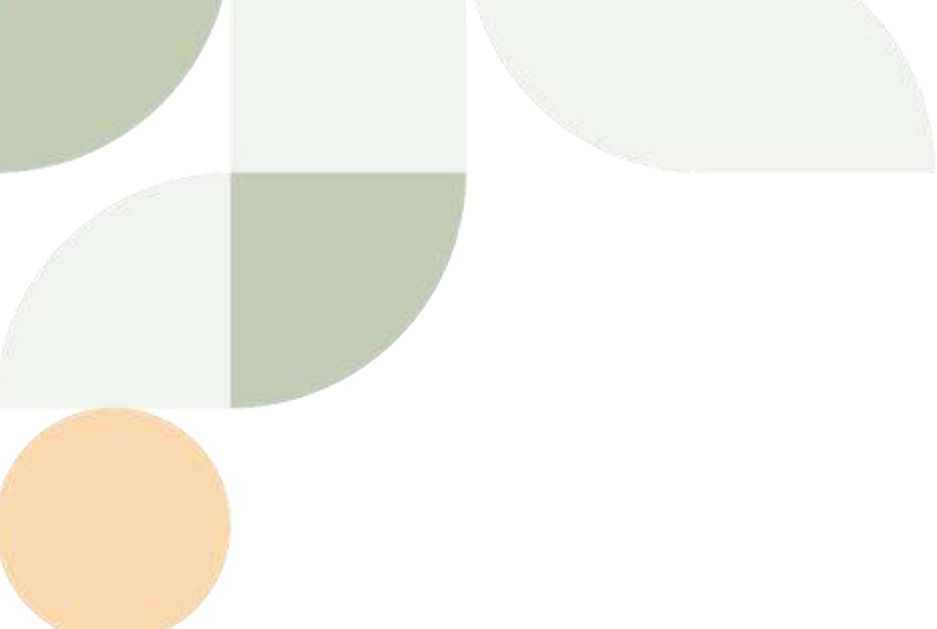




Lime Down

Solar Park

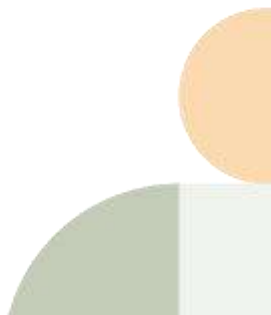
Written Summary of the Applicant's Oral Submissions and Responses at Issue Specific Hearing 5 and Responses to Action Points

October 2026

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The Infrastructure Planning (Examination Procedure) Rules 2010



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1 Summary of Oral Submissions at Issue Specific Hearing 5

Agenda item	Comment
1. Welcome, housekeeping, purpose of the hearing, participant introductions	The ExA introduced the hearing and made some preliminary remarks. The purpose of the hearing is to address matters raised by the ExA following its consideration of the application documents in respect of matters relating to landscape and visual impact, glint and glare, cultural heritage, and hydrology, flood risk and drainage. The following parties then introduced themselves during ISH5: The Applicant: • Claire Brodrick, Partner at Pinsent Masons LLP (solicitors for the Applicant) • Will Threlfall, Senior Project Development Manager at Island Green Power • Christopher Jackson, Director of Landscape Architecture at Lanpro • James Plumb, Senior Technical Consultant at Pager Power • Mark Topping, Director of Design at Lanpro • James Darrall, Director at Transport Planning Associates • Joshua Rigby, Associate Director at Arthian • Dan Maher, Senior Scientist at Geosyntec Consultants • William Barrett, Technical Director at AECOM • Paul Gregory, Director at BST&T Consultancy Services

	Wiltshire Council ("Wiltshire Council") • Odette Chalaby, Barrister Landmark Chambers (Counsel for Wiltshire Council) • Mark Goodwin, Senior Landscape Officer • Will Harley, Director and Landscape Consultant at WH Landscape Consultancy • Brett Warren, Public Protection Officer • Neil Adam, Assistant County Archaeologist • Rohit Singh, Principal Technical Officer • Ben Wedling, Associate at Atkins Realis Stop Lime Down ("SLD") • Daniel Kozelko, Barrister at 39 Essex Chambers (Counsel for SLD) • Celia Reynolds, Barrister at 39 Essex Chambers (Counsel for SLD) • Carly Tinkler, Chartered Landscape Architect of the Landscape Institute • Bruce Bamber, Director at Railton TPC Limited • John van Hoogstraten, Straten Consulting Services Limited • Lucy Nicholson, Heritage Expert • Tom Linington, Marrons Planning • Richard Skeffington, Emeritus Professor at the University of Reading Natural England ("NE") • Kyle Conroy, Sustainable Development Officer The Environment Agency ("EA") • Laura Edwards, Planning Specialist
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	• Susie Bateson, Technical Specialist in Hydrogeology and Contaminated Land • Lucy Sutton, Biodiversity Officer • Philip Sale, Hydraulic Modeller Cotswolds National Landscape Board ("CNLB") • Simon Joyce, Planning Officer Other interested parties: • Mr Seymour-Williams • Anne Henshaw • Catherine d'Agrain
2. Landscape and Visual Impact (including Glint and Glare)	
2.1. Cotswolds National Landscape ("CNL")	The ExA asked clarification questions on previous submissions. The ExA noted that the Tranquillity Statement [REP5-099] sets out that on Alderton Road and the Fosse Way there would be 56 Heavy Goods Vehicle ("HGV") movements per day during peak times of construction, which would be 8 per hour, and 37 movements per day on average, 5 per hour, during the time of construction. The Applicant had set out in the Tranquillity Statement that even if the level of traffic increase is over 10%, that does not automatically mean there is a significant effect. The ExA noted that they are aware of the disagreement over the number of vehicle movements between the parties but that this issue was best left for the Issue Specific Hearing ("ISH") to be held on 16 September 2026. The ExA asked the Applicant to set out for Alderton Road and the Fosse Way the percentage increase of additional HGV movements and percentage increase of non-HGV traffic movements.

Mr James Darrall for the Applicant confirmed the **Highways Technical Note in response to Appendix A of the SLD Deadline 4 Submission [REP5-107]** sets out the latest diagrams and that there are ongoing negotiations being held with SLD on these figures. The figures for Alderton Road and the Fosse Way are 56 HGVs and 21 existing HGVs, amounting to a 265% increase on a peak day. The CNL route allows access to Lime Down A, B and C. Looking at the Construction Programme, Lime Down A and B last for 9 months and there is an overlap with Lime Down C of two months, with Lime Down C lasting for 17 months. Mr Darrall confirmed the figures represent a peak day when Lime Down A, B and C overlap, which amounts to an hourly number of 4 HGVs each way, therefore 8 HGVs an hour. Mr Darrall also stated that there are Network Rail embankment works lasting for 6 months and the Applicant's surveys have noted 19 HGVs in an hour along that route. In respect of total movements for all vehicles, Mr Darrall stated the total existing traffic along Alderton Road and the Fosse Way is 921 vehicles and the total construction movement is 272, which amounts to an increase of 30% on a peak day. At all other times outside of peak times, there are 37 HGV movements on an average day and a total of 150 during construction, representing a 16% increase on the CNL.

The ExA requested confirmation in respect of the peak days and whether this is expected every day or whether this is a singular worst-case scenario. Mr Darrall confirmed the increase on a peak day would be 30%, which would occur during the 2-month overlap with Lime Down A, B and C. The peak flow could be on any day of that 2-month period.

Mr Darrall stated that the Applicant has followed the ISEP Guidelines and has assessed the risk as moderate. The ISEP Guidelines state that transport consultants and experts should provide information to landscape consultants to assess the risk, and this is what the Applicant has done. Therefore, the Applicant has complied with the requirements.

The ExA asked for a response to SLD's representations that the increase in the CNL was beyond the 10% and 30% increase rules of thumb, and how the sustained level of increase above 100% led to the conclusions in the Tranquillity Assessment.

