EAST YORKSHIRE SOLAR FARM

East Yorkshire Solar Farm

EN010143

Note on Scheme Efficiency

Document Reference: EN010143/APP/8.35

Planning Act 2008
The Infrastructure Planning (Examination Procedure) Rules 2010

July 2024
Revision Number: 00

2009

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1. Introduction

1.1 Purpose of this document

1.1.1 The purpose of this note is to provide an overview of the Scheme output, assumptions, and land use efficiency in response to the Issue Specific Hearing 2 (ISH2) on Environmental Topics held on 10 July 2024 as part of the Examination for the Scheme.

1.2 Structure of this document

1.2.1 This document is structured as follows:

a. **Section 2: Peak Output and Overplanting**

b. **Section 3: Peak Degradation**

c. **Section 4: Solar PV Assumptions**

d. **Section 5: Panel Configuration**

e. **Section 6: Land Use Efficiency**

1.2.2 The documents submitted with the Application are also referenced in this document, using the reference number [APP/x.y], where the last two/three numbers are the application document number, as set out in the Examination Library. All documents are also presented in numerical order in the Guide to the Application **[REP2-002]**.

1.2.3 For ease of reference, a table of acronyms used in this document is provided in **Table 1-1** of this document.

Table 1-1. Abbreviations

Abbreviation	Definition
AC	Alternating Current
BNG	Biodiversity Net Gain
DC	Direct Current
DCO	Development Consent Order
FSF	Fixed South Facing
GWh	Giga Watt Hour
ISH	Issue Specific Hearing
kWh	Kilo Watt Hour
MW	Megawatt
MWp	Mega Watt Peak
MWh/yr	Mega Watt Hours Per Year
MWh	Mega Watt Hours
NPS	National Policy Statement

Abbreviation	Definition
NSIP	Nationally Significant Infrastructure Project
PV	Photovoltaic
PVsyst	Industry leading design software used to create the illustrative design layout and calculate the MWp, MW-hours/year (MWh/yr) and MWh
SAT	Single Axis Tracker
WP	Watt Peak

2. Peak Output and Overplanting

2.1.1 The Scheme's grid connection agreement - and therefore the export capacity - is 400 MW ac (alternating current). The Applicant's Deadline 2 'Responses to Written Representations Submitted at Deadline 1' **[REP2-019]** provides more detail on this and states that the Scheme comprises the export of up to 400 MW via a 400kV/132kV transformer at National Grid's Drax 400kV substation (note, the inverters onsite convert the direct current (dc) output generated by the panels into alternating current (ac) for export to the national grid transmission network). This is the maximum instantaneous peak, with MW representing a unit of energy per second.

2.1.2 The indicative design of the Scheme which is subject to the DCO application delivers 480 MW dc (direct current) generation using 580Wp (watt peak) panels. This is an 'overplanting' ratio of 1.2 (120%). This means that 20% more panels are installed than a scheme achieving 400MW for the point in time when irradiance is highest during the year. A scheme without overplanting may not achieve its export capacity due to system losses (i.e., a 400MWdc generating facility is not able to export 400MWac), and if it could achieve it, it would do so only for its first year of generation (before degradation of panels), and for a few hours of the year when irradiance peaks; for the rest of its operational lifetime such a scheme would under deliver and fail to maximise the connection offer.

2.1.3 Section 6.6 of the Statement of Need **[REP2-010]** covers the concept of overplanting. In summary:

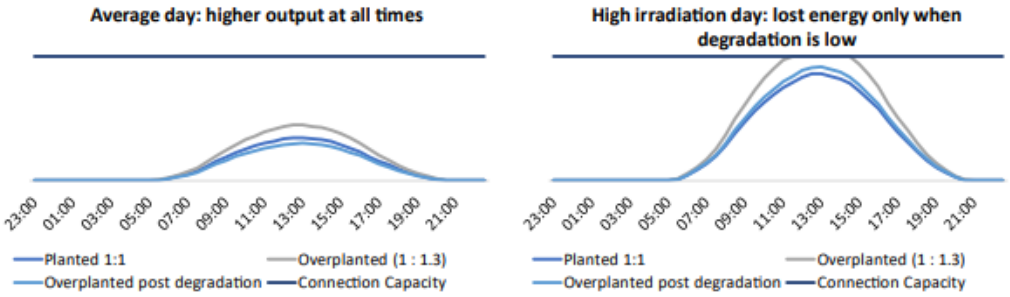
a. Overplanting offsets degradation of panels over time, achieving more hours at 400MW over the lifetime of the Scheme. This is explained in NPS EN-3; Para 2.10.55 of NPS EN-3 states that *"Applicants may account for this [degradation of output over time] by overplanting solar panel arrays".*

b. Overplanting also puts more generation capacity on the ground which means that whenever the conditions are not 'just right' for maximum generation, more electricity is generated and exported than would be the case if there was no overplanting, maximising the use of the export capacity agreement.

