SUNNICA ENERGY FARM
DCO EXAMINATION

WRITTEN REPRESENTATION
ANNEX H – BATTERY ENERGY STORAGE SYSTEMS

SAY NO TO SUNNICA ACTION GROUP LTD
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PEBBEN LIMITED

Desktop study –

Review of Sunnica Battery Energy Storage System (“BESS”) under the Sunnica Energy Farm NSIP Application on behalf of Say No to Sunnica Action Group Limited

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This report has been prepared by Pebben based on documents from the Development Consent Order application by Sunnica Ltd (available on the Planning Inspectorate website), and information provided by Sunnica at public meetings which were relayed to me by parties who attended said meetings. . The documents reviewed were as follows:

SEF_7.6_Oultine Battery Fire Safety Management Plan
SEF_3.2_Explanatory Memorandum
SEF_ES_6.1_Chapter_3_Scheme Description
SEF_ES_6.2_Appendix_16D_Unplanned Atmospheric Emissions from Battery Energy Storage Systems
SEF_ES_6.1_Chapter 16 Other Environmental Topics
SEE ES 6.4 Non-Technical Summary

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Pebben makes no representation or warranty, express or implied, as to the adequacy, accuracy, completeness or reasonableness of any information contained within this report, save to say that the report was completed with due care based on the experience of Alex Dickinson, who has a long-standing history in the energy industry on a world-wide basis, reflecting his views of the development. Mr Dickinson is a BSc (Hons) Mechanical Engineer, with a background in electricity generation. Mr Dickinson has worked across the globe as designer, developer, M&A and performed due diligence on both renewable and non-renewable power generation assets which have been Project Financed with total project values in excess of US$2bn. Most recently, with the move to a low carbon economy in the UK, Mr Dickinson has worked on several renewable schemes including large scale BESS and grid support projects to enable the grid to accommodate more asynchronous generation. Mr Dickinson is independent of Sunnica Ltd and the Say No to Sunnica Action Group Ltd, and he has no conflict of interest. With regards to the Sunnica overall proposals, Mr Dickinson is a stanch supporter of England and Wales having a balanced energy portfolio to protect the environment and avoid financial hardships to consumers. To this effect, Mr Dickinson continues to work on and support all forms of renewable generation including solar, wind, waste to energy, biomass, anaerobic digestion, hydrogen, battery storage and grid support services.

1. INTRODUCTION

1.1. Sunnica Limited (company number 08826077) submitted a planning application to the Planning Inspectorate on 18 November 2021 for the Sunnica Energy Farm (application reference EN010106) which comprises of a large-scale solar farm and the associated development of a Battery Energy Storage Scheme ("BESS"). It should be noted that a solar farm with an installed capacity of over 50MW would be evaluated from a planning point of view under the Planning Act 2008, whereas a large-scale BESS would usually fall outside of NSIP and be considered, from a planning point of view, by the local authority. This would be the case *unless* the BESS is an integral part of the generation application in which case it is considered as associated development and evaluated at the same time, and on the same basis, as the generation scheme. The actual installed capacity of the scheme is unclear as reference is made to 500MW, which implies AC as per the 500MW grid connection, as well as 500MWp which is DC. There is a loss of 20% of energy when converting via an inverter from DC to AC and so the actual size of the PV solar farm should be explicitly declared.

1.2. The scale of the proposed solar farm and the significant opposition due to its scale and impact on the locale is not considered in this report. However, the Say No to Sunnica Action Group contacted Mr Dickinson to ask for comments on the scale, need and dependence on the solar farm on the BESS portion of the scheme. By means of background Pebben Limited has assisted in the development of large-scale BESS in England and Wales, and is familiar with environmental impact, risk and protection and commercial operation of the majority of BESS providers within the UK, as well as the need for BESS to support the grid in its transition towards mainly asynchronous generation as the country drives towards a low carbon economy.

2. BESS AND SOLAR AS JOINT DEVELOPMENT

2.1. As is commonplace, particularly on small, sub 50MW schemes, Sunnica have linked the solar farm development with the BESS project. The question remains as to whether the BESS is an associated development or a stand-alone development which should be considered under its own planning application. I have been directed to the applicable guidance on associated development in writing this paper.