	Mr Mark Topping confirmed the Applicant has assessed the impact from a tranquillity perspective as set out in the Tranquillity Report. He stated that the experience from the site was that when HGVs are experienced, that experience is fleeting and lasts around 100m to 300m visually and audibly. Mr Topping confirmed this has an impact on tranquillity, but those HGVs and vehicles pass through the landscape and the tranquillity baseline returns, notwithstanding any combination effects as set out in the Tranquillity Assessment. Equally, for Public Rights of Way ("PROW") users, they would experience those HGVs at different distances and times, usually infrequently as users are walking across different PROWs. The ExA stated that the ISEP Guidance considers a 10% or 30% threshold and asked for clarity on why this threshold would exist if it can be said that effects are only fleeting. Mr Topping stated from his experience doing the assessment and travelling that route, he was conscious of the quantum and percentage increase in traffic that would be observed initially by receptors using that route. The impact is not a sustained impact. The perception of the vehicles through the landscape is a temporary experience which is removed by the absence of the vehicle, and this is how it would be felt during the construction process. Mr Topping confirmed he also considered further perceptual aspects, including recognising the effect on the landscape and the association of the vehicles with the Lime Down scheme. In response to comments from Mr Bamber that the transport environmental impact from the landscape impact takes a different approach which is not based on people's perceptions of HGVs in reality and that from a transport environmental impact perspective, HGVs do not have a fleeting, temporary impact, Mr Darrall stated that these roads are already used by HGVs and that the percentage increase is over 100% because there is currently fairly low HGV use. Fear or intimidation have been assessed in the Environmental Statement ("ES")
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	[EN010168/APP/6.1/6.2/6.3/6.4] in transport terms. The Applicant has followed the ISEP Guidance and this has been included in the calculations. The ExA asked for confirmation on how the Tranquillity Assessment differs from the ES assessment. Mr Topping stated that the Applicant has assessed the experience of people and receptors as negative experiences, given there is a physical change involving moving off the road, moving away from traffic and pausing routes. The visual, experiential and aural impacts and perceptions have been set out in the Tranquillity Assessment. The ExA stated that at Deadline 6, SLD commented on the Applicant's Deadline 5 Tranquillity Assessment – Effects of Construction Traffic on the Cotswolds National Landscape [REP5-099] and the ExA gave Wiltshire Council, the CNLB and Natural England the opportunity to comment. The ExA asked the Applicant whether the proposed disapplication of the Environmental Impact Assessment (Agriculture) (England) (No.2) Regulations 2006 would remove protections preventing the removal of proposed wildflower meadows at decommissioning. Ms Claire Brodrick for the Applicant responded that the reason for the Applicant seeking to disapply these regulations is because they already include a disapplication where an environmental statement for a planning application under the Town and Country Planning Act 1990 has been done, but they do not specifically include a scenario where an environmental impact assessment (“EIA”) has been done for a DCO application. There is a disconnect between the two regimes and the Applicant is seeking to rectify this in order to note that an EIA has already been done in relation to the decommissioning of the scheme and its return to agricultural use. Ms Brodrick noted that a similar disapplication was made on the Green Hill DCO application and Natural England had
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	agreed to this disapplication. This is available on the PINS website and the Applicant can provide a link to that in written submissions. <i>Post-hearing note</i> <i>The relevant response from Natural England was in response to Request for Information 2 from the Secretary of State on Green Hill Solar Farm, dated 10 September 2026 (Reference C2-002). This has been attached as Appendix A of this written summary.</i> Ms Brodrick further noted that the Applicant will be required to provide a decommissioning plan for approval and will need to confirm if there are any materially new or different effects from those considered in the EIA. Should the nature of the land have changed such that the impacts of removing the wildflower meadow are materially different, that would need to be addressed. There is therefore no need to consider this at the point of decommissioning. In terms of protections, the DCO only disapplies legislation specifically mentioned. It gives planning consent for decommissioning but does not provide any other protections. To the extent that the habitat becomes a protected habitat, that would require a form of additional licence and the DCO would not circumvent that. The DCO does not provide statutory authority to remove any protections that apply at that point in time. To the extent it becomes a protected habitat, it will need to be dealt with at decommissioning. The Applicant does not know what the priority will be in 60 years' time and whether arable land will be the greater priority or whether a wildflower meadow will be the appropriate type of vegetation at that point in time. Ms Brodrick stated that the Applicant does not consider the DCO to remove any other protections, but it provides planning consent and in the scenario that there is a change of land use to agricultural land that would need to be assessed and the Applicant has done that. The ExA asked, if the Environmental Impact Assessment (Agriculture) (England) (No.2) Regulations 2006 were to still be in place, would the Applicant consider that wildflower meadows would be protected from returning to agricultural land as a priority habitat.
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	Ms Brodrick responded that it would depend on the scenario at that point in time. The DCO permits the planning consent. The Environmental Impact Assessment (Agriculture) (England) (No.2) Regulations 2006 includes a variety of measures, and it would need to be seen if additional consents would be needed at that point in time. The DCO does not remove the need to get licences to deal with those, including appropriate mitigation measures or replacement habitats required at that point. The particular provision the Applicant seeks to disapply is in respect of needing an EIA. Ms Brodrick stated that the Applicant has already done an EIA, and the DCO contains an obligation to review this at the point of decommissioning. The ExA requested clarification on the assurances that the Applicant will further the purpose of the CNL, given the wildflower meadows are part of the Applicant's case for fulfilling the purpose of the CNL. The ExA also asked for confirmation that the Applicant has set out that the duty to seek to further purpose of the CNL can be fulfilled even if the wildflower meadows are removed at decommissioning. Ms Brodrick confirmed this was the case, as it is proportionate to the impact of the scheme. When the scheme is removed, the land would return to its current scenario and is therefore furthering the purposes for the duration of the Scheme. In response to comments from Natural England, the ExA asked for clarification from the Applicant on whether the process of the screening opinion and subsequent EIA process for change in land use would be disapplied. Ms Brodrick responded that there are two elements the Applicant is seeking to disapply. The Applicant seeks to disapply the regulations, it does not prevent anything, it just requires an EIA to be carried out. The Applicant is seeking to disapply this for activities that apply for decommissioning as the Applicant has already done an EIA, and to the extent there are
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	differences, these would be assessed as part of the decommissioning plan. All activities for decommissioning fall within that assessment. This does not disapply any other environmental protections or consents, it is just about the method of assessment. Once the site has been decommissioned in accordance with the decommissioning plan, the land is handed back to the landowner. If the landowner wishes to do any of the activities mentioned that would trigger those regulations post-decommissioning, the existing regime continues to apply. Ms Brodrick stated that decommissioning will involve the removal of all the solar infrastructure, but it is not clear what the landowner will want to do with the land post-decommissioning. The Applicant's EIA has assumed that from a soil agricultural point of view, this is a temporary use of land and it will revert to agricultural use. The decommissioning plan and the supporting environmental information supplied at that point in time pursuant to Schedule 16 will need to document how the activities will differ from what was currently assessed in the EIA. The decommissioning activities will still need to be approved by the local planning authority. There are two scenarios: the land stays as a wildflower meadow and therefore there is more permanent loss of agricultural land, or it returns to agricultural land and then removes the wildflowers. The DCO does not remove those consents post-decommissioning. Ms Chalaby for the Council asked whether the EIA has assumed that the impact would be temporary, and has not assessed removal of wildflower. Ms Brodrick confirmed that the EIA has assumed the land will go back to agricultural use but that the hedgerow trees would remain and would not be removed on decommissioning. However, it has assumed the wildflower meadows will be returned to agricultural land.
2.2. Sequential Visual Assessment	The ExA noted that the Applicant has submitted an additional sequential visual assessment at Deadline 6 [REP6-062]. The ExA asked the applicant to clarify whether the percentage change figures provided in the conclusions are a percentage of the distance of the route where any change

