Lake District National Park Authority

Addendum Feasibility Assessment and Outline Design for Solar PV at Wayfaring House

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ELECTRIFYING CHANGE

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Acknowledgement

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We are a boutique, knowledge-based, international renewable energy business, principally focused on the application of solar photovoltaics (PV), energy storage and electronic vehicle (EV) charging.

Our primary trading territories are the United Kingdom (UK) and South Africa (SA), from where we consult on, design and deliver innovative renewable energy solutions to clients around the world.

Since 2006, we have been passionate pioneers in renewable energy, and unwavering advocates for the environmental and value benefits that solar solutions can deliver. We believe that renewable energy can change the world on many levels, from protecting the natural environment to aiding food security. It is this passion that drives the single-minded focus of our brand: “Electrifying Change”.

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Executive Summary

This report has been prepared by RenEnergy Ltd on behalf of the Lake District National Park Authority (LDNPA) and comprises an addendum feasibility assessment and outline design for solar PV technologies at the authority's main offices at Wayfaring House, Kendal. The report has been prepared in addition to the previously prepared Feasibility Assessment and Outline Design for solar canopies, dated March 2025. As such, the findings and recommendations of this report should be read in conjunction with the report for solar canopies.

The feasibility assessment includes modelling for a roof array on the main offices as an addition to the previously proposed solar canopies. The assessment also explores the feasibility of integrating both PV systems with a Battery Energy Storage System (BESS). The analysis and modelling have been carried out using PV*SOL Premium; a German software for dynamic solutions which includes 3D visualisation and detailed shading analysis of photovoltaic systems. The modelling of the roof array takes into account proximity and height of surrounding trees, the presence of roof lights on the building and the eligibility criteria of the Permitted Development Rights (PDRs) for roof-mounted solar PV.

A 17.48 kWp roof array has been modelled which covers the southeast facing roof face of the building, which alongside the 89.76 kWp solar canopy would provide the site with a total of 107.24 kWp of solar PV. As a stand-alone system, the proposed roof array would only provide 8% of the site's total annual electrical demand, however when combined with the solar canopies both systems would generate enough energy to cover 39.1% of the demand. As such it is strongly recommended that the LDNPA proceed with both technologies to maximise their self-sufficiency and reduce outgoing costs of grid supplied electricity.

An option to integrate the roof array and solar canopies with a BESS was also assessed and the results show that the inclusion of the BESS would enable 47.8% of the total electrical demand to be covered by the solar generation. Whilst this would further reduce the site's dependency on grid supplied fossil fuels, the financial appraisal of the BESS shows that the upfront CAPEX and 15-year replacement cost of the BESS greatly weakens the business case for proceeding with the BESS. This is particularly important if the aim of the LDNPA is to generate revenue in the long term, as the financial analysis found that the 25-year cumulative value of the roof array and solar canopies alone is greater than if the technologies are combined with a BESS, despite the reduction in grid supplied energy costs.

In summary, the modelling shows that the integration of the solar canopies with an additional roof-mounted solar array would provide the council with favourable performance metrics and long-term financial returns and as such we recommend both technologies are progressed. Whether to include the BESS will ultimately be dependent on the aspirations and financial constraints of the LDNPA.

This document revision (version 1, revision 1) has been prepared for the purpose of the LDNPA's Invitation to Tender for the Design and Build Contract. As such the financial appraisal and reference to costs have been redacted.

1. Introduction

1.1. The Lake District National Park Authority (LDNPA) are seeking to develop solar PV at their main offices at Wayfaring House, located at the Murley Moss business park in Kendal.

1.2. The rationale for developing solar canopies at Wayfaring House is for the on-site generation of a clean electricity source that will feed directly into the main building and provide a portion of the sites electrical demand. As such, the solar canopies will also contribute to the authority's carbon reduction targets and provide an opportunity for cost savings and long term revenue generation.

1.3. The LDNPA had previously elected RenEnergy to carry out a desk-top feasibility assessment and outline design for solar canopies at Wayfaring House. The purpose of which was to provide the authority with an outline design for a planning application as well as the basis to tender for a Design and Build Contract.

