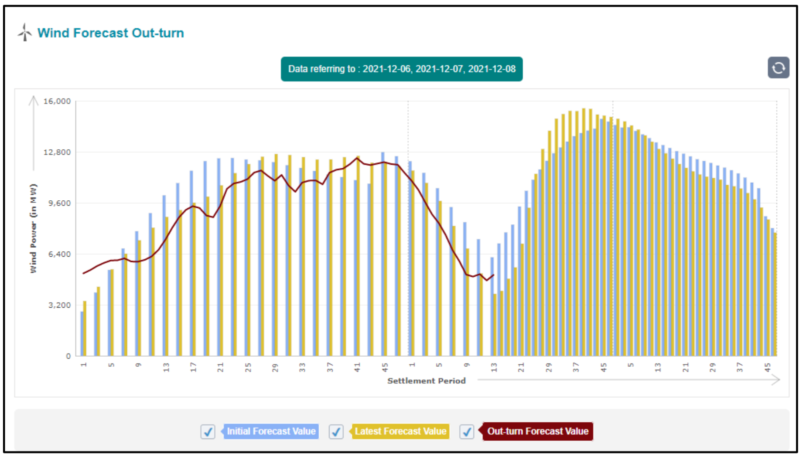


Typical winter demand from 25GW overnight, to 45GW at "peak"; settlement periods 37-38 (around 5-6pm)

(The electricity market day is split into 48 half-hour settlement periods)

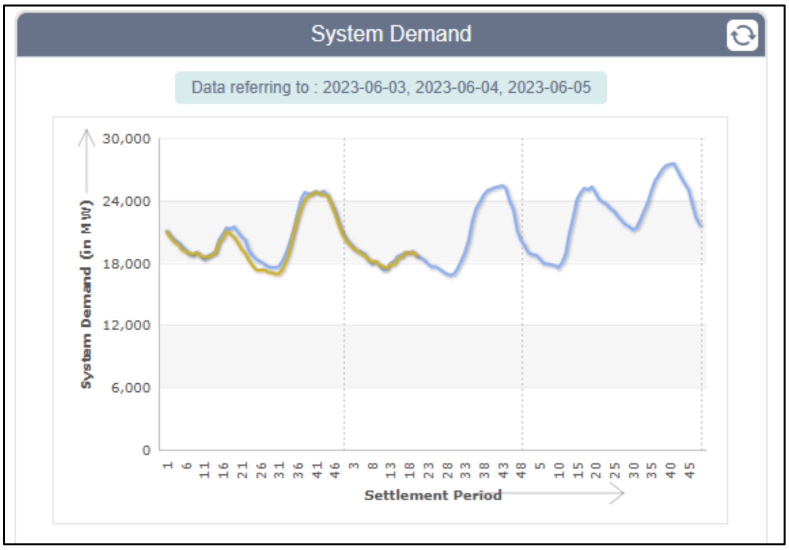


Generation type to meet the demand curve. Significant variable (blue) is wind. CCGT (gold) makes up the majority of the flexible generation (gas fired generation)



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.

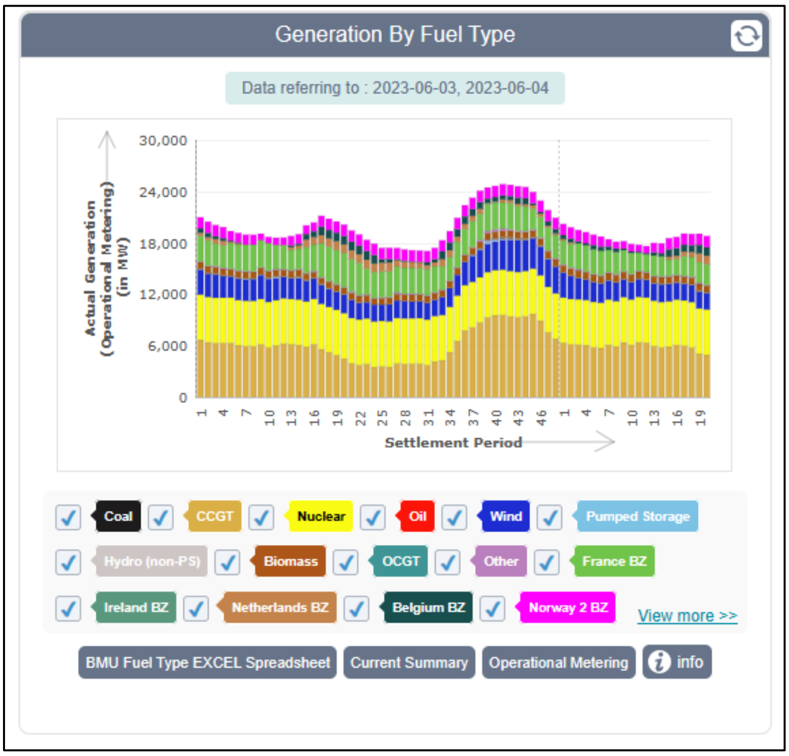
Typical Summer Day – Electricity System (graphs from Elexon website, BMREPORTS.COM)



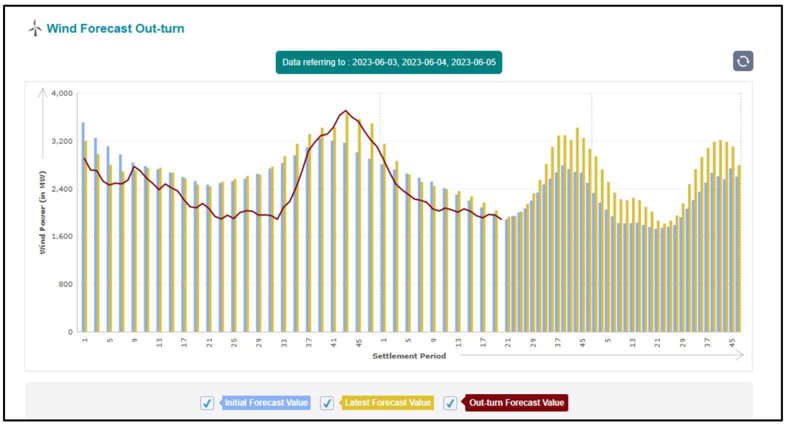
Typical summer demand from 18GW overnight, to 26GW at "peak"; settlement periods 40-41. (around 8pm)

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)



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.