	would be perceptible, regardless of the level of the effect, or whether they relate to a change above a certain threshold. Mr Christopher Jackson for the Applicant confirmed the percentage calculations relate to the direct appreciation of the scheme, so do not relate to magnitude of changes. It is from the moment at which receptors in the landscape are passing and have a view on the scheme as a consequence of its development, which is done on distance. The ExA asked whether the Applicant considers that, where significant experiential change is identified along a route, whether this represents an additional significant adverse effect on top of what is experienced by the individual receptor points, or whether that is already covered. Mr Jackson confirmed that the Applicant has already assessed it within the original LVIA, and the LVIA looked at sequential views and changes as receptors move along routes, looking at the views and also the experience. It is a colloquial term describing the change and experience of the users moving up and down the receptor routes, but it leans on the assessment from the original LVIA. Mr Jackson confirmed there are therefore no further effects that have not already been assessed as a result of the sequential visual assessment. <i>Post Hearing Note:</i> <i>Please refer to the Applicant's response to Action 4 in the Actions Response Table below.</i> In response to comments from Wiltshire Council, Mr Christopher Jackson for the Applicant directed Wiltshire Council to Appendix 2 of the assessment which includes a photographic record (Additional Sequential Visual Assessments[REP6-062]). He stated that the suggestion that no photography was undertaken is incorrect, as the appendix includes photographs for all the additional routes including the Wiltshire Council routes. These were understood to be in addition to the initial LVIA photography.
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	The ExA requested that the assessment include references to viewpoints and photographs in Appendix 2. Mr Jackson confirmed that written representations will ensure suitable referencing. <i>Post Hearing Note:</i> <i>Please refer to the Applicant's response to Action 5 in the Actions Response Table below.</i> Mr Jackson addressed Wiltshire Council's submissions regarding the lack of continuity caused by the breaking down of individual sections. He explained this was predominantly designed to consider the different sections of the route, given they are marked or promoted routes, and stated that Wiltshire Council had asked the Applicant to review sequentially as a user would move down a route, and that the assessment is already subdivided into separate sections and produced in this way. The Wiltshire Council and SLD routes that were requested are generally in and around the solar site itself and an assessment has already been undertaken as part of the LVIA with impacts considered. The request to look back retrospectively is not needed as the Applicant has assessed routes already sequentially and individually as part of the LVIA. Mr Jackson stated that the Applicant would deal with the difference of opinion on sensitivities in its written response, and would also respond in writing to Ms Tinkler's comments for SLD. <i>Post Hearing Note:</i> <i>Please refer to the Applicant's response to Action 4 in the Actions Response Table below.</i> Mr Jackson noted that the ZTV work is a computer-generated programme that looks at theoretical visibility and that the Applicant has used it to understand the potential visibility of individual sites. He stated that while it is a useful initial tool to aid on-site fieldwork, it is not definitive, noting that nothing is more helpful than getting on the ground, and it should not be relied on in its entirety for what will or will not be visible. In respect of the difference in opinion on landscape outside of the DCO and the Applicant's control, Mr Jackson stated that this is outside the Applicant's control but the Applicant would assume that normal countryside management and legislation would ensure a
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	degree of permanence for that vegetation, for example ancient woodland. The dispersed nature of the site relies on that intervening vegetation to provide screening and mitigation along with changes to topography and land. Lastly, in respect of the longer SLD routes requested, Mr Jackson noted that the distance and extension of the routes are large. He stated that some routes, Kingston St Michael for example, are long-distance routes that SLD agreed are well screened and will take time to travel. Mr Jackson stated that there is a need to be cognisant of the time and distance it takes to travel some of these routes, which go over PROWs, footpaths and highways. On Wiltshire Council's comment regarding the lack of schemes assessed, Mr Jackson stated that all assessments are undertaken with reference to the design principles document. There is an acknowledgement of the nature of development to come forward within each field and this is connected and committed to within the DCO. The ExA requested that the Applicant respond to SLD's points on the cumulative assessment developments which are not renewable development being included. Mr Jackson confirmed the Applicant would do so but raised that the consultation process the Applicant had with Wiltshire Council including agreement of the LVIA methodology, which was a cumulative assessment, and this has been consistently followed throughout the LVIA and the subsequent sequential visibility assessments. <i>Post Hearing Note:</i> <i>Please refer to the Applicant's response to Action 5 in the Actions Response Table below.</i> In response to comments from Mr Harley for Wiltshire Council that it expects a full photographic record in both directions, Mr Jackson for the Applicant stated that the photographic record is not the basis on which the assessment is to be undertaken. He stated that the assessment is undertaken in the field, on foot, and then written up. The photographs are helpful but are only a supporting tool and do not constitute the assessment.
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2.3 Glint and Glare	The ExA asked Applicant for update on whether discussions with Badminton Airfield have taken place and whether there is agreement that the predicted glare effects would be operationally accommodatable. Mr James Plumb for the Applicant stated that the Applicant has remained engaged with the owner of Badminton Airfield and has confirmed the owner of the airfield has sight of the Glint and Glare Report (ES Volume 3, Appendix 20-4 Solar Photovoltaic Glint and Glare Study [APP-261]) and has no objections to the findings. Mr Plumb explained that Badminton Airfield is part of Badminton Estate, which is one of the landowners for the solar option areas, and has therefore been engaged with the Applicant through the application and design process. The Applicant understands the airfield is operated by one individual, primarily for infrequent personal use with occasional visiting aircraft. Mr Plumb further stated that the Applicant has assessed the airfield with its current and legally permitted use, and notes that the low volume of air traffic is a significant factor in the assessment. The Applicant has yet to receive a response regarding meetings to discuss the matter. Mr Plumb confirmed that the operator or the owner has not at this stage raised any objections. The ExA asked whether there has been any communication from the airfield operator. Mr Plumb stated that there has been regular communication with the landowner but there has been no direct contact as yet with the individual operator. The ExA asked how, without the view from the operator and having only the Applicant's view that glare effects would be operationally accommodatable, the ExA can be satisfied of this. Mr Plumb stated that the Applicant's judgment comes from its experience with other developments and other airfields, and that there are not necessarily specific measures that need to be taken. Mr Plumb noted there are simple measures, such as being aware of glare or other typical mitigation used for direct sun, such as using sunglasses. Mr Plumb stated that these are relevant measures which are common sense mitigation measures. He noted that pilots regularly encounter direct low
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	sun and there would be direct low sun from a similar direction, so the Applicant would expect that the measures which should take place to accommodate glare are already taking place. The ExA requested that the Applicant try again to consult with the operator of airfield. Ms Brodrick for the Applicant stated that the Applicant is making inquiries but cannot compel the operator to engage, noting that this is an individual rather than a business operating the airfield. <i>Post Hearing Note:</i> <i>Please refer to the Applicant's response to Action 6 in the Actions Response Table below.</i> Ms Brodrick also suggested that, to give the ExA more comfort, the Applicant could look at measures in the Outline Construction Environment Management Plans to provide information to enable the operator to put in place those measures, including whether copies of any relevant draft Detailed Construction Environment Management Plans could be shared with the operator of the airfield at the same time as they are provided to Wiltshire Council. <i>Post Hearing Note:</i> <i>Please refer to the Applicant's response to Action 7 in the Actions Response Table below.</i> In response to comments from Stop Lime Down about the quantification of the yellow glare, Mr Plumb for the Applicant stated that with regards to the size and scope of the development, it is worth noting there is a 4.5 km distance between Badminton Airfield and the first panel area. He explained that this is a visual aerodrome and a pilot is unlikely to be looking at the solar panel area when trying to find a visual reference point. Mr Plumb stated that the Applicant provided a summary of the quantification in the initial glint and glare report (ES Volume 3, Appendix 20-4 Solar Photovoltaic Glint and Glare Study [APP-261]) which includes a statement that glare is predicted to cover no more than 60 minutes on any given day at a particular location between February and April, and then August to November. On frequency and severity, Mr Plumb stated
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	that the Applicant has not reduced the level of assessment due to the frequency of use of the aerodrome and stated it has been assessed in the same way as any other aerodrome which is used for general aviation flying. Mr Plumb explained that the consideration of frequency comes in when considering operational accommodability because it is harder for a larger aerodrome with more regular flights to make these accommodations, including an additional circuit or overflying the runway in advance of landing, depending on which is deemed feasible at that aerodrome. These measures are much more likely to be feasible at a smaller aerodrome where you have one pilot trying to land at a time compared to a large aerodrome. Mr Plumb stated that is where the consideration comes in, rather than the modelling or the base assessment. The ExA asked the Application to identify which other solar DCO projects have used the Pager Power guidance to support a similar approach to assessing impacts on road and rail receptors. Mr Plumb confirmed that the Pager Power glint and glare guidance has been used in the assessment of consented solar project DCOs, including Cleve Hill Solar Park, Corsham Solar Park, Gate Burton Solar, Cleve Hill and West Burton. The ExA asked whether these are examples which primarily consider the field of view and then only go on other considerations if a reflection is geometrically possible within the field of view. Mr Plumb confirmed that for all these assessments the Pager Power methodology has been used and that the field of view consideration is an integral part of the methodology. Some of these assessments also assess railways. Mr Plumb stated that the Applicant has reviewed the recommendation lists and decision reports for all projects consented and the Pager Power methodology has not been questioned or criticised in any of these. Mr Plumb stated this demonstrates a precedent of acceptance of the methodology and that it has been used for projects of scale.
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	The ExA asked whether Pager Power is the only company that produces these reports in the UK, and if so, whether the methodology the company works to is therefore not challenged. Mr Plumb stated that Pager Power is the largest supplier of glint and glare assessments in the UK but that there are other companies which produce these reports. He confirmed that there is no formally adopted methodology and that Pager Power sees variants but that companies are broadly working on similar concepts. The ExA asked whether, from the time Pager Power has undertaken these assessments, there has been a change in methodology and continual professional development in the field. Mr Plumb stated that the current guidance is in its fourth edition and that the fifth edition is currently being written. He confirmed he would provide in a post hearing written submission when the first edition was published but believed this was 2013. [Correction: 2017]. Mr Plumb stated that Pager Power's processes include looking at processes and guidance published globally, including guidance published in Australia. <i>Post Hearing Note:</i> <i>Pager Power's Solar Photovoltaic and Building Development – Glint and Glare Guidance Fourth Edition</i> <i>(September 2022) is provided in Appendix C of this written summary.</i> In response to comments from Stop Lime Down that the Pager Power guidance was generic in nature and lacked a risk assessment matrix that defines severity vs likeliness, Mr Plumb for the Applicant stated that to address what is considered a local road, the Applicant would look at the broad characteristics of what is going to be a primary road, including lane markings and indications it will be used more frequently. He stated that the Applicant does not have a threshold for the number of traffic movements. If a road is more frequently travelled, it is more likely that a road user will meet another road user and therefore the severity of any glare is directly impacted by the
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	frequency of the use of the road. Mr Plumb stated that the severity of an impact resulting from glare cannot be separated from the operational environment and frequency of travel on a road. The ExA asked the Applicant to clarify which model was used, noting that the representations stated calculations were run with the Pager Power model and the Forge Solar model. Mr Plumb for the Applicant stated that the submissions at Deadline 3 of the glint and glare modelling outputs have come from Pager Power's internal model, which was used for all the receptors to submit data in the same format. The Forge Solar model was additionally used for aviation receptors to do the intensity calculation, which is why there are two models. He confirmed that the results are very comparable and the models operate in a similar way. The ExA asked whether evidence that the models are producing similar results could be provided at Deadline 7. This evidence has been provided as Appendix D to this written summary. <i>Post Hearing Note:</i> <i>Please refer to the Applicant's response to Action 9 in the Actions Response Table below.</i> Ms Anne Henshaw, speaking as an interested party, raised a question regarding the new plantations and new plantations along roadsides. Mr Jackson for the Applicant directed to the Outline Water Resources Strategy [APP-290] which provides an early-stage evaluation of quantities of water required and the source. He stated that the final watering regime, requirements, method and delivery will be confirmed within the detailed Landscape and Ecological Management Plan ("LEMP") and will set out the requirements for the initial establishment and ongoing management and maintenance of the mitigation planting.
3. Cultural Heritage	