1.4. The purpose of this report is to carry out an additional assessment for the inclusion of rooftop solar PV alongside the proposed solar canopies at the Murley Moss building. This solution has been proposed to maximise the generating capacity of the site and therefore enable the LDNPA to maximise the potential for cost savings and revenue generation.

1.5. A drone survey was carried out as part of this additional assessment to obtain accurate measures of the building and surrounding tree heights. The results of the survey have informed the modelling and design of the proposed roof mounted array, as well as enabled an accurate assessment of shading from the surrounding trees.

1.6. The Site Context, summary of LDNPA's commitment to Net Zero and Energy Consumption Analysis, can be found within the previous report prepared for solar canopies. This report should therefore be read in conjunction with the report, titled 'LDNPA_Wayfaring House_Feasibility and Outline Design' dated 17th March 2025.

2. Planning and Design Considerations

2.1. Proposals for roof-mounted solar PV on non-domestic premises can be approved via Permitted Development Rights (PDRs) under Part 14, Class J of the General Permitted Development Order (GDPO), subject to the development meeting the following criteria.

Permitted Development

The installation, alteration or replacement -

a) Micro generation solar thermal equipment on a building;
b) Microgeneration solar PV equipment on a building; or
c) Other solar PV equipment on the roof of a building,

Development not permitted

a) The solar PV or solar thermal equipment would be installed on a pitched roof and would protrude more than 0.2 metres beyond the plane of the roof slope when measured from the perpendicular with the external surface of the roof slope.
b) The solar PV equipment or solar thermal equipment would be installed on a flat roof, where the highest part of the solar PV equipment would be higher than 1 metre above the highest part of the roof (excluding a chimney);
c) The solar PV equipment or solar thermal equipment would be installed [on a roof and] within 1 metre of the external edge of that roof
d) The solar PV or solar thermal equipment would be installed on site designated as scheduled monument; or
e) The solar PV equipment or solar thermal equipment would be installed on a listed building pr on a building within the curtilage of a listed building.

Conditions

Development is not permitted by Class J(a) or (b) if –

a) The solar PV equipment or solar thermal equipment would be installed on a wall and would protrude more than 0.2 metres beyond the plane of the wall when measured from the perpendicular with the external surface of the wall;
b) The solar PV equipment or solar thermal equipment would be installed on a wall and within 1 metre of a junction of that wall with another wall or with the roof of the building; or
c) In the case of a building on article 2(3) land, the solar PV equipment or solar thermal equipment would be installed on a wall which fronts a highway.

2.2. Class J(c) development is permitted subject to the condition that before beginning the development the developer must apply to the local planning authority for a determination as to whether the prior approval of the authority will be required as to the design or external appearance of the development, in particular the impact of glare on occupiers of neighbouring land, and the following sub-paragraphs apply in relation to that application.

2.3. 'Class J(c)' relates to 'other solar PV equipment', which means other than microgeneration which is considered to be anything < 50kW. As such, the condition to apply to the LPA for Prior Approval only relates to proposals which exceed 50kW.

2.4. An in depth assessment of planning considerations was included in the previous report for solar canopies, however this is less relevant for the proposed roof-mounted solar PV system.

2.5. Planning approval was granted for solar canopies on X under application reference '20251051PASOLAR'.

3. Options Appraisal

3.1. The following section of the report presents the results of the modelling which was carried out using PV*Sol Premium; a German software for dynamic solutions which includes 3D visualisation and detailed shading analysis of photovoltaic systems. The full PV Sol reports can be found in Appendices 1-3.

3.2. The site's electrical consumption data for the main meter and EV chargers were imported into the software to assess the performance of the proposed solar array against the energy demand of the site.

3.3. Several scenarios have been modelled to provide the authority with a complete understanding of how the proposed roof array would meet their electrical demands as a standalone solution, or when integrated with solar canopies and/or a Battery Energy Storage System.

Modelling/Design Parameters

Existing Solar Array

3.4. An existing solar array is installed on the internal roof faces which face towards the courtyard of the Murley Moss building. The system is 29.7kWp and was installed in 2015. Figure 1 shows the existing system at the site.

Figure 1: Drone photograph showing existing solar array

3.5. As previously outlined within the assessment for solar canopies, it has been assumed that the electrical consumption data provided already accounts for the site's consumption of the energy generated from the existing roof-mounted solar array which was installed in 2015. The data therefore reflects the site's electrical demand from the grid after it has consumed electricity from the existing solar array.