c. This comes at a cost during times when conditions are 'just right' for maximum generation. At these times, more electricity will be generated than can be exported, and the energy will be capped by the inverters and deliberately lost (to the duty cycle in the inverters or as waste heat). Only a maximum 400MW ac will ever be exported under the connection agreement with National Grid.

d. This is illustrated in the Statement of Need Figure 6-4 **[REP2-010],** which is reproduced below in Figure 1.

Figure 1. Illustrating clipped generation verses optimised generation on overplanted schemes verses unitary schemes



3. Panel Degradation

3.1.1 Degradation of panels is the reduction in Wp (the peak watt output) that can be achieved by the panel as it ages. This is due to several factors such as corrosion, delamination, oxidation, etc, due to the panels being exposed to the air and weather.

3.1.2 Degradation is typically about 0.5% per annum for a well-maintained PV system in ideal conditions (e.g., avoiding extreme weather). It differs based on the climatic conditions and model to model. An example panel by SunTech that is currently available on the market guarantees <1% loss of its peak capacity in its first year of operation and up to 0.4% each year thereafter.

3.1.3 Chapter 6 Climate Change [APP-058] states the Applicant's assumption that *"the output of the Solar PV panels [are] assumed to degrade by 2% in the first year and by 0.45% per year thereafter*" for the calculation of its lifetime energy generation; this is a conservative assumption for the purpose of calculating (avoidance of) greenhouse gas emissions and therefore to avoid inadvertently overestimating the benefit of the Scheme. Nevertheless, it is not too dissimilar to the industry-expectation outlined above.

3.1.4 Therefore, the MW dc peak generation is expected to be at about 90% of its installed peak capacity after 20 years, reducing to 80% after 40 years. The 20% overplanting (i.e. ratio of 1.2) will help offset some of this degradation. As mentioned above, this aligns with the principles of overplanting outlined in NPS EN-3.

4. Solar PV Assumptions

4.1.1 The Applicant has used PVsyst, the industry leading design software, to create the illustrative design layout and calculate the MWp, MW-hours/year (MWh/yr) and MWh over the lifetime of the Scheme. PVsyst models the precise field geometry and forecast irradiance levels for the Site where the Scheme is proposed.

4.1.2 As presented in the Outline Design Principles **[REP1-051],** the panels will be single axis tracker (SAT) configured north-south, up to 3.5m above ground, with a tilt range of plus or minus 60 degrees from horizontal to the east and west (except in Flood Zone 3 where it is set to ensure a 300 mm freeboard above 1-in100 year (1% likelihood) plus climate change flood level scenario is maintained at all times).