3.1 Designated Heritage Assets	The ExA invited Wiltshire Council to clarify whether it considers the residual harm to the Rodbourne Conservation Area and Grittleton House would amount to 'no harm' as assessed by the Applicant or 'less than substantial harm, following the Applicant's confirmation that there would be no substantive works to the access. Ms Chalaby for Wiltshire Council stated that Wiltshire Council agrees there would be no harm to the Rodbourne Conservation Area. The ExA asked whether the impact on the setting of the asset in respect of Grittleton House would amount to 'no harm' as assessed by the Applicant or 'less than substantial harm. Ms Chalaby stated that there would be no harm, but this is subject to the agreement of the appropriate socio-economic safeguards to avoid indirect effects. She stated that discussions are ongoing with the Applicant about this and the socio-economics adviser to Wiltshire Council will be able to discuss that matter the following week. The ExA requested confirmation from SLD of whether the assets listed in the Statement of Common Ground ("SoCG") accurately reflect SLD's position on the assets it believes would experience significant adverse effect, being Bradfield Manor, Norton Manor, Fosse Way, the archaeological asset D2401 and Pillow Mound. Ms Alice James for the Applicant stated that the Applicant has consulted with SLD in the SoCG on the areas of disagreement and has set out the differences. Ms James stated she understands there is agreement with Wiltshire Council and Historic England in terms of the assessment of assets listed by SLD.
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	The ExA asked whether there are ongoing discussions with SLD in respect of Bradfield Manor, Norton Manor and the Fosse Way. Ms James responded that the Applicant will continue dialogue with SLD, but that she suspects it will end up as a disagreement. Mr Kozelko for SLD confirmed this is accurate.
3.2 Archaeological Mitigation	The ExA noted the updated geophysical surveys where submitted at Deadline 5 (Final Cable Route Corridor Geophysical Survey Report [REP5-104]) and asked whether Wiltshire Council has any concerns arising from the updated surveys. Mr Neil Adam for Wiltshire Council stated that the updated geophysical survey has been completed to Wiltshire Council's satisfaction. The ExA asked for clarification on what that meant for the mitigation strategy. Mr Adam stated that Wiltshire Council considers a detailed archaeological mitigation strategy needs to be submitted prior to submission, ideally. He stated that the problem with the outline strategy is that it is not detailed enough and is a stepping stone. Mr Adam stated that he would like to see a document presented which would lead to more detailed site-specific written schemes of investigation. This would also outline the strategy to secure the protection of areas to be preserved. The ExA stated that the overarching mitigation strategy is still a requirement and this needs to be in place before submission. Mr Adam confirmed this, and stated that he understood this is also Historic England's position. <i>Post Hearing Note:</i>