2.2. Solar farms have a generally accepted availability of 11% meaning that the output compared to installed capacity and hours in the year is at 11%. The 11% is the accepted level of applicable daylight hours across the year to produce the full output, or Full Load Equivalent ("FLE") of installed capacity verses output. The actual output will vary, depending on daylight hours, cloud cover, etc and so the solar farm will be producing for more than 11% of the time, just not producing at full load. Hence the FLE of 11% is used when evaluating solar schemes. Specifically to the Sunnica case, a 500MW solar farm generated 500 x 0.11 x 8760 = 481,800MWh per year; about the same as a 60MW thermal power plant such as gas, waste or biomass which has an actual availability of around 92% with limited output reduction due to weather (60X8760X0.92 = 483552MWh per year).

2.3. In principle, BESS can be directly related and subordinated to an electricity generating scheme if the design is such that over capacity of the solar farm is installed with the intent to charge the batteries whilst also exporting electricity to the grid. Similarly, this could also occur if there was the potential that the electrical distribution system could become overloaded with generation (periods of low demand, alternative generation 'having to run' for security of supply) and the grid selected to 'constrain the Solar production off' (i.e. ask the solar farm not to export due to constraints on the supply network), then having the BESS to utilise this electricity by storing it at times of generation without access to the electricity network, and releasing it at times of no generation but network availability (winter evening peak hours for example) would indicate that the BESS was directly related to the solar farm and subordinate to the main development's use as an energy generation asset. However, as limited details of the electrical connection agreement have been provided other than it being capable of both import and export, it would suggest that the large scale (500MW) import connection is there to allow the BESS to operate independently of the solar farm, and neither supports the construction or operation of the solar farm, but simply utilises a common connection for commercial purposes.

2.4. A major cost in the development of any generation scheme is the cost of electrical connection. Being able to utilise this over a longer period would significantly benefit the overall scheme's financial viability (as this cost would then be spread over a longer period, lowering the impact on a cost per MWh basis). Installing BESS alongside solar provides this financial benefit as the connection is available (under usual circumstances) 24/7. The solar may only be utilising it for say 8 hours per day (still considerably longer than the FLE of 2.64hours) and the BESS could then utilise it for the remainder. The details of the BESS are not provided but it is likely that they will be C2 Batteries (see paragraph 4.2 below) which means they can discharge for 2 hours and be charged in 2 hours, therefore a cycle can take 4 hours. Therefore it could conceivably utilise the electrical connection for 4 cycles or, for 16 hours compared to the Solar only 8-hour use. In this instance, the BESS is simply utilising shared infrastructure, the electrical connection, and does not enhance the construction or operation of the solar farm as would be expected of an associated development.

2.5. Any grid support contracts specifically linked to the BESS, such as any capacity market contracts, dynamic containment contracts, inertia, etc would also demonstrate if the BESS were linked to the solar or being operated as a stand-alone venture, however no such details have been provided.

2.6. I have considered the description for the BESS in the Sunnica scheme. It would appear all sites are proposed to have the capacity to import and export electricity from the grid (the electrical connection is for 500MW import and 500MW export. This allows the Batteries to be charged using power from the grid, presumably at low prices, to then be stored and subsequently discharged to the grid at times of higher prices). This strongly suggests that the intention of the BESS design is to operate as a stand-alone asset rather than import (or charge) directly from the solar farm and is not to enhance and ensure the renewable generation asset of the solar farm. This view is supported by the standard electrical connection agreement provisions which are sized for export (i.e. generation) with very little import capacity. Most power stations have an export capacity to meet its installed capacity for generation, with a small (5%) import capacity. The purpose of the imported electricity is to provide power for essential services (safety monitors, control systems and maintenance activities) when the plant is not generating its own power. The fact that the electrical connection can import 500MW suggests that the BESS is, in fact, a stand-alone commercial venture which should be considered on its own merits by the proper planning legislation for such a scheme.