3.6. For the modelling to calculate the total energy covered by the existing solar array and the additional solar, we would need consumption data dated before the installation of the existing roof array. However, data from pre-2015 would not accurately represent the site's current electrical demand which most likely has changed in the last 10 years.

3.7. Therefore, the result of the modelling only represents the contribution of the additional solar, and do not reflect how much of the site's total demand is covered by the existing and proposed solar PV systems.

3.8. What the modelling does represent is the exact amount of kWh/year still consumed from the grid after the site has consumed from the existing roof array and the proposed solar.

Tree Assessment

3.9. Tree measurements were taken as part of a drone survey which was carried out on site on the 30th May. The heights of the trees surrounding the building have been included within the PV Sol modelling to accurately assess the impact of shading upon the proposed solar panels. The results of the drone mapping can be found in Appendix 4.

Scenario 1 – Standalone roof array (17.48 kWp)

3.10. Additional solar panels have been modelled on the Murley Moss building as shown in Figure 2. The system would comprise of 38 no. PV modules (Longhi LR7-54HTH-460M) with a total generating capacity of 17.48 kWp, and 1 electrical inverter (Fronius Symo Advanced 15.0-3-M). Figure 2 shows the proposed layout of the solar array.

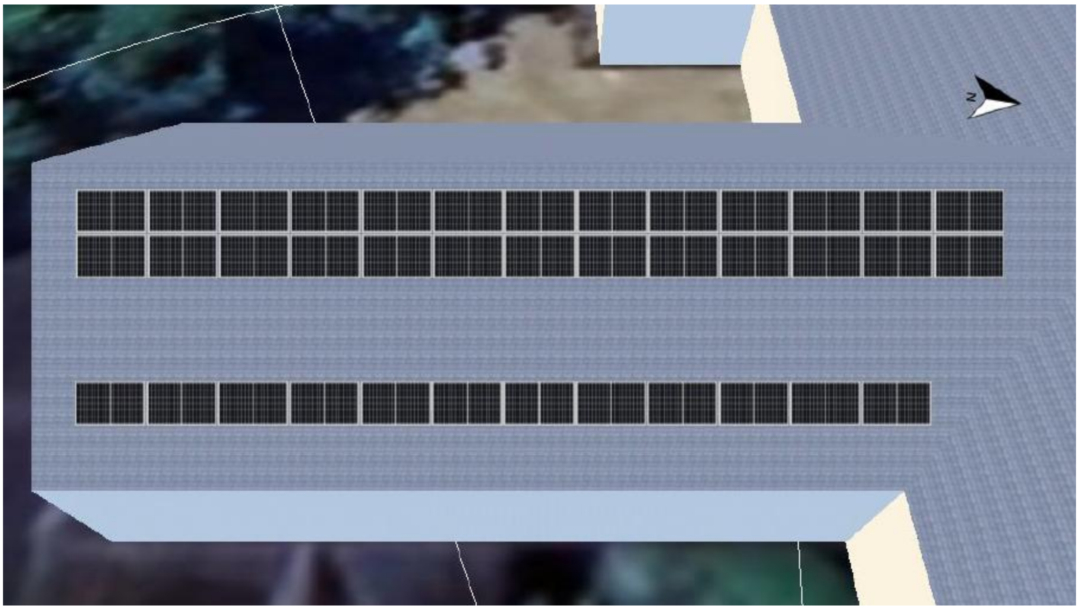

Figure 2: Proposed layout of roof-mounted solar array

3.11. The system would generate approximately 12,880 kWh/year. Throughout a year, 91.7% of the generation would be consumed, which on its own would contribute to 8% of the site's electrical demand.

3.12. The modelling found that there would be 9.7% yield reduction due to shading of the solar panels from adjacent trees. Typically, we would aim for no more than 5-10% yield reduction from shading, therefore the removal or regular pruning of trees could be considered, should the authority wish to enhance the performance of the system.

Scenario 2 – Roof array and solar canopies

3.13. When combined with the previously proposed solar canopies, the total generating capacity would be 107.24 kWp, generating approximately 86,739 kWh/year. The site would consume 66.4% of the energy generated by the integrated system, thereby contributing to 39.1% of the site's total electrical demand.