2.3 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). Therefore, a scheme rated at 500MW, would, on average produce the equivalent of around 50MW for the year. This output however, would be skewed, 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, which align with National Energy Action data)

Wind power is similarly intermittent, but 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, therefore has the lowest average yield, and highest range of intermittency.

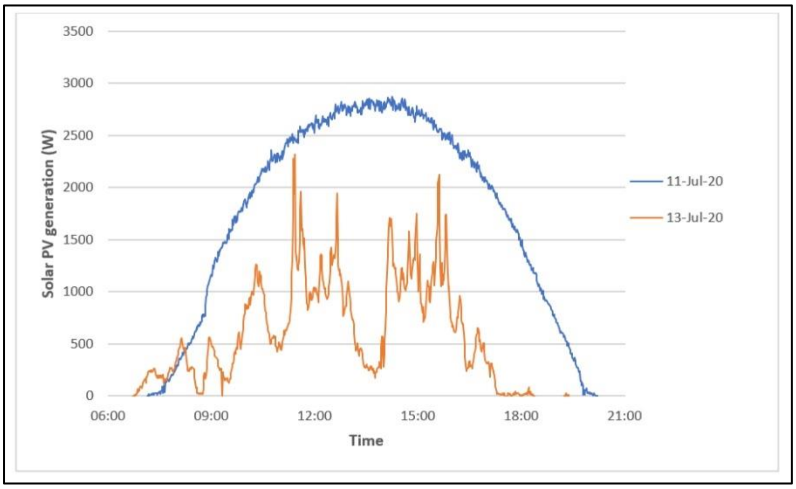
Increasing any intermittent renewable capacity, without the ability to manage demand, or store the power, means that there is a greater risk of curtailment, i.e. restricting the generation contribution of wind and solar generation because it is surplus to requirements. In turn, this will reduce the yield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

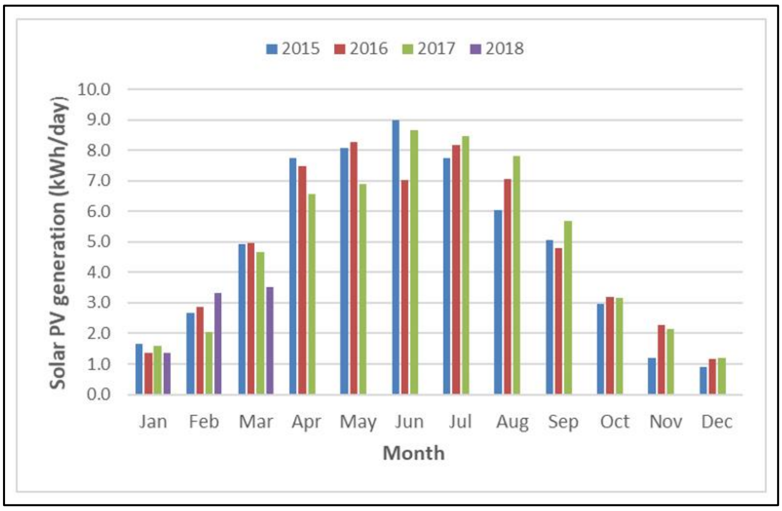
With solar capacity of 70GW, and offshore wind between 50GW to 100GW, the 2050’s could regularly see between 100GW and 150GW of intermittent generation available to the grid, and that is before considering any onshore wind, nuclear or any remaining flexible generation necessary to stabilise the electricity grid. For a summer day today, of around 25GW of demand, it is clear that the success of such expansion of renewable energy is 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.

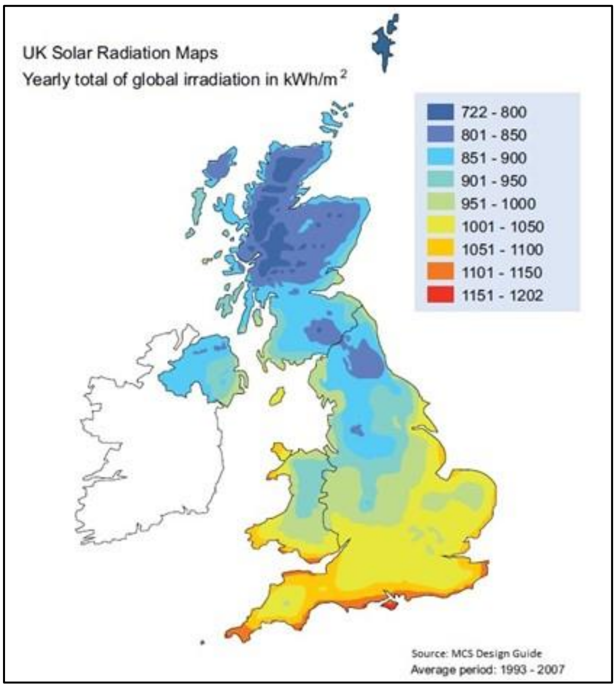
Indicative solar output in UK (Data from National Energy Action)



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.

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

The Gate Burton Energy Park describes the generation capacity of 500MW as being “equivalent to providing enough clean energy to power over 160,000 homes”.