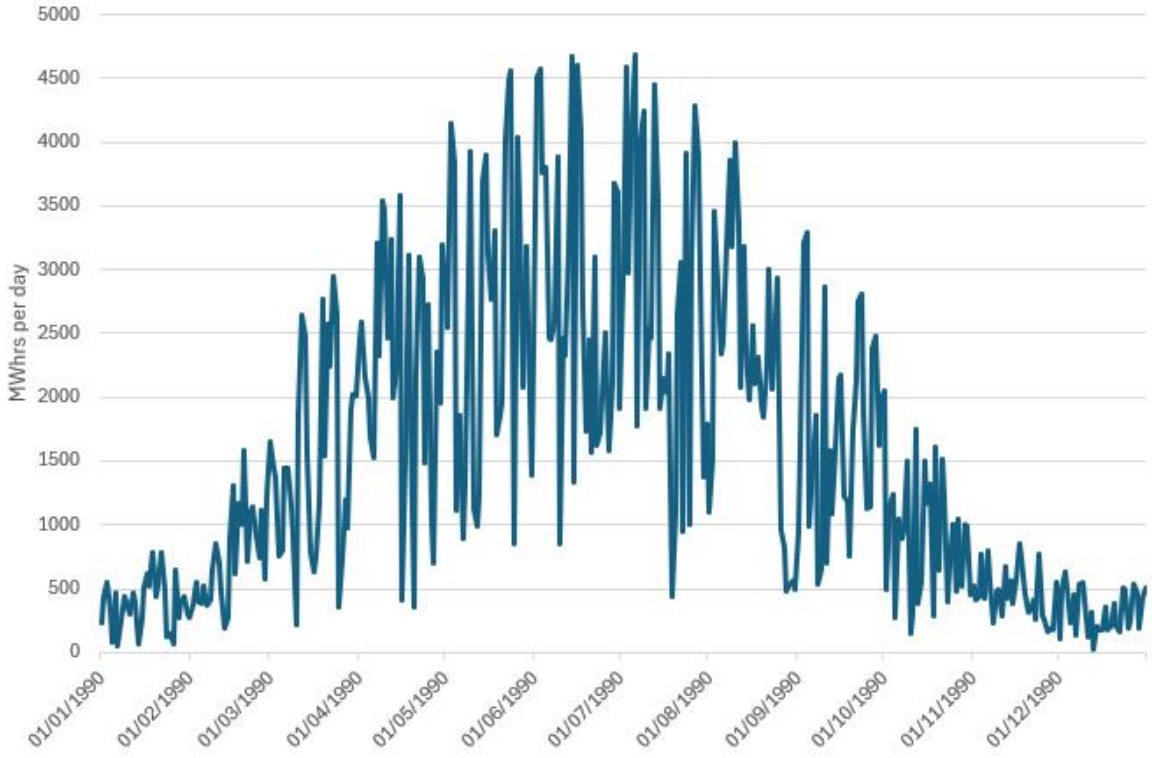
4.1.3 The panels are assumed to be 580Wp. As mentioned in Table 2-1 in Chapter 2 The Scheme **[APP-054]:** "*Each panel is expected to have a watt-peak capacity of between 400-1000 watts, depending on the technology available at the time of procurement."* The draft DCO does not cap the peak wattage of the panels because it is not relevant to the environmental or other consenting impacts of the scheme. It is very likely that the Wp will improve by the time the Applicant looks to procure the panels; there are already panels available on the market at >720Wp, albeit the Applicant cannot be sure these would be available at the time of procurement. This expected enhancement in panel efficiency has the potential to reduce the footprint of the Scheme and still deliver 480MWp. It is in the Applicant's interest to minimise the amount of land required and procure the most efficient panels available, but flexibility is sought at this stage to ensure the project is deliverable.

4.1.4 A modelled 580Wp panel produces 663.5 kWh per year, as taken from PVsyst.

4.1.5 The illustrative design includes 828,900 panels, giving an installed capacity of 480.8MWp DC with a yield of 549,760,279 kWh per year. This is a load/capacity factor of about 13% (i.e., due to hours of darkness or cloud cover, the Scheme will generate about 13% of its theoretical maximum), which is normal for solar (and other forms of renewable energy such as onshore wind).

4.1.6 Figure 1 provides a sample illustration of the MWh per day that may be produced by a 480MW dc scheme (based on 1990 irradiance levels - the generation will vary year on year depending on weather conditions). It is this variability across seasons that makes overplanting an important aspect of the design, to maximise the grid connection offer and deliver as much renewable energy as possible throughout the year.

Figure 2. Illustrative MWh/day across a typical year for a 480MW dc scheme (based on 1990 weather data)



5. Panel Configuration

5.1.1 Single axis tracker (SAT) configurations are tried and tested on the international market but relatively uncommon in the UK. Following a reduction in the cost of SAT, this technology is being considered by many solar developers because it can deliver more renewable energy over its lifetime than a fixed south facing (FSF) configuration (for the same MW ac grid connection). There are at least 8 solar NSIPs currently that incorporate SAT, with Mallard Pass Solar Farm being the first consented SAT solar farm NSIP. This is confirmed in the Examining Authority's report which states at paragraph 1.3.16 that single axis tracker arrays are one design option for that scheme. Further information on land take and single axis tracker arrays for the Mallard Pass scheme is available under "Scale" of the Examining Authority's report (beginning at paragraph 3.2.93) and under "The principle of the development" of the Secretary of State's decision letter, beginning at paragraph 4.18 of that letter.

