

Post-Hearing Submission (ISH2: Ecology and Biodiversity): Dr Edmund Fordham

Dated: 16th December 2022

Annexes EF36 and EF37 uploaded separately

THE PLANNING INSPECTORATE

EN010106 – Sunnica Energy Farm

**APPLICATION BY SUNNICA Ltd for an Order Granting Development Consent
for the Sunnica Energy Farm Project pursuant to The Planning Act 2008**

To the Examining Authority (ExA)

POST-HEARING SUBMISSION: ISH2: Ecology and Biodiversity

Eurlng Dr Edmund John Fordham MA PhD CPhys CEng FInstP

Interested Party – Unique Reference: 20030698

Please note:

1. These comments are being submitted as required by Deadline 4 (16 December 2022). They are confined to questions of local micro-climate changes caused by the presence of large acreages of solar PV panels.

SUMMARY

A thorough evidence-based appraisal of changes in the local microclimate consequent on the very large acreages of solar PV arrays is critical to any complete appraisal of the effects of the scheme on local Ecology and Biodiversity.

No such Appraisal has been provided.

Comments at ISH2

1. My principal comment at ISH2 (Ecology and Biodiversity) was that no account has been taken of changes to the local microclimate caused directly by the presence of large acreages of solar PV arrays. It has been established in the technical literature since at least 2016 (from actual measurements) that such changes do occur, both in air temperatures, soil temperatures, and humidity measures, changes seen both in diurnal variations and in seasonal variations.

Annexed papers

2. Two scientific papers were cited at the ISH2 and are Annexed hereto by request of the ExA.

Reasons for changes in microclimate

3. There are obvious reasons why this might occur, requiring no more than the principle of Conservation of Energy to understand. Solar PV arrays are black (and not green) and dark colours are well-known to be good absorbers of visible and infra-red radiation. It is inevitable that any efficient solar PV cell will be black in colour.

However, solar PV cells are not very efficient. Once again, the Applicant has failed to state any Efficiency figure, although a definite value must have been used, in conjunction with a solar model, to make the estimates for lifetime energy output claimed. One question the ExA could usefully ask is: what Efficiency for the solar PV cells has been assumed in the energy output estimates ?

At the time of the famous book by the late Prof Sir David MacKay FRS¹, efficiencies for commercial cells were around 10%. Making the generous assumption that efficiencies of commercial solar PV cells are now around 20%, this means only 1/5 of the incident solar radiation is converted to useful electricity. Whilst some incident radiation may be reflected, the black colour means that the reflected fraction is likely to be small. Hence up to 80% of the incident solar radiation remains, and can only go into making the panels hot.

These are of course indicative values only, but one must accept that the solar energy going into heating the cells will be several times the useful electric energy output.

4. With huge acreages of solar cells, the claimed maximum output power of 500 MW on a bright summer's day could thus imply around 2000 MW (2 GW) of solar radiation converted to heat in the panels.

¹ *Sustainable Energy: Without the Hot Air*. D J C MacKay (2009) UIT Cambridge Ltd

5. This may be significantly larger than the heat generated by solar energy incident on the ground *before* the panels were installed, because of the dramatic change in colour. If the land was covered in green grass or crops before being panelled over, it will now be largely black. (It is ironic that a scheme claimed to be “green” in reality would convert land from actually green, to black).

In technical language, the surface albedo has been changed.

6. The “Urban Heat Island” (UHI) effect is a direct consequence of the above considerations. The UHI effect is now very well-established in micrometeorology with major cities (London being the classic example) having a microclimate typically several degrees warmer than surrounding countryside at the same latitude. There is no reason not to expect similar effects above, under, between, and for a significant distance outside, the solar PV arrays.

Effects on Ecology and Biodiversity

7. The annexed papers report highly significant changes in soil and air temperatures, and humidity measures, all dependent on locations above, under, or between the solar PV arrays.

8. It is inevitable that this will affect germination and plant growth, and may tend to favour an entirely different biome, certainly in respect of plant life, with knock-on consequences for insect and animal life dependent on the local flora.