	<i>As Historic England did not attend the hearing, this statement has not been able to be verified but records the Applicant's understanding.</i> In response to comments from Wiltshire Council that a detailed archaeological mitigation strategy needs to be submitted prior to submission, the ExA asked whether more detail in the outline strategy would be sufficient. Mr Adam for Wiltshire Council stated that if the Applicant can convert the outline document into a Detailed AMS from an outline that would be satisfactory. The ExA asked whether the Applicant is clear on the information being requested by Wiltshire Council. Ms James for the Applicant stated that it might be useful for Wiltshire Council to prescribe what detail it would like. She added that in terms of the outline archaeological strategy provided, the Applicant considers that it is proportionate and appropriate and is sufficient for the required purposes. The document has been derived to create the optimal method for ensuring delivery of archaeological mitigation works and securing the best outcome for archaeological remains. Ms James stated that the key point is that the Applicant is dealing with a solar scheme. She stated that as set out in NPS EN-3, the impacts of a solar are generally noted to be limited, and this is reiterated in section 4 of the recently published Archaeology Solar Farms Good Practice Guide, which Ms James confirmed could be submitted into examination (see https://www.archaeologists.net/sites/default/files/2026-04/Archaeology-and-Solar-Farms-GPG---FINAL-2026-04-14.pdf). <i>Post Hearing Note:</i> <i>The Applicant has provided this as an appendix to this written summary at Appendix E.</i>
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	Ms James explained it should be noted for a Solar Scheme the detailed design occurs post-consent of the scheme. Therefore applying excessive detail or a high level of detail at this stage to the Archaeology Mitigation Strategy (“AMS”) would be contrary to getting the best result for mitigating archaeological remains. The Applicant wants to ensure there is sufficient flexibility to ensure the optimal approach to archaeological mitigation. As stated at paragraph 1.1.2 (ES Volume 3, Appendix 12-6 Outline Archaeological Mitigation Strategy [REP6-012]), the AMS is providing an overarching methodology for undertaking a programme of archaeological mitigation within the scheme. The mechanism allows site-specific written schemes of investigation to be appended, where further detail can be applied as requested. Ms James further stated that the mechanisms being put in place to mitigate archaeological remains are standard compared to other solar schemes, including East Yorkshire Solar Park, Cottam, West Burton, Tillbridge, Gate Burton etc and that this is the mechanism that other sites have used. While the Applicant notes that there are regional differences to the nature of the buried archaeological remains, the Applicant has not identified any archaeological remains within the Scheme that would require a materially different strategy to ensure appropriate mitigation is undertaken. Ms James stated that the Applicant considers the strategy provided will secure the best outcome for archaeological remains, without the requirement of further detail either at this stage or once there is a detailed design. The ExA noted that it would be helpful for Wiltshire Council and the Applicant to discuss what detail is missing and, if the document stays as an outline document, what extra detail could be included. The ExA noted that if this affects the dDCO, final positions will be needed by Deadline 7. The ExA asked Wiltshire Council if they would like to respond to the Applicant's statement. Wiltshire Council confirmed in their response that “the outline mitigation strategy as it stands is good and acceptable the outline mitigation strategy as it stands is good and acceptable. However, the way we approach the protection of archaeology in Wiltshire, and these things do vary county to county, and we do like to secure the detail of work to be carried out in mitigation prior to the submission of an application.”
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	<i>Post Hearing Note:</i> <i>Please refer to the Applicant's response to Action 10 in the Actions Response Table below.</i> Wiltshire Council also commented that part of their concern related to securing archaeological assets that would be preserved in situ prior to a decision on the Scheme that can be secured through the DCO. In response to comments from Wiltshire Council that the detail of the works to be undertaken need to be set out now, Ms James for the Applicant stated that the AMS already details areas proposed for preservation in situ (i.e. through areas of no development or micro siting). The final mitigation will come down to the detailed design which the Applicant is unable to commit to at this point. The Applicant needs to factor in engineering needs. Ms James highlighted that the AMS provides sufficient scope for what can be mitigated adequately by record and excavation or by preservation in situ. She stated that the Applicant is continuing this discussion with Wiltshire Council and Historic England and would welcome further feedback, and as appropriate will update the document. The Applicant also noted the timescales required to meet the forthcoming deadline needs as set out by the ExA.
4. Hydrology, Flood Risk and Drainage	
4.1 Assessment of flood risk and drainage – impact of PV panel on run-off	The ExA invited the Applicant, Wiltshire Council, and the Environment Agency ("EA") to comment on SLD's submissions Responses to the ExA's second written questions [REP5-130] (Appendix D – Modelling enhanced runoff from solar panels at Lime Down Farm) and section 2.3 (Hydrology) [REP6-081]. The ExA stated it seeks clarification on the extent to which the Applicant's flood risk and drainage assessment has considered those submissions and whether any further assessment, mitigation or management measures are required. The ExA asked the Applicant to display figures 7 and 8 of the Responses to the ExA's second written questions [REP5-130]. The ExA asked for comments on the impact of large tracker panels and their orientation on surface