5.1.2 West Burton Solar Farm, Cottam Solar Farm, Tillbridge Solar Farm, and Byers Gill Solar Farm also incorporate SAT and are currently in pre-examination, examination, recommendation, or determination stage. A comparison with these schemes is provided later in this note.

5.1.3 Paragraph 2.10.20 of NP EN-3 refers to SAT, saying "In order to maximise irradiance, applicants may choose a site and design its layout with variable and diverse panel types and aspects, and panel arrays may also follow the movement of the sun in order further to maximise the solar irradiance". This implies that SAT is acceptable in seeking to maximise generation from the PV panels at a given site.

5.1.4 Section 6.5 of the Statement of Need **[REP2-010]** discusses the technology selection, comparing SAT with FSF configurations. In summary:

a. FSF panels will generate a greater peak during the year than SAT.

b. "*It should be noted that generally: (a) SAT requires more land per MWp but has the potential to generate more MWh/MWp than FSF. (b) FSF requires more land per MWp but has the potential to generation more MWh/MWp than E-W."*

5.1.5 As inferred above, SAT does require more land than FSF to maintain adequate distances when the panels are horizontal and because field margins are typically greater (because each string of panels comprises 27 panels attached to a single motor and therefore is not as flexible as FSF where strings of panels are shorter). However, the Applicant has sought to maximise the renewable energy generation from the 400MW ac export agreement. NPS (for Renewable Energy) EN3 is clear that a developer should maximise renewable energy delivery and there is a strong need for energy in the UK. This is discussed in Section 2.12 of the Statement of Need **[REP2-010],** which says that "Urgent and unprecedented action is needed on an international scale to meet the commitments established through the Paris Agreement for urgent actions to decarbonise society and stop global warming".

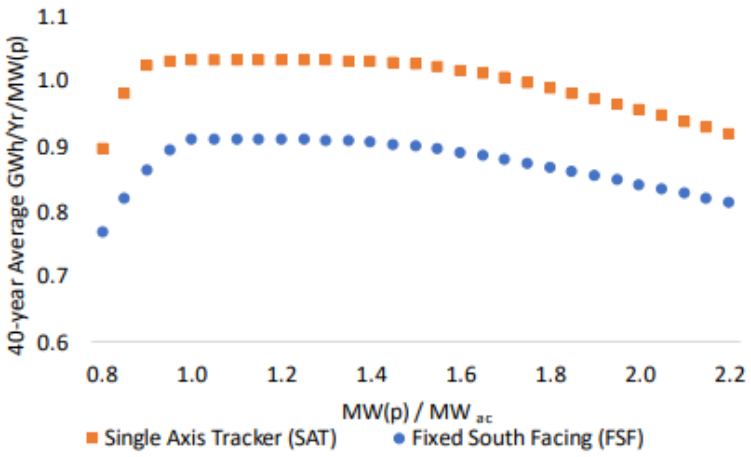
5.1.6 A SAT configuration generates more MWh/MWp than either FSF or fixed E-W configurations.

5.1.7 Figure 6-6 of the Statement of Need **[REP2-010]** is reproduced in Figure 3 and shows the 40-year average GWh/yr per MWp for both a SAT and FSF configuration at various levels of overplanting. It demonstrates:

a. An overplanting ratio of 1.2 is within the optimal design range for producing the maximum power per year as a ratio of the MWp.

b. SAT delivers approximately 15% more energy per year as a ratio of the MWp relative to FSF. In other words, SAT maximises the grid connection agreement by delivering more renewable energy over its lifetime. (Note, for the Scheme specifically, PVsyst shows SAT generates 12.3% more renewable energy than FSF for a 400MW ac export).

Figure 3: Illustrative comparison of energy generation per year as a ratio of the peak output for SAT verses FSF



5.1.8 The output from PVsyst shows:

a. A modelled 580Wp panel produces 591.0 kWh/yr in a FSF arrangement, verses 663.5 kWh/yr as a SAT. The FSF may have a higher instantaneous generation (dc) peak, but the SAT configuration produces 12.3% more renewable energy over a year.

b. If the Scheme had been FSF, the annual yield for the same number of panels would reduce by c12%. With the same number of panels, the SAT configuration yields 549,760,279kWh per year, compared with 489,764,661kWh per year from a FSF configuration (i.e. SAT will yield an extra 59,996,618kWh per year, or 12.3% more). This does not optimise the renewable generation potential of the grid connection agreement.