2.7. I understand that Sunnica Ltd say that importing electricity is only one of the features of the BESS, and that the storage is still needed *primarily* to support the energy generation of the PV cells. This could be true, if the circumstances are that the BESS is infrequently or rarely used for uses other than supporting the electricity generating part of the scheme. If this were the case however, why would a 500MW import facility, on the same availability as the export connection facility, be required? A trickle charge solution would be more cost effective. To consider this further we need to look to the capacity of the BESS, the generation capacity of the solar and how these relate to the export capacity of the grid connection. This is something I consider below.

3. BESS TECHNOLOGY, RISK AND RISK MITIGATION

3.1. The NSIP application is mute on the BESS technology selected and is also mute on the precise size of the development. However, Chapter 3 of the EIS, Scheme Description, does provide some insight into the BESS design, stating that the BESS will be containerised (15 x 5 x 6m high) with foundation pads possibly piled depending upon ground conditions and lithium batteries arranged in racks protected by structures/containers inside a compound with containers/structures having automatic water/mist fire-fighting systems, with a maximum of 242.5m³ water storage in external tanks. The fire water will be captured in bunded tanks and fed to a bunded lagoon for storage and presumably off-site disposal. The bunded storage will be 410m³. None of these facts provide any indication whatsoever as to the installed and operational capacity of the scheme, or the suitability of the risk mitigation factors.

3.2. This chapter also references that a "Rochdale Envelope" permission is required as detail is not known at this stage. This is a common practice to maintain a competitive, commercial approach to battery selection and should not be dismissed (too much detail of the preferred battery selection could essentially have the developer, Sunnica, held to ransom by that particular manufacturer and so the approach is quite normal to ensure a competitive edge in supplier selection can be maintained). However, whilst retaining value on the selected technology, more detail should be provided as to the size etc. of the development. This is discussed in the following section 4 Capacity of BESS.

3.3. In Appendix 16D, Unplanned Atmospheric Emissions, paragraph 1.2.2 references the battery type has not yet been selected, (Lithium iron phosphate or Nickel Magnesium Cobalt), that cells will be separated by thermal barrier and the racks will be housed in the aforementioned metal containers. When considering the options for the Battery chemistry, both have merits and disadvantages and driven by different costs, depending on the prevailing market for the raw materials. Whilst I am not qualified to comment on the most suitable chemistry, I can comment that Nickel Magnesium Cobalt is accepted as more energy dense storage, therefore there is potential to store even greater capacity within the same footprint. Section 2 of this appendix then goes on to model potential source of emissions to air from a battery fire. The hazard assessment selected was the Fire Protection Research Foundation ("FPRF") for BESS up to 100kWh in size, referencing that they may be greater than this in size but are modular and so the modelling works. This indicated that outdoor BESS burned for 3.7 hours with no fire suppressant. This is only correct is there is fire break spacing (at least 6m) between 100kWh modules. Such spacing is unlikely to be accommodated within the area however, lack of detail on the application does not allow this to be properly considered

3.4. Paragraph 2.1.7 then goes on to explain that a typical container could house 35 racks with fire retardant separation, and states that with no suppression total hydrogen fluoride of 2.07kg could be produced from five racks, i.e. below health guideline limits. Furthermore, it says that methane, carbon monoxide and chlorine are not considered further as these too will not cause elevated concentrations at receptors.

3.5. Paragraph 2.2.4 then provides criteria for hydrogen fluoride concentrations on a conservative basis without reference back to the stated 3.07kg in paragraph 2.1.7.

3.6. Paragraph 3.2.1 then also assumes a conservative limits of 1 µg/m3/s for modelling using the ADMS model for air dispersion to again show that there is no potential risk to public health. All estimates are justified by the developer on the basis that detailed emission rates will not be known until detailed design has taken place.

3.7. There is also an outline Battery Fire Safety Management Plan, Volume 7. This document makes reference to potential indoor or outdoor BESS systems in table 2, however this appears at odds with the rest of the EIS which refences only outdoor installation (albeit in Containers). It should be noted that the fire properties and protection required for indoor compared to outdoor vary, and so the Fire Safety Management Plan should be specific to the installation. This appears to be the intent of Sunnica who reference in paragraph 2.3.5 that a Fire Safety Management Plan will be issued for approval by the relevant bodies, and based on the outline FSMP provided, should planning be granted.