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 Gate Burton Energy Park:

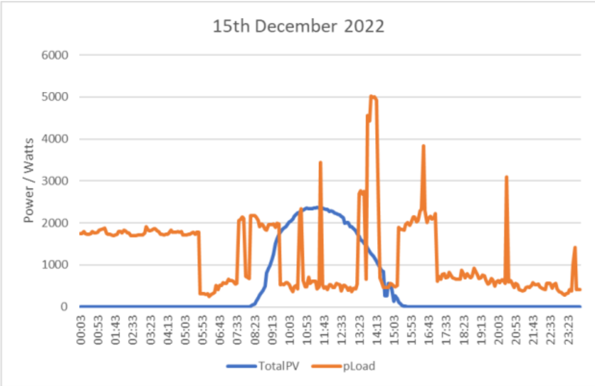
> 500MW x 365 days x 24 hours x 11% yield factor, the average annual production = 481,800MWh
>
> The average household electricity use is dependent upon many variables, but Ofgem use 2900kWh as an average:

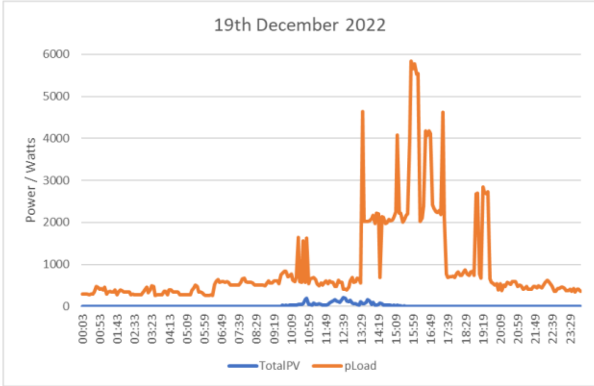
Energy Use	Example – home type and number of residents	Typical annual electricity use (kWh)
Low	Flat or 1-bedroom house; 1-2 people	1,800
Medium	2-3 bedroom house; 2-3 people	2,900
High	4+ bedroom home; 4-5 people	4,300

> In terms of output, 481,800 MWh is 481,800 x 1000 kWh, therefore
>
> Equivalent number of homes powered = (481,800 x 1000) / 2900 = 166,138 households

For the Heckington Fen scheme, Ecotricity demonstrate their calculation, 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. This shows the sensitivity of the claimed number of houses supplied to the assumptions made (noting that to achieve a figure of “over 160,000” Gate Burton have already chosen the higher end of the range of 9-11% of solar output in the UK).

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 and the sharp variability of domestic demand. On the bright, sunny day, the solar production even has the capacity to outstrip the immediate demand for a short period – potentially leading to curtailment, even during winter, 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.

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.

Thei seasonal as well as daily variations in supply render the concept of solar being able to power 160,000 homes as a meaningless and oversimplified claim, that is being used to mislead the public, particularly in the absence of both intra-day and inter-seasonal energy storage.

2.3.2 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). 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).

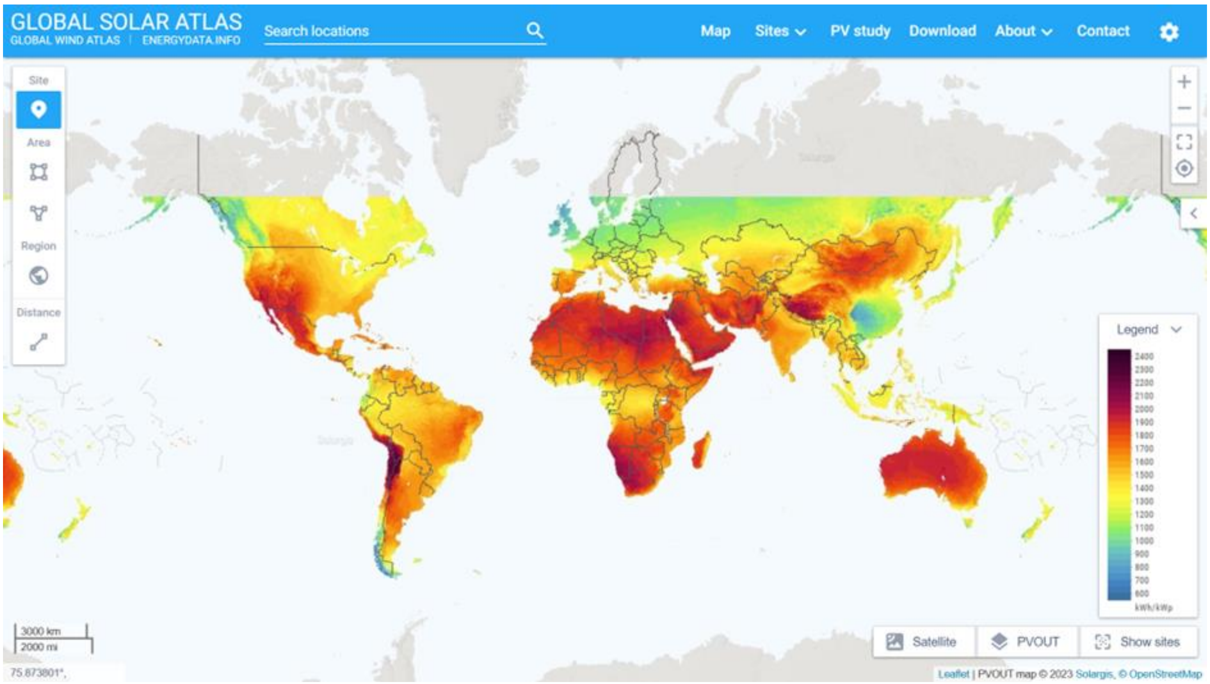
2.3.3 Solar gain and Energy Density

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", 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.

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). As well as having high solar gain, these areas have much less competition for land use.



In the graphic above (from Global Solar Atlas), 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. To deploy large scale ground mounted solar in such circumstances, the UK must first have clarity that it can afford to use land in this way.