	water run-off, the proposed use vegetation between the panels to mitigate runoff and potential off-site flood risk, and the potential impact resulting from climate change resilience, given the recent summer of drought. The ExA invited Wiltshire Council to provide comments on those three points. Mr Rohit Singh for Wiltshire Council stated that in previous submissions, Wiltshire Council has required a certain amount of hydrological verification. Mr Singh stated that this does not require detailed hydraulic modelling but Wiltshire Council needs that quantitative assessment. Ms Chalaby for Wiltshire Council stated that Wiltshire Council does not consider this gives rise to a fundamental concern to be addressed at the application stage. She noted that SLD's evidence shows that different assumptions can lead to different conclusions, and that there must be a hydrological verification framework. The ExA asked whether, if there is a potential increase, Wiltshire Council's view is that this can be controlled with appropriate wording in management plans. Mr Joshua Rigby for the Applicant stated that the Applicant is in agreement with the EA and Wiltshire Council apart from the requirement for a separate hydrological verification framework. He explained that the Applicant has reviewed the PV-SMaRT modelling and these form the basis of the control measures within the management plans. Mr Rigby stated that the model considers the soil characteristics, soil bulk density, slope conditions, panel configuration and compaction of the soils and these are controlled through the Outline Soil Resources Management Plan [REP6-035]. Mr Rigby further noted that the Outline Landscape and Ecological Management Plan (Outline LEMP) [REP6-031] controls vegetation establishment and management and the Outline Operational Environmental Management Plan (Outline OEMP) [REP6-031] provides for inspection of erosion, rilling and channelisation and corrective action where required.
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	Mr Rigby stated that it is worth considering the baseline at this site, where there is greater than 90% of agricultural land and the land goes through significant changes every year. Mr Rigby explained that post-construction it will be controlled through the management plans as a grass field and any sign of potential detriment occurring which could accelerate the rate at which rain gets towards the natural catchment is controlled within those plans. The Applicant's position is that whilst it appreciates that Wiltshire Council requires an additional plan, all the impacts or effects that could be caused through the spatial redistribution of surface water around a panel itself are already controlled through the management plans. The ExA asked what the worst case scenario looks like if there is no vegetation coverage as required to help control the flow of water, due to climate change and droughts, and how this is accounted for. Mr Rigby stated that with regards to vegetation coverage and what the impact would be, that would occur with the baseline if the construction was not undertaken. He stated that if there is no vegetation in the baseline because of drought, the situation would be the same. The ExA stated that the Applicant is relying on the vegetation to control run-off so as not to exceed current rates, and asked what happens if the vegetation does not take and how much cover is required to achieve what is required. Mr Rigby stated that the Applicant is relying on the vegetation to take in order to assume it is the same as the baseline. The ExA stated that the baseline is a vacant field and that the Applicant would produce a field covered in panels, which changes how the water reacts. The ExA referred to figures 7 and 8 [REP5-130] and stated that looking at how water would interact, figure 7 shows water coming off and landing in channels. The ExA asked what percentage of vegetation cover is necessary to achieve greenfield run-off.
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	Mr Rigby stated that the mitigation as part of the drainage strategy does rely on coverage of grassland. It is assumed that the grass field is established as part of the construction environmental management. If there is non-taking, remediation measures would be in place, whether that is additional planting and watering, and this would be considered at the time. Mr Rigby stated that the established vegetation would rebound once there is rainfall following any drought period. It would be part of the operational management plan to ensure grassland is re-established. Ms Brodrick for the Applicant added that there are two elements. The first is the activities required for the grassland to establish in the first place, which are provided for in the management plans. Separately, if the grass then turns brown during a drought, the Applicant's position is that the management plans provide for that scenario. Mr Singh for Wiltshire Council stated that the Applicant has not provided a number in respect of the panelled areas for what it has assumed for providing the greenfield rate. He stated that this should be the basis for the Applicant's commitment and the Applicant should aim to maintain this percentage of unimpacted soil and vegetation. The ExA questioned at what point there is an issue with ground coverage before an increase in greenfield run-off rate is experienced, and also detail on an adaptive management plan for the sward. The ExA asked what happens if the sward does not take and extreme weather events continue to be experienced. The ExA asked what would happen if for example, Lime Down A is installed and operated and there is no grass sward as the ground has been cut up by machinery. Mr Christopher Jackson for the Applicant stated that the Outline LEMP [REP6-037] is the control document for all the vegetation across the scheme and that the way the grass establishes is connected to hydrology means it is key that the grass establishes through that control mechanism. Mr Jackson referred to the current wording in the Outline LEMP [REP6-037] and explained this will include an assessment of soil type, pH, nutrient levels which may affect the species that will
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	establish. He stated that the detailed LEMP needs to be materially aligned with the Outline LEMP [REP6-037]. Mr Jackson stated he can see no limitation as to why the approach of that selection and choice of grass species cannot continue throughout the lifetime of the scheme. The LEMP also recognises that poor vegetation establishment can reduce infiltration capacity and increase run-off if unmanaged. The detailed LEMP will need to ensure appropriateness of seed mix and establishment and needs to promote high levels of success. Mr Jackson stated that there is an ongoing management piece in place with all landscape elements, and there is no reason this would not include or prejudice the grass sward beneath the panels. The ExA asked at what point the preparation of the grass sward required for the solar farm takes place. Mr Jackson stated this would start from day one and will be worked into the approach to the construction management plan, including focusing on soil compaction, soil storage on-site, compounds, the HGV movements and soil compaction concerns. As the seasonality progresses, the Applicant will be seeking to get the grass sward established as soon as possible. The ExA asked whether there is a window where the grass sward will not be sufficiently in place. Ms Brodrick for the Applicant stated that the level of detail is not available for the exact sequencing of events. For example, some sites have the inter-array cabling and those are subject to grid connection. There are preferable times for particular works. For example, the Outline LEMP [REP6-037] references preparation of fields before conversion to grasslands and other activities to manage the land in the meantime, such as dealing with agricultural weeds and cereals. Ms Brodrick stated that there are a variety of factors which are site dependent. She confirmed that the Applicant takes on board the point, which she understands to be that if the potential impact is from the day the panel is erected and grassland is established later, what happens in the intervening period, if there is one, to assure being able to maintain the greenfield run-off rate. Ms Brodrick
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	stated that this is separate to the point on whether the grassland later fails, and that Mr Jackson has responded on that point regarding monitoring and replacement. The ExA stated that this would depend on soil types in the particular areas as well. The ExA stated that further details are required at Deadline 7. The ExA requested a comment from the Applicant that links the percentage of vegetation needed to address surface water runoff. The ExA also stated it needs further comments about adaptive management measures to take account of climate resilience, including climate resilience, minimum levels to maintain greenfield run-off rates and whether further SUDS measures need to be considered. Mr Jackson stated that the current wording of the Outline LEMP [REP6-037] is that an inspection will be undertaken in early August in the first year following seeding of grassland at the relevant site of PV sites and inspection will be undertaken by the operating company. Mr Jackson explained that should the proportion of bare ground be greater than 20%, sowing with an appropriate grass and seed mix should be undertaken or repeated in these areas, depending on the initial methodology for grassland creation. The ExA asked whether the 80% figure is linked to hydrology performance. Mr Jackson stated that this is separate within the Outline LEMP [REP6-037] and that it would be looking at the mix underneath the panels independently. He stated that it is not directly linked, but is linked to the performance of plant species. Mr Jackson noted that given the interrelationship of the grass sward and hydrology, there will be a correlation between the two. The ExA asked what happens if the site is finished in January and remediation is not undertaken until August.
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	Mr Jackson confirmed that as currently worded, the review mechanism would be in August. The ExA stated that this needs to be reviewed. <i>Post Hearing Note:</i> <i>Please refer to the Applicant's response to Action 10 in the Actions Response Table below.</i> The ExA noted that Mr Calderbank's submission (Responses to Second Written Questions [REP6-083]) at Deadline 5 raised issues regarding flooding at the two cottages at Foxley by Norton Brook. The ExA asked the Applicant to comment on the impacts at location Area B. Mr Rigby stated that the Applicant's position is that the proposed scheme will not increase or detrimentally impact water run-off offsite and therefore will not have a detrimental impact downstream. The ExA requested the Applicant give a formal response to Mr Calderbank's representation at Deadline 7. <i>Post Hearing Note:</i> <i>Please refer to the Applicant's response to Action 12 in the Actions Response Table below.</i> <i>For clarity, the Applicant does not rely on a fixed percentage of vegetation cover as a hydraulic threshold. The 20% bare-ground trigger referred to in the Outline LEMP is an establishment and management criterion and is not intended to represent the point at which runoff would increase above baseline conditions. Hydrological performance within the panel areas depends on the combined condition of the soil and vegetation, including soil structure and compaction, maintenance of permeable ground and diffuse runoff pathways, and successful establishment and management of the grass sward. These matters are controlled through the Outline Soil Resource</i>
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	<i>Management Plan [REP6-035], Outline Landscape and Ecological Management Plan [REP6-034], Outline Construction Environmental Management Plan [REP6-029] and Outline Operational Environmental Management Plan [REP6-030], including inspection and corrective action where bare ground, erosion, rilling, rutting, compaction or channelised runoff is identified.</i> The ExA asked whether a percentage increase of attenuation needs to be provided through SUDS to cater for climate resilience. Ms Brodrick for the Applicant stated that there is a Water Resources Management Plan and noted that water is currently used for agricultural purposes. The Outline Water Resources Strategy [APP-290] contains indicative information on likely quantities of water required. The final watering regime will be set out in the detailed LEMP on a site-by-site basis. The ExA stated that these matters will be further addressed on Thursday at the ISH7 hearing. Ms Brodrick stated that the Applicant has applied a strategic approach and all the specialists have spoken to one another. The various management plans sit and work together, and the Applicant's view is that a further management plan to cover the same area is not needed. Ms Brodrick stated that a strategic approach has been taken on flood management in conjunction with all the other matters under consideration, considered across the suite of mitigation measures. She stated that the holistic approach will be evidenced in the various management documents. Mr Rigby stated that the PV Smart calculation undertaken is analogous with the methodology the Applicant has applied. Run-off is controlled by the condition of the soil and vegetation between the panels. The site requires a good grass sward to not have detrimental impacts off-site. Mr Rigby noted that the catchment is predominantly agricultural land, the condition and vegetation cover of which varies seasonally as part of the existing baseline which is the current baseline situation that the site faces and will continue to face if the scheme does not come forward. The construction and environmental management plan does have a surface water management aspect to it. If corrective measures are required during extreme events, this will be managed as part of that plan. Mr Rigby
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	stated that the Applicant has silt and sediment controls, protection for drainage and temporary drainage measures for the disposal of potentially contaminated water. The Applicant has to return the site to existing use post-decommissioning. Mr Rigby stated that implementing hard drainage features, which could involve excavation and importing gravel, all of which would need to be taken away post-construction, would not seem conducive to this operation. The research the Applicant has relied on shows that the scheme will not have material impacts as long as the grass sward is in place. Mr Rigby suggested that grass swards are a form of SUDS. Applying extra built SUDS features with little benefit which need to be removed post-operation would not seem conducive to this operation. The Applicant is implementing positive drainage measures including blue-green SUDS, which will be drain and filter features complying with Wiltshire Council's policy requirements. Mr Rigby stated that the Applicant does not disagree that panels can distribute surface water directly around them, but the Applicant's research suggests that as it hits the ground, if it is an improved grass sward, it would run off, infiltrate and would pass more equitably across the landscape as it currently would.
4.2 Assessment of Flood Risk and Drainage – Lime Down D	The ExA asked the EA for an update on the hydraulic review. Mr Sale for the EA stated that the EA has reviewed the hydraulic model for Gauze Brook. The EA is broadly happy with the estimation of flood flows although it did raise a comment regarding verifying the hydrograph shape applied within the model. Mr Sale stated that the Applicant has used an un-gauged method and that the rationale for that is because of measurement uncertainty, so the EA has asked the Applicant to carry out some checks on the flood flow hydrograph. Mr Sale noted that the Applicant provided a response which looks reasonable and noted SLD's comments on the peak flows at the Rodbourne gauge. He stated that the gauge is uncertain in its measurement accuracy at high flows. Mr Sale stated that this is something for the Applicant to explore in terms of the modelled flows against the observed flows and placing that in the context of the development proposals as well as the freeboard allowance. In respect of the model construct itself, Mr Sale stated that the Applicant has addressed some of the points the EA made related to the South Wales Main Line bridge, which the EA is happy with. The updated model for the watercourse