9. A rational ecological evaluation is seriously incomplete unless the local microclimate changes are fully evaluated, together with an evaluation of the consequences for the local flora and fauna.

10. No such analysis has been provided by the Applicant. Any appraisal of effects on Ecology and Biodiversity is critically incomplete until such an analysis is done.

11. In particular, unless and until the lateral extent of microclimate shifts is established, no appraisal can be made of the effect of local microclimate shifts on the Ramsar-designated wetlands in close proximity to the solar PV areas.

These are highly sensitive areas and must be expected to suffer significant harm if the ecological balance of local flora and fauna is disturbed by shifts in the micro-climate.

12. A thorough evidence-based appraisal of the likely changes in microclimate, and their spatial extent, consequent on the very large acreages of solar PV arrays, should therefore be provided.

(753 words)

EJF 16/12/22

Glossary, and updated list of Annexes referred to follows; Annexes uploaded separately

GLOSSARY

Abbreviations used in the interests of brevity.

Legislation and statutory permissions:

CLP	– the Classification, Labelling and Packaging Regulation
COMAH Regs 2015	– the Control of Major Accident Hazards Regulations 2015
CQ	– Controlled Quantity (of a HS as defined in P(HS)Regs 2015)
DCO	– Development Consent Order
dDCO	– draft Development Consent Order
HS	– Hazardous Substance (as defined in the Schedule to P(HS)Regs 2015)
HSC	– Hazardous Substances Consent
PA 2008	– The Planning Act 2008
P(HS)A 1990	– The Planning (Hazardous Substances) Act 1990
P(HS)Regs 2015	– The Planning (Hazardous Substances) Regulations 2015
QQ	– Qualifying Quantity (of a “dangerous” substance) in the COMAH Regs 2015; similar to CQ in the P(HS)Reg 2015
S or “S”	– any “substance used in processes” which on its own or in combination with others may generate HS defined in Parts 1 or 2 of the Schedule to the P(HS)Regs 2015
Seveso	– the “Seveso III Directive” 2012/18/EU of 4 July 2012
UN MTC	– United Nations Manual of Tests and Criteria

Direct quotations from legislation are shown in blue

Policy documents:

NPPF	– National Planning Policy Framework
NPS	– National Policy Statement
EN-1	– Overarching National Policy Statement for Energy (EN-1)

Direct quotations from policy documents are shown in magenta

Competent authorities:

CA	– COMAH Competent Authority
DHCLG	– Department for Housing Communities and Local Government
EA	– Environment Agency
ECDC	– East Cambridgeshire District Council (LPA)
ExA	– Examining Authority
FRS	– Fire and Rescue Service
HSA	– Hazardous Substances Authority
HSE	– Health and Safety Executive
HSE(NI)	– Health and Safety Executive for Northern Ireland
LPA	– Local Planning Authority
SoS	– Secretary of State
WSC	– West Suffolk Council (LPA)

GLOSSARY (cont.)

Parties:

- Sunnica – the Applicant, or the proposal under Examination
SNTSAG – Say No To Sunnica Action Group Ltd (continued)

Documents

- OBFSMP – Outline Battery Fire Safety Management Plan
BFSMP – Battery Fire Safety Management Plan
LIR – Local Impact Report

Technical:

- BESS – Battery Energy Storage System(s)
Li-ion – Lithium-ion
M-factor – Multiplying Factor used for certain substances Toxic to the Aquatic Environment in eco-toxicity classifications
SoC – State Of Charge of cells, usually given as percentage, between fully charged (100%) and completely discharged (0%)
STEL – Short Term Exposure Limit, i.e. limiting allowed concentration for short-term exposures (typically 15 minutes)
VCE – Vapour Cloud Explosion
IUPAC – International Union of Pure and Applied Chemistry
GCMS – Gas Chromatography Mass Spectrometry
CAS – Chemical Abstracts Service, maintains a catalogue of unique chemical substances with reference numbers
IDLH – Imminent Danger to Life and Health
AEGL-3 – Acute Exposure Guideline Levels
SLOT – Specified Level of Toxicity
SLOD – Significant Likelihood of Death
UHI – Urban Heat Island