2.2.4 Solar and Decarbonisation

Chapter 6 of the Applicant's Environmental Statement examines various aspects of CO2 intensity, comparing solar to current UK grid carbon intensity and Combined Cycle Gas Turbine (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, the solar panels produce nothing, so cannot serve to reduce the CO2 intensity, without other storage technologies.

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.

Section 2: Summary

From National Grid Future Energy Scenarios (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 58GW to 90GW.
- 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:

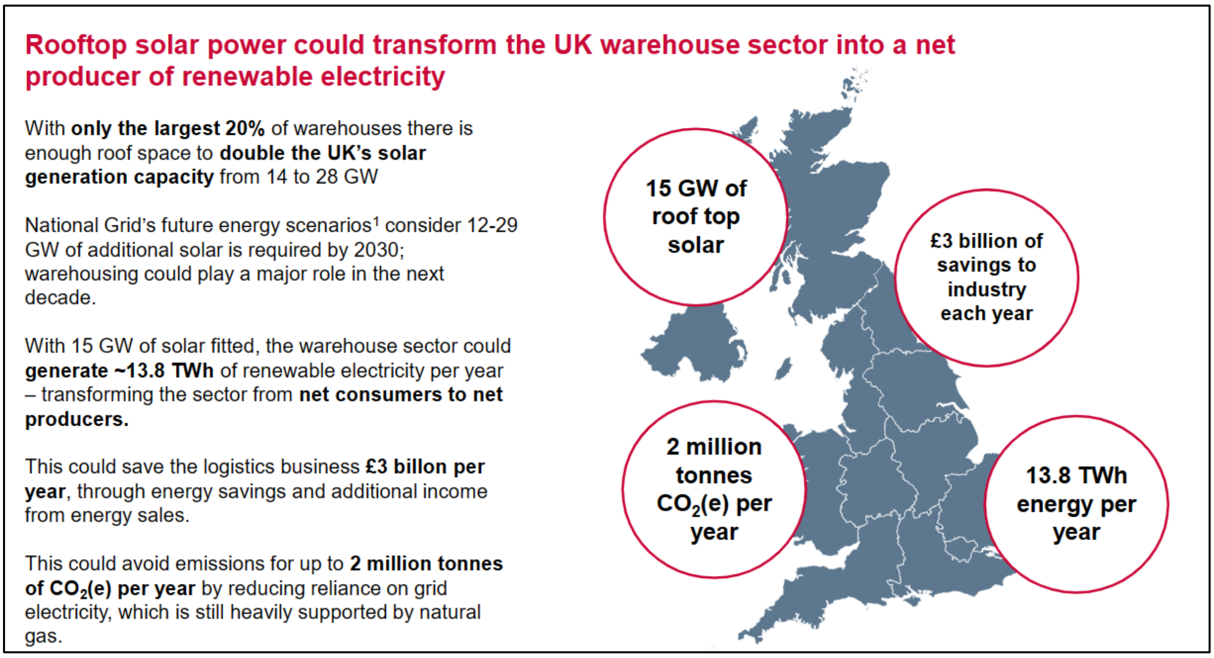
- In the UK, solar schemes will typically yield between 9 and 11% of their rated capacity – much lower than other renewable sources.
- The intermittency of solar causes the grid problems in particular, because of the high degree of intermittency and the fact that solar production is at its peak when 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 solar schemes can power 160,000 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 3: Potential for Rooftop Solar as an Alternative Solution to Solar Capacity Targets

One of the great mysteries of the moment is the urgent need for decarbonisation, which drives the need for a huge increase in solar power, yet 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.

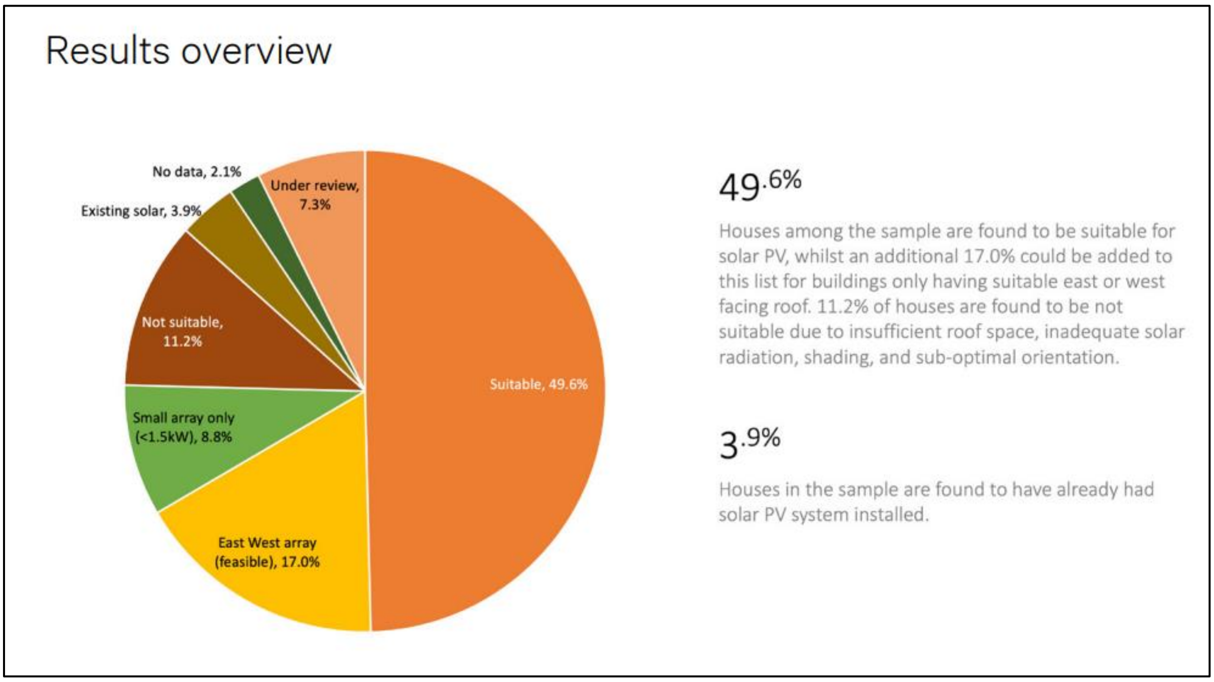
Two recent reports have highlighted the potential for domestic and commercial solar to contribute to the increased solar capacity.