3.8. In this report the operational risk matrix has been considered, as this is the area which gives most concern to the general public. Risk of overheating which can be caused by incorrect operation, and so essentially events 4, 5 and 6 in the table, are given a low probability post mitigation in order to give a low overall risk. The mitigation measures are essentially RMM 01, 02, 03, 10 and 21.

3.9. Briefly summarising; RMM01 is the installation of thermal barriers between cells, the responsibility of the manufacturer; RMM02 is the instalment of correctly rated switches and circuits, again the responsibility of the manufacturer; RMM 03 is to have the electronic boards which avoid fire contamination, again the manufacturers responsibility; RMM 10 is to have fire detection, protection and notification equipment installed, again the responsibility of the Manufacturer.

3.10. In short, Sunnica's approach appears to place all critical safety aspects onto the manufacturer by specifying thermal barriers as key fire mitigation, to have automated sprinkler/mist system in the containers, and to collect any water from the sprinkler system in adequately sized sumps. They have also advised that they will adhere to a 6m spacing to prevent thermal runaway spreading from one container to other containers (although the actual layout is not provided therefore what is, and is not, separated is not clear). No mention has been made to the 10m recommended separation of transformers.

3.11. It appears therefore that the potential for thermal runaway is recognised, and in Sunnica's view is a low probability, therefore giving an overall low scoring. If therefore the unlikely scenario does occur, it would appear that one option being considered is to simply let it burn out.

3.12. A thermal runaway fire can last for 48 hours or longer. Six meter spacing of units is the common practice however this is not usually the separation between individual containers, but rather groups of containers and is usually a requirement of insurers to limit the potential loss of any one incident (i.e. if there are 8 containers grouped together and one develops thermal runaway, then the overall loss is limited to the 8 containers as there is then a 6m fire space to the next group of 8 containers). Whilst this approach may satisfy the insurers, I would be surprised if it satisfied local residents who would be subject to witnessing the fire, whilst the local fire brigade sought water source in a remote location to try and prevent further spread and cool the containers to lower the risk of thermal runaway as there is no fire hydrant ring proposed in the development.

3.13. The EIS does prompt questions which should be asked as to why more detail cannot be addressed at this time. Far more detail is available than references specifically aimed at large scale BESS and should be addressed by Sunnica in any application, either as an associated development of which it does not seem to meet the criteria or as a stand-alone commercial development seeking planning permission through the Town and Country Planning Act. These include:

a) Why has the Orsted Liverpool fire risk and evaluation not been considered?

b) Why have the leading BESS fire prevention standards, UL 9540 and BS EN 61936, not been used as reference points for fire prevention in BESS and transformers?

c) Why has the now common place dry automated outdoor rack suppression been considered rather than water sprinkler/mist?

d) Given the water tanks and collection sumps have been sized, it is clear that Sunnica must have an understanding as to how many containers this volume is to service. Why has this number not been declared?

e) The statement that fire water will be collected recognises that there is potential for contamination of the fire water. The collection is via sump and then bunded lagoon, however the lagoon will not know if the water in it is collected fire water or rainwater. How will Sunnica ensure such a lagoon does not overflow and thus potentially contaminate ground water?

f) As can be seen from the Liverpool fire and other thermal runaway tests and observations, if thermal runaway occurs then the fire can last for up to 48 hours with the typical method of reducing this being water cooling. The volumes of water referenced are for the automated sprinkler/mist systems. What is the source of cooling water and proposed collection method if thermal runaway does occur?

3.14. The above-referenced questions are key environmental and health potential impacts and should be addressed in the application and not hidden within the Rochdale envelope approach.

4. CAPACITY OF BESS

4.1. The documentation references 3 BESS sites within the 4-site solar development, specifically:

- 66,000m² East A (6.6Ha)
- 162,000m²East B(16.2Ha)
- 83,000m²West A (8.3Ha)

There is no proposed BESS at West B.