Chemical substances:

- CH₄ – Methane
C₂H₄ – Ethylene
C₂H₆ – Ethane
CO – Carbon Monoxide
CO₂ – Carbon Dioxide
Co – Cobalt (as metal) (not to be confused with CO)
CoO – Cobalt (II) Oxide
Cu – Copper (as metal)
CuO – Cupric (or Copper (II)) Oxide

Cu ₂ O	– Cuprous (or Copper (I)) Oxide
H ₂	– Hydrogen
HCN	– Hydrogen Cyanide
HF	– Hydrogen Fluoride
Mn	– Manganese (as metal)
MnO	– Manganese (II) Oxide
Ni	– Nickel (as metal)
NiO	– Nickel Monoxide
ONiO	– Nickel Dioxide
Ni ₂ O ₃	– diNickel triOxide
POF ₃	– Phosphoryl Fluoride

Li-ion cell types:

NMC	– Nickel – Manganese – Cobalt; a popular Li-ion cell type, with cathodes based on complex oxides of those elements
LFP	– Lithium – Iron [chemical symbol Fe, hence “F”] – Phosphate; another type of Li-ion cathode chemistry
LCO, NCA, LATP	– other cell cathode chemistries mentioned in text
LMO	– Lithium Manganese Oxide
LNO	– Lithium Nickel Oxide

Measurement units:

GW	– gigawatt, or one billion watts, or one thousand megawatts
MW	– megawatt, or one million watts, a unit of <i>power</i> , i.e. <i>rate</i> of transfer of <i>energy</i>
MWh	– megawatt- <i>hour</i> , or one million watt-hours, a unit of <i>energy</i> e.g. the <i>energy</i> transferred by a <i>power</i> of 1 MW acting for 1 <i>hour</i>
m ²	– square metre (area)
ha	– 1 hectare = 10,000 m ²
MWh ha ⁻¹	– energy storage density (on the land) in the BESS compounds, as MWh energy storage capacity, per hectare of land allocated
MWh / tonne or MWh tonne ⁻¹	– energy density of the BESS cells themselves, as MWh energy storage capacity, per tonne of cells
Wh / kg or Wh kg ⁻¹	– energy density of the BESS cells themselves, as Wh energy storage capacity, per kg of cells 1 MWh / tonne = 1000 Wh / kg
mg / Wh or mg (Wh) ⁻¹	– gas generation from cells in failure, in milligrams gas per watt-hours of energy storage capacity
tonne	– 1 metric tonne or 1000 kg or 1 Mg
µg m ⁻³	– trace concentrations of highly toxic gases, in micrograms of toxic contaminant per cubic metre of air

List of Annexes referred to: –

Post-Hearing submission: ISH2
of Dr Edmund Fordham
(dated 16th December 2022)

EF1 – Personal details

EF2 – “Safety of Grid Scale Lithium-ion Battery Energy Storage Systems”
by E J Fordham (Interested Party), with
Professor Wade Allison DPhil and
Professor Sir David Melville CBE CPhys FInstP

EF3 – “Hazardous substances (Planning) Common Framework”
CP 508 Presented to Parliament by the SoS for DHCLG August 2021

EF4 – Directive 2012/18/EU of the European Parliament and of the Council
on the Control of Major-Accident Hazards involving dangerous substances
commonly known as the “Seveso III Directive”

EF5 – The Planning (Hazardous Substances) Regulations 2015

EF6 – Explanatory Memorandum to the P(HS)Regs 2015

EF7 – The Planning (Hazardous Substances) Act 1990

EF8 – Overarching National Policy Statement for Energy (NPS EN-1)

EF9 – Speech of Dame Maria Miller MP, House of Commons, 7 September 2022
Hansard, (House of Commons) Volume 719, Columns 275-277

EF10 – Battery Storage Guidance Note 1: Battery Storage Planning. Energy
Institute, August 2019, ISBN 978 1 78725 122 9

EF11 – D. Hill (2020).
“McMicken BESS event: Technical Analysis and Recommendations”
Technical support for APS related to McMicken thermal runaway and
explosion.
Arizona Public Service. Document 10209302-HOU-R-01
Report by DNV-GL to Arizona Public Service, 18 July 2020.