The UK Warehouse Association published "The Investment Case for Rooftop Solar in Warehousing" 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.



In May 2023, Ecotricity published "The Rooftop Revolution We Need" 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" housing was estimated to be a staggering 37.7GW. (See the extracts from the Ecotricity report on the following page). 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.

Given there is an existing solar capacity installed in the UK of 14GW, an additional 14GW from the largest 20% of existing warehouses, plus 37.7GW from "suitable" domestic properties is already 65.7GW of capacity. This capacity already exceeds one of National Grid's scenarios for solar to meet net zero by 2050, i.e. the "System Transformation" scenario which requires 58GW. It is also very close to achieving the UK Government's current "ambition" of 70GW, and this is without considering any new-build commercial or domestic solar developments.



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**

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). Up to 81% of these can be houses, rather than flats ("Home building stats show continued increase in starts and completions despite pandemic", 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 retro-fit of solar to existing households, as advocated by Ecotricity.

During the last two years of work on the Gate Burton Energy Park planning process, houses continue to be built without solar; in this time, far more solar capacity could have been installed than will be delivered by the capacity of the Gate Burton Energy Park. In short, with the right planning incentives, solar could be 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.

According to the UK Government's Renewable Energy Planning Database (April 2023), there are currently over 900 ground-mounted solar projects registered as either being in development through to construction, with a capacity of over 21GW. Of this figure, 15 projects are of NSIP-scale (i.e. above 50MW capacity), with an aggregate capacity of 8.9GW. The database does not include NSIP-scale developments that are in the very early stages of consultation, such as Tilbridge Solar (Tillbridge Solar Ltd), Springwell Solar Farm (EdF), East Yorkshire Solar Farm (Boom Power) or Fosse Green Energy (Windell Energy), which alone would create a further 2GW of capacity.

This development, on top of that achievable from roof top solar reaches over 90GW of solar capacity, some 20GW beyond the UK Government's "ambition" – reflecting a "Wild-West" style rush for development that has the potential to provide more solar capacity than is needed or is useful, exacerbating the future energy curtailment (wastage) issues.

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.

Stripping out NSIP-scale development still leaves 12.1GW currently in development through to construction and would lead to almost 80GW of solar capacity, when combining existing solar with achievable rooftop solar, still more than sufficient to exceed the UK Government ambition for solar.

This would have the additional advantage that the planning determination would be local, rather than national.

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.

Section 3 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 14GW of capacity, i.e. 65GW – 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 Gate Burton Energy Park will produce.
- There is already over 21GW 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 8-10GW are large NSIP-scale ground mounted solar projects.
- There is no 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 4: Connection of Solar to the Electricity System

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 inverters and a series of transformers, for connection to the National Grid, for onward distribution, before being stepped down to domestic voltages for consumption. Apart from the obvious technical inefficiency of stepping voltages up and down, using this connection to the National Grid at Cottam and West Burton would sterilise the use of high voltage substation connections, and preclude their use by future high-power applications.

Individual solar panels produce low quantities of power (Gate Burton quote between 400 and 800W per panel in their PIER). For a capacity of 500MW (e.g. Gate Burton Energy Park), this would therefore require between 625,000 and 1.25 million solar panels. Hence, it is only where solar panels are combined in such numbers, that a 400kV, 500MW connection would 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 (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.

Gate Burton, Cottam, West Burton and Tillbridge locations appear to have been selected on the basis of making use of 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 grid 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.

At present, there is also 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). 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 (for instance, Gate Burton appear to have a connection date of July 2030, whereas the operation date in the PIER is expected in Q1 2028).

Installation of low-capacity solar schemes, such as on domestic rooftops often do 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 Distribution networks) are required. Pursuit of rooftop solar therefore has the potential to be deployed sooner (and enable earlier decarbonisation) than many schemes that require grid and distribution connections that can only be made many years into the future. Furthermore, by occupying connection applications in the National Grid queue, for solar projects that do not really need 400kV connections some solar developers are actively worsening the grid connection backlog situation faced by National Grid, potentially delaying other, more effective means of decarbonisation.

Section 4 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.

Section 5: 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 energy from the summer, to avoid curtailment, for use in the winter. The proposed Battery Energy Storage System (BESS) cannot deliver this.

Details of the BESS are limited, but in headline terms the storage capacity is 500MWh, with an import capacity of 140MW and an export capacity of 250MW. In simple terms, this means the BESS has the capacity to store one full hour of output from the solar farm, and it can use this to supply 2 hours at a maximum rate of 250MW.