3.14. When modelling the roof array with the solar canopies, there would be an 11.6% yield reduction due to shading. As discussed in the previous assessment, it is assumed that the trees located at and adjacent to the central island would be removed due to the significant amount of shading that they would create (45% yield reduction). As such these trees have not been included within the modelling.

Scenario 3 – Roof array, solar canopies and BESS

3.15. The final scenario includes a BESS (Vilion EnerArk2.0-M-NBN-P30c107) with the integrated roof array and solar canopy system, to maximise the consumption of the energy generated. The modelling shows that with the inclusion of the BESS, the site would consume 82.8% of the total energy generated by the roof array and solar canopy, providing 47.8% of the site's electrical demand.

Exclusion of other roof faces

3.16. Having reviewed the other roof faces, the modelling shows that the majority are shaded too much to be feasible, unless significant tree removal or regular pruning were carried out.

3.17. When modelling the scenario with no trees, the results show that the site would only consume 50% of the total energy generated (when integrated with the solar canopies). Whilst this would cover 53.3% of the site's annual energy demand, the business case is much weaker given only half of the energy is consumed.

3.18. The only area which wouldn't be significantly shaded by the trees is the north facing roof. Modelling was carried out for additional solar on this roof face, integrated with the east facing roof array and the solar canopies. The total capacity would be 153kWp however the results show that by increasing the solar PV to this amount, the self- consumption drops to 58.7%. A scenario was therefore modelled with the north facing roof areas instead of the east facing roof, alongside the solar canopies (135kWp), which would have a slightly more favourable self-consumption of 62%.

3.19. Having reviewed the above detail regarding the other roof faces, the LDNPA have confirmed that they wish to proceed with the east facing roof face and solar canopies only. Therefore, no further assessment has been carried out for the other roof faces.

4. Roof Array Design

4.1. The proposed roof array would comprise 38 PV modules and 1 electrical inverter. As shown in Figure 2, the panels have been modelled in a landscape position to maximise the number of panels on the roof. This is due to the presence of sky lights on the roof (see Figure 3 below) which would only allow for a singular row of modules to be located between the skylights and the roof ridge in a portrait position.

Figure 3: Drone photograph showing sky lights on the Murley Moss building

4.2. A 1m buffer has been included between the panels and external roof edges to ensure the proposal complies with the criteria of the Permitted Development Rights as outlined in section 2.

4.3. As the proposed roof-mounted system would only have an installed capacity of 17.24kWp, the scheme will be exempt from the requirement to submit a Prior Approval application to the local planning authority as it is less than 50kW. This assumes the proposal maintains compliance with all other eligibility criterion outlined in section 2.

4.4. The solar PV system would connect back into the site via a DC cable which will connect to the electrical inverter, most likely to be situated within the plant room adjacent to the inverter for the existing solar array. The inverter will convert the energy to AC and connect into the site’s main incomer for use at the building.

4.5. If the LDNPA choose to progress with an AC-coupled BESS (as proposed within this assessment), both the roof array and solar canopies would connect into their associated electrical inverters from which the AC energy will be distributed to the site for use, to the BESS for storage or the grid for exporting any surplus energy. Before the energy can be stored in the BESS, the AC energy must be converted to DC energy. At the point the site needs to consume the electricity stored within the BESS, it must then be converted back to AC so that it can be used by the site.

4.6. For a comparison, in a DC-coupled BESS system the DC energy generated from the solar panels flows directly to a converter feeding the BESS, therefore removing the requirement to convert the energy from AC and back to DC before being stored. As such, the energy is converted only once from DC to AC when the energy flows from the BESS for consumption on site or to the national grid.

4.7. AC-coupled BESS are the most common system for residential and commercial solar installations and is therefore proposed at Wayfaring House due to the relatively small scale of the scheme.

4.8. The chosen contractor for delivering the Design and Build Contract should carry out a roof condition survey to determine the appropriate mounting solution for the solar panels on the roof. An electrical survey is also recommended to review the condition of the site’s electrical infrastructure which will inform the exact method of connecting the system and whether any upgrade works are required.