	crossing between Norton and Chadlington requires clarification as to the reason it is lower than the previous submission. Mr Sale noted a reporting point, stating that the latest Flood Risk Assessment for Lime Down D ES Volume 3, Appendix 11-6: Flood Risk Assessment and Outline Drainage Strategy – Lime Down D [REP5-055]) does not reflect the results of the latest modelling and seems to reflect the previous version of the hydraulic model. He asked that the Applicant updates this and considers the comments in relation to design flow estimates, appreciating the uncertainty with the Rodbourne gauge measurement. Mr Rigby stated that in respect of the downstream gauge for the Rodbourne gauge, the Applicant will update the report to reflect the discussion and extra information. The additional crossing with a lower level is due to additional survey and will come out in the updated version of the hydraulic modelling report. Mr Rigby confirmed that the Lime Down D flood risk assessment appendix (ES Volume 3, Appendix 11-6: Flood Risk Assessment and Outline Drainage Strategy – Lime Down D [REP5-055]) will be updated, noting that the previous version was due to the timing of the submissions. Overall, Mr Rigby stated that the hydraulic model, as will be presented with the slight changes which are representative rather than changing the model, is representative of the actual flood risk. The Applicant does not expect the results of the model to change. <i>Post Hearing Note</i> <i>Please refer to the Applicant's response to Action 15 in the Actions Response Table below.</i> The ExA asked whether this will be resolved by Deadline 7. Mr Rigby confirmed that there is ongoing dialogue and that these are administrative issues which the Applicant will close off. The EA confirmed this could be resolved by Deadline 7. The ExA asked whether this is an issue in the SoCG. Mr Rigby stated that the remaining points are open and will be closed off in the latest version of the SoCG.
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	<i>Post Hearing Note</i> <i>Please refer to the Applicant's response to Action 13 and Action 14 in the Actions Response Table below.</i> The ExA noted that in the EA's Comments on any submissions received at deadline 5 [REP6-074], the EA stated it was unclear whether the predicted flood impact to the proposed development had changed following the updated hydraulic modelling. The ExA asked whether this will be updated. Mr Rigby confirmed that this will be updated. Ms Reynolds asked why the Applicant would not test its model against this available data, noting the Applicant's approach aligns with guidance. In response to comments from other parties about the hydraulic modelling, Mr Rigby stated that there is always some uncertainty built into hydrology modelling, including using a 1 in 100 year storm as a design event. He noted that the responsiveness of a catchment depends on where rainfall is inputted, at what time, for how long, what the antecedent conditions are, and all of those things are infinitely variable. Mr Rigby stated that this is why the Applicant applies standard hydraulic methodologies to ensure decisions can be made on what is being designed against. To deal with that uncertainty, the Applicant builds in sensitivity tests based on accepted methodology using ungauged catchments and changes the parameters that could impact flows and levels. Mr Rigby stated that the flood risk depends on how much water is put in. The Applicant has applied four different sensitivity tests, depending on how quickly the water travels, including +/- 20% roughness, +/- 20% flows, additional rainfall on top and +/- 30% downstream boundary conditions. Mr Rigby stated that the modelling is as robust as what can be put into it. The Applicant has done this per guidance and in consultation with the EA.
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	The ExA raised a potential action point following discussions with the EA and the potential to update the outline drainage strategy and supporting figures. <i>Post Hearing Note:</i> <i>Please refer to the Applicant's response to Action 15 in the Actions Response Table below.</i> The ExA turned to the Lime Down D – Natural Flood Management Viability Report [REP5-109]. The ExA stated that Wiltshire Council, the EA and SLD to comment on the report and its conclusions (Lime Down D – Natural Flood Management Viability Report [REP5-109]). The ExA asked whether the parties agree with the Applicant. The ExA noted that the wording in the NPS does not require natural flood management but that SUDS are required. The ExA requested a post-hearing note from Wiltshire Council to include its view on the policy position of the implementation of natural flood management measures. In response to comments from Wiltshire Council and Stop Lime Down, Mr Rigby stated that Lime Down D was chosen specifically for the hydraulic model due to the proximity to Corsham and it being immediately downstream of the site, and as this has the potentially greatest positive impact on the community. The work the Applicant carried out showed that to have a meaningful impact, the Applicant would have to control the course at 8 metres, which is a significant volume of water. The Applicant ran the Q30 following conversations with the EA and this showed that natural flood management did not have a material impact. During the lower flows, the downstream sensitive receptors do not flood, so there is no reason to install natural flood management. Mr Rigby stated that the Applicant has not assessed the other sites for net positive natural flood management, but there is potential flooding prevention. Mr Rigby explained that the remoteness of most of the sites, the impacts of any minor retention of water has no meaningful impact off-site and that retaining water on a site such as the Lime Down
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	schemes rather than allowing it to pass through would not be a wider community benefit. Mr Rigby stated that the embedded mitigation set out in the hydrology flood risk ES chapter considers the embedded mitigation. The improved grassland would be the definition of a SUDS measure and could be classified as a natural flood intervention. The amount of water that would need to be retained on the site is not possible as it is such a low percentage of the total size of the catchment. The Applicant has further developed the model but there are only hard interventions available. The Applicant is making that available to the public to develop. The ExA noted that the EA commented on [REP5-109] and the EA to clarify its position. Mr Sale for the EA stated that it is difficult to understand whether there was a change in water level. He stated it would be helpful to present the information as a difference in water levels rather than just the differences in extent, and to place it in the context of run-off. Mr Rigby stated that the Applicant has already produced the depth difference maps, which will be submitted at Deadline 7 for Lime Down D. With regards to more frequent storm events, the Applicant has run the 3.3% annual probability storm as a lower return period storm. Mr Rigby stated that the Applicant will run a smaller storm to further supplement that and to capture more frequent storm events. The ExA requested that those figures be submitted for Deadline 7. <i>Post Hearing Note:</i> <i>Please refer to the Applicant's response to Action 17 in the Actions Response Table below.</i> The ExA invited the parties to comment on the potential effects of sewage flows discharged into the Gauze Brook. The ExA asked whether Wiltshire Council is aware of any sewage flows in the area or whether it wishes to defer. Mr Singh stated that Wiltshire Council will defer to Wessex Water. SLD also stated that Wessex Water should know what the flow is.
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	Ms Brodrick stated that the Applicant has had meetings with Wessex Water and made them aware of questions raised by SLD, but the Applicant cannot compel them to respond. Ms Brodrick noted that the ExA may wish to request information from Wessex Water directly if it considers it useful. Mr Rigby stated that this is the reason the Applicant has sensitivity testing built within the hydrology testing. He noted that wastewater treatment is relatively common. The Applicant has asked for Wessex Water's permitted discharge. Mr Rigby stated that the Applicant considers the impact on its assessment is extremely low. The ExA turned to the functional floodplain in Lime Down D. The ExA invited the Applicant to explain how the outputs of its hydraulic modelling inform its conclusions regarding the extent and treatment of functional floodplain within Lime Down D and how this has informed the Design Principles and Parameters [REP4-043]. The ExA asked the Applicant to set out how the outputs of the hydrology modelling informed its conclusions regarding the extent and treatment of functional floodplain within Lime Down D. Mr Rigby stated that the placement and layout of the proposed development is determined by embedded mitigation within the hydrology flood risk ES chapter. He referred to the interaction with the built environment and noted the Applicant has undertaken full detailed hydraulic modelling to determine what the flood zone 3B extent is, as that is not available on the EA flood maps. Mr Rigby stated that the Applicant then applied those embedded mitigations, but where they cannot be taken out of the flood zones, the Applicant has controls such as the freeboard. He confirmed that flood zone 3B has only a small amount of interaction with the panels and that the panels need to be a minimum of 600mm above the 1/100 year plus climate change flood extent. The ExA noted that in the Deadline 6 submissions (Applicant's Response to Submissions Received at Deadline 5[REP6-060]) the Applicant stated that the substations have been