c. To offset the reduced yield, a FSF scheme would have had to incorporate 15% more panels (to make up for the 12.3% shortfall in yield), increasing the number of panels to c 972,000 (143,100 extra). This would introduce several new or elevated environmental impacts, such as the substantial increase in HGV deliveries, the large increase in onsite cabling and trenching, the need for more inverters and transformers which are the primary noise sources onsite and have embedded carbon (making the scheme more carbon intensive), coupled with a reduction in field margins and spacing which would lower the ecological benefits recognised in the BNG Assessment Report **[REP1-061].**

5.1.9 This supports the comment made in the Statement of Need **[REP2-010],** paragraph 7.6.14, which says "*SAT is currently preferred at the Scheme because of its enhanced MWh to MW ratio vs. FSF technology*".

6. Land Use Efficiency

6.1.1 The ExA queried whether the Scheme is an efficient use of the land during the ISH, referring to it using 6 acres / MW.

6.1.2 A response to the efficiency of the footprint of the scheme was provided ahead of the ISH in Section 1.5 of the Applicant's Responses to the ExAs Written Questions for D1 **[REP1-081]** in response to Q1.5.1: *"….Taking the total acreage of the Solar PV Areas within the Solar PV Site and excluding the buffer zones within these areas for fencing, public rights of ways, access, overhead lines and landscape and ecological mitigation and enhancement zones of 1836 acres and the total DC power of 480MW, this equates to approximately 3.83 acres per MW power output, which is within the range presented in paragraph 2.10.17 of NPS EN-3."*

6.1.3 During the ISH the ExA suggested that the ratio should be based on MW ac export and including the ecology mitigation land and grid connection corridor. This is discussed below.

6.1.4 Firstly, the Applicant is committed to as efficient use of land as possible; the Applicant intends to lease the solar PV land via the voluntary Option agreements in place. The Applicant also requires compulsory powers to ensure the delivery of the NSIP Scheme in the event that the voluntary Option agreements are not honoured or due to landowner insolvency or similar event (see paragraph 5.1.3 of the Statement of Reasons **[APP-021]),** as is the standard approach on all solar DCOs granted to date. As such, it makes economic sense to minimise the footprint of the Scheme to minimise the rent due under a voluntary agreement or any compensation liability. It is not in the interest of the Applicant to produce a Scheme that does not use the land efficiently. In addition, East Riding of Yorkshire Council as relevant local planning authority will have responsibility for approving the detailed design of the Solar PV site pursuant to Requirement 5 of Schedule 2 of the draft DCO which will include the layout and scale of the Scheme (see Requirement 5(1)(a) and 5(1)(b) respectively).

6.1.5 At the same time however, the Applicant needs to ensure that the Scheme is buildable, and therefore flexibility is incorporated into the application (and illustrative design layout). It is expected that in the next few years manufacturers will adapt to the UK market and introduce strings that incorporate fewer SAT panels per motor, allowing installation closer to field margins, and panels with higher Wp capacity; both these changes have the potential to substantially reduce the overall footprint of the Scheme. The Applicant has chosen to avoid introducing risk by basing the application on current technology, ensuring it is deliverable - this is a reasonable and prudent approach, basing the EIA on worst case parameters, and providing resilience in case the expected improvements in the panel technology are not available or viable at the point of procurement.

6.1.6 In terms of calculating the acres / MW, the Scheme comprises 8 distinct areas (referred to as Works No. 1-8), as follows:

a. Works No. 1: This is the maximum area within which solar PV and field stations can be installed and comprises 748.7 hectares (1850 acres). This is slightly higher than the 1836 acres referred to in the Applicant's Responses to the ExAs Written Questions for D1 **[REP1-081],** which

excluded buffer zones within these areas for fencing, public rights of ways, access, overhead lines.

b. Works No. 2: This is for the onsite substations and comprises 2.01 hectares (5 acres).

c. Works No. 3: This is for the high voltage 132kV electrical cabling connecting to the National Grid Drax Substation, which will be reinstated for agricultural use following construction. It comprises 261.1 hectares (645 acres).

d. Works No. 4: This is for general works as described in the Draft DCO **[REP1-006]** and therefore covers most of the area within the Order limits including the Grid Connection Corridor but excludes the operational and maintenance building, access and highways, and habitat management area (Works No. 6 – 8). It comprises 1016.4 hectares (2512 acres).