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

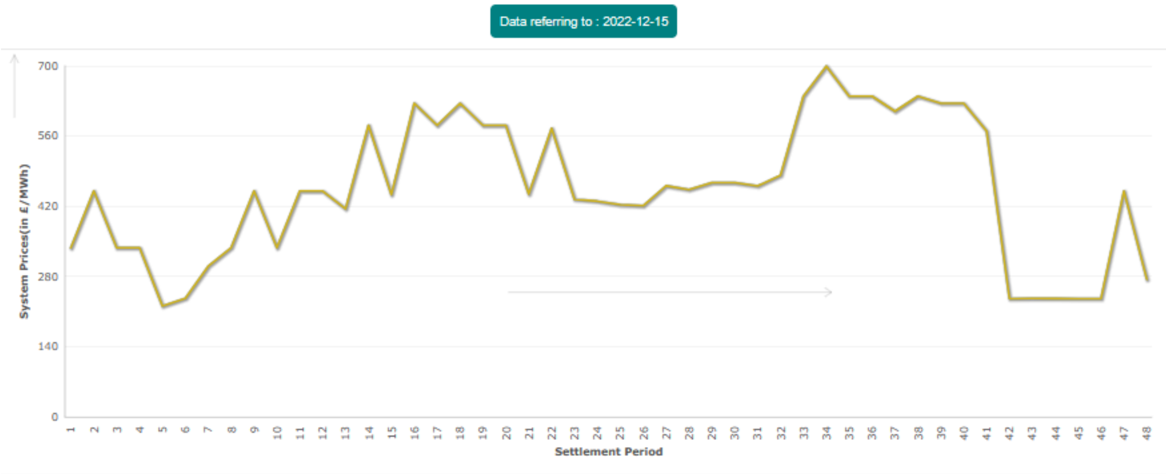
- In July, the solar scheme would produce, on average, around 1970MWh per day. In theory, therefore, the battery would be able to store a maximum 25% of the day's output to be able to provide power at periods of no-solar, or to potentially reduce curtailment.
- In December, the scheme would produce, on average, around 355MWh per day, which would be insufficient to charge the battery.

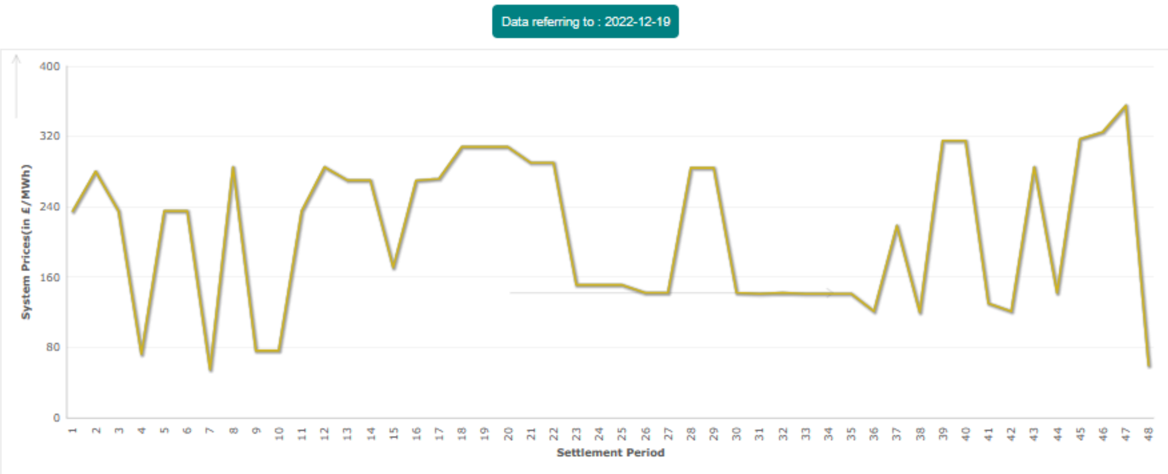
What is more likely, is that the BESS would be used for intra-day balancing, where the BESS can take advantage of the 140MW import capability, which would charge the battery over around 3.5 hours to reach 500MWh capacity, taking advantage of low-priced electricity, and selling this back to the grid over 2 hours at higher-priced periods. 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, nominally 10kW according to the Applicant (ES Chapter 6).

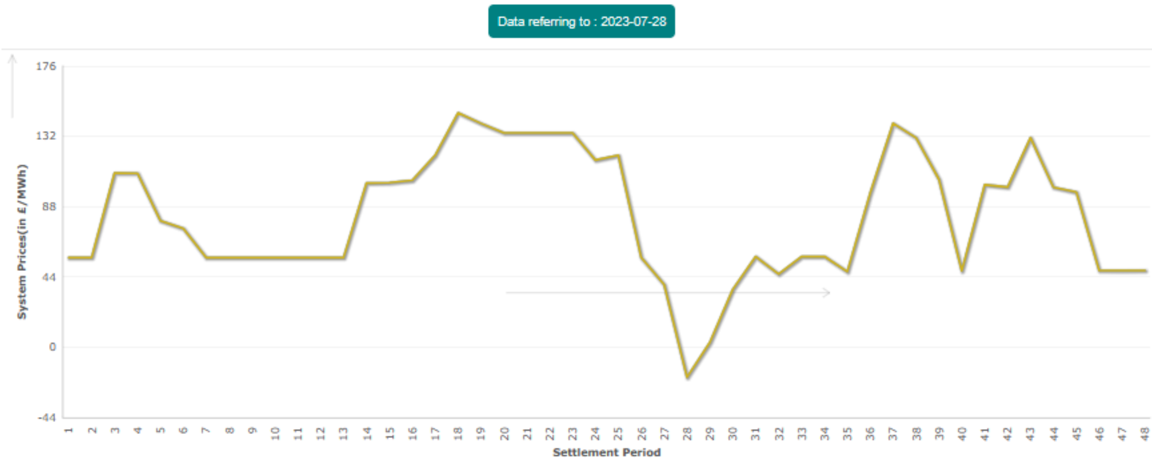
Using the previous examples of sunny and cloudy winter days in December 2022 (using indicative price Data from BMReports, see graphs on next page), using BESS to buy at low price periods and sell high could yield a spread of £150/MWhr (for 19/12) to £400/MWhr for (15/12). For 500MWhrs, these would be worth £75,000 to £200,000 per day respectively. Spreads of this nature are not uncommon and such economics 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 £20,000 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 latest CfD Allocation Round (4), 2.2GW of solar capacity secured contracts at a strike price of around £46/MWh. Given the capacity of the Gate Burton Energy Park, will be 500MW and 11% load factor, this would mean the income of the scheme would be c. £22.16m 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 massively increase the financial return of the scheme, independently of any genuine need for associated development.