5. Summary and Discussion

5.1. For the purposes of comparing all of the scenarios that have been modelled so far (including the previous assessment for solar canopies alone), Table 1 provides a summary of the key performance metrics for each option.

Table 1: Summary of modelling for solar canopies and roof array

Metric	Solar canopy	Solar canopy with BESS	Standalone roof array	Roof array with solar canopy	Roof array with solar canopy and BESS
PV Generator Output	89.76kWp	89.76kWp	17.48kWp	107.24kWp	107.24kWp
BESS Capacity	/	107 kWh	/	/	107 kWh
Annual Generation (kWh)	72,971	72,971	12,880	86,739	86,739
CO2 reductions (kgCO2/year)	6,472	7,784	1,917	12,916	12,698
Self-Consumption	71.7%	86.7%	91.7%	66.4%	82.8%
Solar Fraction	35.5%	42.1%	8.0%	39.1%	47.8%

5.2. As shown in Table 1, the addition of the roof mounted solar array with the proposed solar canopies would result in a reduction in self-consumption but an increase in the percentage of the site's electrical demand covered by the solar energy. This is expected due to the increased generation afforded by an increased amount of solar on site. Therefore, whilst the percentage that is consumed would be less, the absolute value of energy that is being consumed by the site is greater and therefore a greater amount of energy from the grid is being displaced by solar energy.

5.3. When compared with the financial analysis of the previous assessment for solar canopies alone, the inclusion of the roof array would provide a greater 25-year cumulative value. In addition to a greater 25 year cumulative value, the payback period with the inclusion of the roof array would be shorter than the payback from the solar canopies alone. This is due to the lower cost per kWp of roof mounted solar PV. As such, it is strongly recommended that the LDNPA proceed with both technologies at Wayfaring House.

5.4. The table shows that installing both the roof array and solar canopies alongside a BESS would enable the site to consume a favourable 82.8% of the energy generated by the solar panels (facilitated by the BESS) which would provide the site with 47.8% self-sufficiency – almost half of their energy requirements. This means the site would essentially cut their outgoing electricity costs in half, whilst simultaneously generating a revenue from selling the surplus 17.2% of energy back to the grid (assuming the site is granted the required export agreement).

5.5. Whilst the short term CAPEX required to cover the costs of the installation will be greater with the inclusion of a BESS, typically the long term savings outweigh these costs by displacing a greater amount of grid-supplied electricity and therefore enabling the site to generate a higher return on their investment. However, at Wayfaring House, the financial analysis shows that the scenario with solar PV only would generate a greater 25-year cumulative value than with the inclusion of the BESS.

5.6. This is likely due to the relatively small amount of solar PV proposed, meaning there is a low amount of surplus energy for storing within the BESS. As such, the BESS is displacing energy from the grid at a lower rate and therefore generating a return at a lower rate. Given the high upfront cost of the BESS, the payback period for the system is longer and the 25-year cumulative value of the project is lower than compared with the scenario for solar PV only. The payback period is also extended by the requirement to replace the BESS, further lowering the 25 year cumulative value of the project.

5.7. As such, whilst the inclusion of BESS is shown to enable a greater amount of the site’s electrical demands to be covered by the solar PV, the cost of achieving this is not shown to be a worthwhile investment in the long term due to the high CAPEX of the BESS and low rate of return.

5.8. However, the value of the investment will ultimately be dependent on the aims of the LDNPA. If the LDNPA are aiming to maximise the self-sufficiency of the site and reduce its dependency on fossil fuels, then pairing the solar PV with a BESS is shown to be the most effective way of achieving this. However, if the main aim is to generate revenue in the long term, then the inclusion of the BESS is shown to be less valuable than proceeding with just solar PV.

In any case, the next steps for progressing a project would be to:

Next Steps

1. Review the proposed options to inform a decision on likely design to take forward as a project. This should be done in conjunction with a review of the previous assessment prepared for solar canopies.

2. Instruct a contractor for the Detailed Design and Build Contract, to progress the scheme on behalf of the LDNPA.

3. The chosen contractor should submit the G99 application for the appropriate system size and instruct the upfront technical surveys that are required to complete the detailed design.

4. Once designs have been finalised the project can be mobilised in line with the chosen contractor’s procurement and construction programme.