4.2. The papers I have seen do not tell us the capacity that will be installed at each of these BESS sites and, as mentioned above, the differing battery chemistries also offer different energy density of storage. As Lithium ion is the more common place, I have limited comparisons to this chemistry. Typically, the outdoor racks (or containers) would be grouped into 6 or 8 blocks with 6m spacing between blocks and 10m spacing from the transformers This spacing provided fire breaks (gaps to prevent the fire spreading should a fire event occur) and is the generally acceptable level of potential loss from an insurance point of view. (i.e. Insurers will offer insurance with acceptable excess levels where the potential fire loss is limited to 8 blocks, therefore the remainder of the asset can continue to operate post fire event, and lower replacement costs are needed for the limited replacement) making loss and lost revenue insurance more readily available. In these circumstances, typically 50 MW capacity can be located on 1ha. This implies that East A could accommodate 330MW, 810MW on East B and 415MW on West A. This obviously depends on the sub-station and connection arrangements but implies a potential of 1555MW BESS capacity could be accommodated, or even greater if Nickel Magnesium batteries were used. Neither is there clarity on what type of BESS is proposed in terms of discharge time of discharge. The original commercial BESS plants only had 30 minutes discharge, and are now referred to as C0.5. Developments then saw an increase to 1 hour (now C1) and the now common 2 hour (C2) with proposals from some manufactures to develop 3- and 4-hour discharge rates (C3 and C4). It is probable that C2 Batteries are proposed, and so a C2 S00MW BESS would have a supply of 1000MWh per charge and discharge cycle

4.3. As paragraphs 2.4 and 2.5 above reference, in a freestanding BESS scheme commercial drivers typically have the BESS sized to meet the electrical connection. This is to maximise the use of (and therefore the value obtained from) the connection. However, in circumstances where the BESS is connected to a generating scheme the situation is more complex. In Sunnica's case there appears to be only one reference to the connection capacity (being 500 MW, in the summary to the Statement of Need, p.3). On the basis of the lack of information I have considered the following :

4.3.1. The most likely scenario is that the electrical connection is driven by the peak generating capacity of the solar installation. That would give a connection of 500MW AC (in line with the Statement of Need). Solar is only 11% available throughout the year in the UK (based on accepted sunlight hours) giving an 89% non-solar use possibility. The BESS could be 3 times the capacity of the connection if indeed the 1555MW capacity above is installed. If the solar utilised the connection for say 12 hours summer and 8 hours winter, but was only at peak load for 4 and 2 hours respectively as the sun is not providing full utilisation of the entire array for the entire daylight hours available, the BESS could commercially utilise the connection outside of this period. Certainly allowing 1 cycle (2-hour charge and 2-hour discharge) in the summer and so there is the potential for the BESS capacity to be three times that of the solar at 1555MW and commercially exploiting the connection for the 12 hours summer (3 times 2 hour charge, 2 hour discharge) non solar use. With this potential increasing in the winder months. With the BESS being 3 times the capacity of the solar this is possible, with the BESS potentially at 1555MW being charged for 6 hours overnight, and then discharged throughout the day at varying loads as economics dictate. As there is no definition of the BESS installed capacity we simply don't know.

4.3.2. A second scenario could be the electrical connection is non-firm and therefore liable to be interrupted by grid. This is most unusual at 400kV but possible at 132kV, depending upon other generation connected within the system and the demand (consumers) on the system needed for balance. In this situation, to allow the solar to be fully utilised, it would need the BESS so that it could charge the BESS if constrained off (prevented from supplying to the grid) during daylight hours, and the BESS then supplying when the system became available for connection but there was no, or limited sunshine. This then would certainly mean that some BESS was associated development however, as the actual installed capacity of the BESS is not defined, the level of potential associated development is unclear. The Solar is 500MW AC (600MWp) and its production is weather dependent, it can only charge up to 500MW AC of BESS and therefore why have the potential for a BESS installation over 1500MW? If the primary driver for the BESS is to utilise solar production, then the BESS should be defined as 500MW capacity and the rationale behind a 500MW connection import requirement explained.