EF12 – Underwriters Laboratories incident report into McMicken explosion

EF13 – (5 items) News items and English translation from Chinese of official
accident investigation into April 2021 BESS fire and explosion in Beijing

EF14 – (3 items) Reports from Merseyside Fire and Rescue Service into September
2020 BESS fire and explosion in urban Liverpool

EF15 – Larsson *et al.* (2017), *Scientific Reports*, **7**, 10018,
DOI 10.1038/s41598-017-09784-z

- EF16 – Paper with Professor Sir David Melville CBE: “Hazardous Substances potentially generated in “loss of control” accidents in Li-ion Battery Energy Storage systems (BESS): storage capacities implying Hazardous Substances Consent obligations.
- In public domain on *Research Gate* preprint server
DOI 10.13140/RG.2.2.35893.76005
- EF17 – Golubkov *et al* (2014) *RSC Advances* DOI 10.1039/c3ra4578f
- EF18 – Research Technical Report by *FM Global*: Flammability characterization of Li-ion batteries in bulk storage”
- EF19 – Bergström *et al* (2015) Vented Gases and Aerosol of Automotive Li-ion LFP and NMC Batteries in Humidified Nitrogen under Thermal Load
- EF20 – (2 items) Victorian Big Battery Fire, July 2021. Report of technical findings. Also compendium of news items with aerial photography.
- EF21 – (2 items) Letter from Commissioner Sandra D. Kennedy, Arizona Public Service Company, August 2019, regarding McMicken explosion.
- Also letter with Fire Department report into earlier 2012 BESS fire with eye-witness reports on flame length.
- EF22 – Technical Memorandum from Golder Associates re composition of BESS at Kells, Northern Ireland
- EF23 – Ouyang *et al.* (2018), *J. Thermal Analysis and Calorimetry*, DOI: 10.1007/s10973-018-7891-6
- EF24 – Essl *et al.* (2020), *Batteries*, **6**, 30 DOI: 10.3390/batteries6020030
- EF25 – Chen *et al.* (2020), *J. Hazardous Materials*, **400**, 123169
DOI: 10.1016/j.jhazmat.2020.123169 (Citation only: article copyright)
- EF26 – Held *et al.* (2022) *Renewable and Sustainable Energy Reviews*, **165**, 112474
DOI: 10.1016/j.rser.2022.112474
- EF27 – Wang *et al.* (2019) *Energy Science and Engineering*, **7**, 411-419
DOI: 10.1002/ese3.283
- EF28 – Hazard Assessment of BESS, Technical Report by Atkins (Consulting Engineers) for Health and Safety Executive for Northern Ireland HSE(NI)
- EF29 – Letter 13/05/2022 from HSE(NI) to Ards and North Down Borough Council
- EF30 – Letter 22/09/2022 from HSE(NI) to Derry City and Strabane District Council
- EF31 – Letter 10/09/2021 from HSE(NI) to Armagh City, Banbridge & Craigavon Local Planning Office
- EF32 – Letter 18/07/2022 from HSE(NI) to Derry City and Strabane District Council
- EF33 – Letter 20/05/2021 from HSE(NI) to to Armagh City, Banbridge & Craigavon Local Planning Office

EF34 – Research Technical Report by *FM Global*: “Development of sprinkler protection guidance for Lithium-ion based energy storage systems”

EF35 – P. Andersson *et alia*, “Investigation of fire emissions from Li-ion batteries”, SP Technical Research Institute of Sweden, 2013.

New Annexes added this submission (16 December 2022)

EF36 – Barron-Gafford *et al.* (2016). The photovoltaic heat island effect: Larger solar power plants increase local temperatures. *Scientific Reports* **6**, 35070, DOI: 10.1038/srep35070

EF37 – Armstrong *et al.* (2016). Solar park microclimate and vegetation management effects on grassland carbon cycling. *Environmental Research Letters* **11**(7) 074016 DOI: 10.1088/1748-9326/11/7/074016