Section 5 Summary:

- With only 1-2 hours of storage capacity, BESS cannot contribute to solving the season-to-season storage issues that plague solar.
- The BESS can make a limited contribution to reducing summer curtailment.
- The BESS has the potential to be a highly lucrative trading tool, in balancing the electricity system, but this is not associated development for the CfD-based solar scheme.
- The grid connection import capability has been sized to enable system balancing.

Section 6: Decision on Longfield Solar Farm

The decision of the Secretary of State on the Longfield Solar Farm was published on 26th June 2023. In many ways, this was a milestone decision, in that it was the first scheme of such capacity (500MW) to be considered for Examination as part of the National Infrastructure Planning process.

Reflecting on the decision. a number of material issues raised in this WR did not appear to be adequately addressed in the Examination, in particular:

a) Land use considerations were relatively narrow, largely being in relation to whether land could be considered Best and Most Versatile (BMV), rather than assessing overall efficiency of land use. This would appear to be a serious omission, particularly given the intense competition land faces, and the potentially adverse impact such development may have on overall decarbonisation outcomes by displacing necessary decarbonisation measures where there are genuinely no alternatives, e.g. tree planting.

b) Although the Examining Authority concludes the scheme would make a "meaningful" contribution to the development of a decarbonised energy system, and would "positively contribute towards a secure, flexible energy supply". It is not clear how this has been assessed or evaluated, either in the scheme's contribution to the energy system or to decarbonisation, e.g. in light of considerations such the need to match supply and demand, the impact of intermittent generation, the need for long-term energy storage, risk of curtailment, or compromising land use where there is direct competition for land needed to decarbonise.

c) The specific need for large scale ground mounted solar was not thoroughly examined. The Examining Authority appears to have been satisfied by the Applicant's account that rooftop generation generates much less than solar at scale. This is clearly not the case, as evidenced in Section3 of this document, and this erroneous position has been carried forward into the determination. It is clear, therefore that all reasonable alternatives have not been explored.

d) The Examining Authority states that the Applicant has explained that Essex (Longfield) is a favourable location owing to "high solar gain". This is clearly not the case, as has been demonstrated in Section 2. In fact, the solar gain is 1246.4 kw/m^2 (even this is 7.5% higher than the solar gain at Gate Burton, 1155.9 kw/m^2), using Global Solar Atlas, global tilted irradiation at optimum angle. It is also worth noting Longfield project benefitted from close proximity to a major load centre (South East England). Not only does this mean that the local area would benefit from the power, but it would also reduce transmission losses from the scheme. By comparison, given Gate Burton Energy Park's distance to load centres, it would likely incur at least 1-2% additional transmission loss than the Longfield scheme. The combined effect of solar gain and transmission loss would mean the Gate Burton scheme would produce around 10% less power – and benefit, than the Longfield scheme.

Section 6 Summary:

- The Longfield Solar examination appears to have omitted some material aspects considered in this WR, specifically:
- Efficiency of land use and the potential to adversely impact decarbonisation through misuse of land that may be otherwise needed for decarbonisation,
- Actual contribution to the electricity system and decarbonisation,
- The capacity for rooftop solar as an alternative
- The extent to which the UK is an area of “high solar gain”.

Section 7: Gate Burton Statement of Need

The Statement of Need (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, 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 in order 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

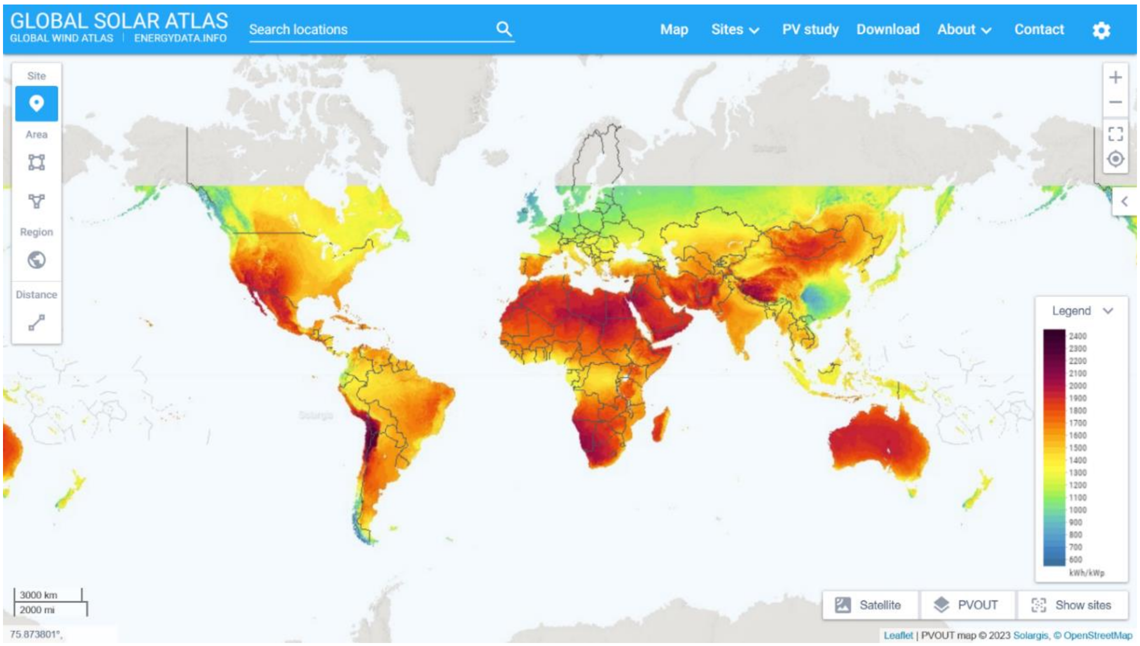
7.1 Output of Solar in UK

In over 130 pages of detail, the SoN chooses to omit any basic description of solar output in the UK. Specifically avoiding the issue of load factor, where solar will return between 9% and 11% of rated capacity in the UK, whereas other renewable technologies will provide significantly greater (although this is partially indicated within one table). 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 2 of this WR and will not be repeated.