4.3.3. Having associated development for the BESS is more energy efficient, but again lack of detail prevents this being considered properly. A 500MW connection allows for 500MW AC to be supplied to the grid. The solar PV generates electricity in DC. To convert this to AC the power passes through invertors, which have about a 20% loss factor, therefore the installed capacity of the scheme would need to be 600MWp or DC in order to supply at 500MW AC. As the BESS is also DC, there is an energy efficiency in charging the BESS directly from the solar, as it does not need to lose the 20% losses in the invertor or the similar 20% losses in the rectifier to chare the DC Battery. The capacity of a solar generating station, as addressed by the solar media webinar addressing the 50MW planning limit, is the installed and not the export capacity. This is regardless of whether it is AC or DC as it is capacity and thus it states that the 'sweet spot' for solar development is 49.9MWp DC. The Sunnica application appears to be for a 500MW solar scheme. This would suggest that the installed capacity is 500MWp and so it is only capable of exporting 400MW AC, yet it has a 500MW connection. The additional 100MW of connection capacity gives greater flexibility to the BESS, particularly if the potential 1555MW of BESS capacity is installed and so again indicates that the economic drivers of the BESS sit outside of any potential link to the solar installation.

4.4. These potential conclusions suggest that the capacity of the BESS is way out of proportion to the generating capacity of the scheme and the grid connection capacity. There is simply not the power being generated by Sunnica to be stored. This indicates that the BESS would primarily be used for buying and selling externally produced power and adds weight to the argument that the BESS development is a stand-alone commercial venture.

4.5. It should also be noted that the actual discharge/charge regime of the BESS has not been disclosed. As referenced above, current BESS are generally C2 rated, meaning they can discharge for 2 hours, compared to older BESS which could only discharge for 1 hour (C1). There are also developments for longer discharging batteries.

4.6. Batteries can be charged quickly (essentially similar to its discharge rate), or trickle charged more slowly. A charge and discharge is a cycle. If the batteries were simply there to support the solar farm and take charge from the solar when it was constrained off, the batteries would be sized on that basis and utilised on an infrequent basis, offering little economic value. However, as these batteries are connected to the grid for charge and discharge purposes, with the possibility of being 3 times the solar capacity, they can be cycled as economics demand.

4.7. Batteries will degrade whether used or not, but the more they are cycled the more they will degrade. Degradation starts immediately, however batteries have a useful, safe life until they are down to about 65%-70% of initial capacity. Typically, a battery which is only cycled once per day will last for 15 years before it degrades to 65%, if cycled twice a day on average then this lifespan reduces to circa 12 years. This is obviously subjective to the actual operation of the BESS however it does show that, for a 40-year lifetime span, each battery cell will need changing at least two times.

4.8. The EIA chapter 16, paragraphs 16.7.16 and 16.7.17 states that operational waste will have to be discarded but that such waste arisings are expected to be minimal. Having to replace the entire batteries at least twice during a 40-year lifespan cannot be considered minimal and must be taken into account in the operation phase.

5. CONCLUSION

5.1. There are many features in the Sunnica scheme where lack of detail indicates and supports that the BESS included within its application is a stand-alone commercial venture with little or no reliance on the solar facility. The BESS and electrical connection has the capacity to import and store energy. Indeed, Sunnica Ltd in its own documentation indicates that the BESS will be used at some point to do this. The importation and storage of energy, or any other form of arbitrage, is not at all related to the solar generation part of the scheme. The same can be said of a number of the other features where Sunnica say the BESS can be used (e.g. grid balancing). This is all indicative that the BESS and the generation are separate and distinct commercial entities.

5.2. On this basis, it appears to me that the BESS is an independent project which seeks to utilise any remaining capacity in the grid connection. It is located adjacent to the solar scheme to improve the financial performance by maximising the use of the electricity connection from circa 11% which reflects the average power output of solar, by up to 60%for a 2 cycle per day (2-hour charge, 2-hour discharge) 1500MW BESS operation.

5.3. Given the relative merits of this electrical connection utilisation, this suggests that the BESS is the predominant source of economic gain. It is hard to see the BESS as anything other than its own aims which is neither directly related to nor subordinate to the electrical generating capacity of the solar panels.