e. Works No. 5: This is for the construction and decommissioning compounds, which are located within the area covered by Works No. 1. It covers 27.6 hectares (68 acres) and can be built over with solar PV.

f. Works No. 6: This is for the operations and maintenance building. It comprises 0.3 hectares (1 acres).

g. Works No. 7: This is for access provision and includes offsite highways modifications. It comprises 14.0 hectares (35 acres).

h. Works No. 8. This is for areas of habitat management and comprises 126.5 hectares (313 acres). As mentioned below, the DCO decision for Mallard Pass Solar Farm - EN010127 – clarified that ecological mitigation and enhancement areas do not need to be considered when calculating the amount of land used by solar farms.

6.1.7 In preparing this submission, The Applicant has applied the approach that was agreed by the ExA and SoS for Mallard Pass Solar Farm which incorporates SAT configuration and presented an acres / MW ratio based on Works No. 1 and the MWp dc. This includes the buffer zones mentioned above for fencing, public rights of ways, access, and overhead lines.

6.1.8 Applying this methodology for the Scheme, this generates a ratio of 3.85, as follows:

a. 1850 acres / 480 MW dc = 3.85 acres/MW

6.1.9 The ExA's Recommendation Report for Mallard Pass Solar Farm - EN010127 – includes discussion on "output" at Paragraph's 8.2.84 onwards, including recognition that the acres/MW ratio can be reasonable based on Work No. 1. It says: "*This is based on the assumption, as argued by the Applicant, that the range is intended to include 'associated infrastructure' as stated but not mitigation and enhancement areas. It is noted that, if the whole of the Order Limits were to be included, then the ratio figure would be significantly higher, noting the extent of mitigation and enhancement areas required in this case. However, we consider that this could reasonably vary from case to case, based on the project specific circumstances*."

6.1.10 The Applicant does acknowledge however that Works No. 2, 6 and 7 are required to deliver the Scheme and are not available for agricultural use during the operation of the Scheme. Including these areas – although it does

include areas where there are offsite highway modifications which is not usually included in this ratio - generates a ratio of 3.94, as follows:

a. 1891 acres / 480 MW dc = 3.94 acres/MW

6.1.11 Both 3.85 and 3.94 acres/MW are within the guideline 2 – 4 acres per MW that is set out in NPS EN-3. Paragraph 3.10.8 of EN-3 also goes on the acknowledge that this range may vary significantly depending on the site. For example, a site with smaller fields, more hedges, or other environmental constraints will inevitably have a higher ratio.

6.1.12 The Applicant has compared the Scheme against other solar NSIPs consented or pending determination and confirms that they all fall within the suggested guideline range of 2-4 acres/MW. Other SAT projects that have been examined by the ExA (Mallard Pass Solar Farm, Cottam Solar Farm, and West Burton Solar Farm) range between 2.5 and 2.9 acres/MW. The Applicant has also reviewed Byers Gill Solar (EN010139) and Tillbridge Solar (EN010142) which are currently at pre-examination stage and also SAT configuration. Insufficient information exists in the application documents to accurately determine the land use ratio but based on the Works No 1 for solar PV for Byers Gill covering 1032 acres and an 180MWac grid offer (assuming it is overplanted by 1.3) gives a ratio of 4.4 acres/MW. Tillbridge Solar Works No 1 for solar PV covers a developable area of 1827 acres and has a connection offer of 500MWac (assuming 1.3 overplanting ratio), giving a ratio of 2.8 acres/MW.

6.1.13 The Decision Letter for Mallard Pass Solar Farm "*acknowledges that the Proposed Development is of substantial scale but not significantly larger in terms of acres per megawatt peak when compared with other solar NSIPs*". Ultimately the Secretary of State concludes that *"… the [Mallard Pass Solar Farm] Proposed Development will make a substantial contribution to the urgent need for utility scale solar PV…and therefore agrees with the ExA's assessment that there is an urgent need for the Proposed Development and attributes this matter substantial positive weight, inclusive of considerations relating to climate change."* The Applicant considers this summary applies also to East Yorkshire Solar Farm.

6.1.14 In summary, the Applicant considers that the Scheme adheres with NPS EN-3, has an appropriate level of overplanting, and uses a reasonable amount of land for the grid connection offer (within the 2-4 acre guideline outlined in NP EN-3), which maximises the renewable energy yield for the grid connection offer.