The SoN does describe the equation for capacity utilisation (load factor), and points out that historical capacity utilisations have been high, (>80%). It also asserts that load factor is an important factor in site selection, without examining or describing the very low load factor associated with solar in the UK, or the issues that arise through mismatch of when solar provides its power (load factor) and when it is needed.

Within the SoN, the Figure 8.1 shows a graph of wind and solar load factors over a year, but chooses to omit the scale from the "y" axis. The graph attempts to portray that a combined portfolio of wind and solar provide level of "generation dependability", based upon the author's model which uses monthly data. In reality, 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. The sharp variations in solar production simply make meeting this shape more challenging. For the SoN to assert that “solar will smooth 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 refers to the level of irradiation in Lincolnshire as having “large areas of developable land which receive high levels of solar irradiation”, this is not quantified in any way, although a solar irradiation map of the UK is used to create the impression that this is the case. Using the same source as the SoN (Global Solar Atlas), but zooming out from this map, shows a very different picture. The first point is that the colour map which 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 Gate Burton 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 the 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.



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%

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.

7.2 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, and in this regard, the SoN chooses to avoid describing the 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 "ambition" level of the Government at 70,000MW, 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 the way the SoN opens the subject of the UK Capacity Mechanism as being the primary route for ensuring sufficient electricity capacity is available to National Grid (system adequacy), adds that wind and solar are now included in this market and provides the example that 2.2GW of solar projects have secured contracts. While the SoN also mentions that assets generate based upon their "de-rated capacity", it omits to state that the de-rating factor of solar is the lowest of all generation technologies, at 4.98%, owing to the low load-factor of solar and the likelihood of capacity being needed when solar cannot be relied upon. Therefore, from the 2.2GW figure quoted by the SoN, the expected contribution of this during a Capacity Market "stress event" would be just below 110MW, i.e. c. 0.2% of a peak national demand of 48,000MW.

For the SoN to conclude that solar can play an important role in the resilience of the electricity system is therefore misleading.

7.3 Curtailment:

The SoN makes little reference to curtailment. It fails to describe the basics of the issue and neglects to describe the extent to which solar is a primary causes of this issue. The SoN refers to FES 2022 in its brief treatment of the topic, advocating the need for "whole system thinking", but fails to include any of the key points that relate to curtailment from FES 2022.

As has been described in Section 2, 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 55TWh to 85TWh 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.

The main time when curtailment events 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, undermining the claimed contribution the scheme can make. 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 2022.

Where SoN does refer to curtailment, it seems to rather miss the main point, either in error or deliberately, e.g in relation to "unmanageable network constraints" (failing to point out that the oversupply of solar is likely to be the source of the generating capacity that is facing constraint), or taking about self-curtailment in the context of "overplanting".

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, Gate Burton may decide to install 550MW or 600MW 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, and they would clearly need to determine the financial advantage of reducing the 9-11% load factor of the scheme's "unconstrained capacity".

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

7.4 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), 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. Within the SoN, rooftop solar is mentioned once, fleetingly, in reference to “other forms of solar” – without any evaluation of its potential as an alternative.

7.5 Land Use

Objectively, solar has the lowest energy density of any energy source. For the SoN to devote a chapter that asserts “Large-scale solar is the most efficient use of land for energy purposes” is grossly misleading.

The SoN opens the chapter by arguing that the land necessary for ground mounted solar is very small as a proportion of total UK land area or arable land. It also makes reference to the likely proportion of land that solar would take in comparison to development of industrial or commercial units. This is a clear distraction from the topic of land use for energy purposes. Discussing land use for industrial or commercial development is spurious, as in these cases, there are seldom alternative ways such development may be brought forward, similarly with housing, reservoirs or any other land use challenge the country faces.

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.

7.6 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 SoN acknowledges that solar is not included in the scope of the current NPS suite, but crucially, even the Draft NPS EN-3 (Renewable Energy Infrastructure) considers typical example solar farm being only 50MW. The size of the current wave of schemes being proposed is not foreseen by even the draft 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 Gate Burton development fails to address, given the scale of development against the size of communities impacted.
d) The NPS 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, it is clear that within this region, there is a demonstrable link between agriculture, the environment and the local economy, therefore the exception should apply.

From this, it is clear that:

a) The policy landscape demonstrates that thinking evolving over time, rather than being a settled position.
b) Within even the draft NPS, schemes of the size being proposed by Gate Burton is not envisaged.
c) Rooftop solar is clearly advocated in the policy landscape, much more and much earlier than ground mounted solar.
d) The Gate Burton SoN fails to adequately consider place, land use, alternatives.
e) There is no clear policy for ground mounted solar development at the scale of Gate Burton.

Section 7 Summary:

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

- The low load-factor (yield) 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 that the de-rating factor for solar means that only 4.98% of the scheme's output would be considered.
- 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 draft NPS framework, solar schemes at the scale of Gate Burton are not envisaged.

Section 8 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, providing the impression that the scheme can power 160,000 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 Gate Burton Energy Park 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 existing NPS suite makes little reference to solar other than pointing out the difficulty associated with intermittent generation. Even the revised draft NPS suite from 2023 does not foresee large-scale ground mounted solar of the size proposed for Gate Burton Energy Park.

What is strongly consistent, however throughout all Government energy policy and strategy announcements, as well as the existing and draft 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 case 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 Gate Burton, with all the associated impacts and environmental considerations that are required.

All of this renders large-scale ground mounted solar development unnecessary. This means that should the GBEP not be approved, the UK can still easily meet its ambition to install 70GW of solar capacity.

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.

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