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	sequentially located within Flood Zone 1 and no flood-sensitive electrical infrastructure is proposed within Flood Zone 3B. The ExA queried how this is secured within the DCO. Ms Brodrick stated that the various measures are set out in the Design Principles and Parameters [REP4-043] in terms of substations and other infrastructure. The ExA asked whether the Applicant has identified a list of plant and equipment critical for operations that will not be located in Flood Zone 3B. Mr Rigby stated that it would be part of the management plans where the locations of the proposed equipment and stockpiles are all located sequentially within the development where practicable. He noted that it is not always possible to locate all plant and equipment outside the flood zone, but the construction environmental management plan requires a flood response plan. Mr Rigby stated that plant and equipment would be stored outside Flood Zone 3 when not in use, although temporary construction plant may need to operate within flood-risk areas where necessary, subject to the controls within the Construction Environmental Management Plan and Flood Response Plan. Mr Singh for Wiltshire Council stated that the Applicant should not cause any detriment to the floodplain's storage and that risk should not be increased elsewhere. He noted that the EA has an extensive knowledge base of the floodplain and how much the Applicant should provide. Mr Singh stated that he will defer to the EA. Mr Sale for the EA stated that the Applicant is correct and that the EA has simulated the 3.3% annual probability event and understands the Applicant will only place panel legs in the functional floodplain. The EA has carried out an assessment of the volumetric impact of those panel legs and the storage loss is negligible. Mr Sale noted that there will be a point on the model verification. In terms of the sequential approach during the operational phase, the EA is happy with that. The EA recognised the need to have plant within that area during construction, which can be dealt with in
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	the emergency response plan. Mr Sale stated that the EA has a comment on substation Lime Down C, but is broadly content that the storage loss and leg supports have been adequately assessed. The ExA asked where in the Design Principles and Parameters [REP4-043] this is located. Ms Brodrick stated that the Design Principles and Parameters [REP4-043] secures the floodplain and other measures. She referred to page 10, table 2.2, which relates to the BESS and the annual exceedance probability. Ms Brodrick stated that there is wording on the mounting structures point. In the Outline CEMP [REP6-029], at pages 27 and 28, there is wording in relation to temporary stockpiles, materials and plant. Ms Brodrick stated that the Applicant can add a specific reference. The ExA stated that it would be useful to have the siting of the BESS and substation explicitly in the Design Principles and Parameters [REP4-043], and requested that this be added for Deadline 7. <i>Post Hearing Note:</i> <i>Please refer to the Applicant's response to Action 18 in the Actions Response Table below.</i> The ExA stated that the construction environmental management plan and operational management plans should reflect protection of Flood Zone 3B as well. Ms Brodrick stated that in respect of storage and plant materials, there is already wording in the outline documents. She asked that Wiltshire Council provide additional wording if required so that it can be added to the plan. Ms Brodrick stated that the Applicant can then consider the proposed wording but believes the management plans achieve the protections required.
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	The ExA invited Wiltshire Council to set out its position on the ordinary watercourse between fields D22 and D1, including any implications for drainage design, flood risk assessment or consents and an update following the submission of Deadline 6. Mr Singh for Wiltshire Council stated that Wiltshire Council understands fields D22 and D1 form part of the local ordinary watercourse network and that no increase in flood risk arises. He noted that the scheme incorporates waterflow buffer zones and water management plans and issue controls. Mr Singh stated that Wiltshire Council expects appropriate maintenance access to be retained and that interaction with the watercourse should be subject to Wiltshire Council's consent. He confirmed that Wiltshire Council does not consider the watercourse to represent a fundamental constraint to the scheme, provided any interaction with the watercourse is appropriately addressed, designed and managed through the detailed design process and approvals. In response Mr Rigby confirmed that the watercourse has been considered throughout the development and that this is why there is a separation. This has been subject to the Scheme's protection measures in the same way and the Design Principles and Parameters [REP4-043] require existing drainage corridors and conveyance to be maintained and watercourses protected from inappropriate development. He further stated that the buffers in the watercourses ensure that the watercourse's flow route is maintained. Proposed crossings would be subject to the relevant controls and approvals contained in the protective provisions of the Draft DCO [REP6-005]. Mr Rigby explained that the Applicant has been in discussions about disapplying the ordinary watercourse permitting regime to ensure that it is working through the crossings efficiently. The protective provisions provide the relevant mechanisms for Wiltshire Council to maintain control over the watercourse. In response to comments from Mr Singh that no mechanisms have been provided for the disapplication of the provisions of the Land Drainage Act, Ms Brodrick stated that the protective provisions are included in Part 9 of Schedule 15 and that the mechanism is already there. She
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	noted that Wiltshire Council may need to check internally as the Applicant was under the impression this was already agreed. The ExA stated that this matter should be discussed further at the DCO hearing the following week and updated in the SoCG.
4.3 Assessment of Flood Risk and Drainage - Lime Down C	The ExA invited the Applicant to explain the location of the substation in Lime Down C1 and where matters stand in respect of its siting. Mr Rigby for the Applicant stated that the substation has been located with regards to the electrical design of the scheme and considered with the flood risk identified and assessed within ES Volume 3, Appendix 11-4: Flood Risk Assessment and Outline Drainage Strategy – Lime Down C1 [REP6-010]. Mr Rigby noted that field C33 is located wholly within Flood Zone 1 and that the more localised issue is a surface water flow route running generally west to east across the southern extent of the site. Mr Rigby explained that the mapped flood depths along that route are predominantly shallow, generally below 300 mm and not exceeding 600 mm. When producing the reports, the Applicant did not have sight of the EA's updated NaFRA2 surface water flood mapping. Mr Rigby stated that the updated mapping does not materially alter the Applicant's assessment. At detailed design stage, once the Applicant has the actual layout of that development, this will require ground level changes at the northern end of the site and if that still interacts with the flow route the Applicant will need to maintain the conveyance of the flood storage and provide compensation. Mr Rigby stated that those measures will be secured through Requirement 5 within the detailed drainage measures secured through Requirement 11 of the Draft DCO [REP6-005]. On that basis, the Applicant believes the existing flood risks are manageable and that the risk to any proposed substation will be low. The ExA asked the EA to confirm whether it still needs a new requirement to cover this matter or would updates to the design principles and parameters document address concerns.

	Mr Sale for the EA stated that the EA being consulted at the detailed design stage would be sufficient where practicable and confirmed that what the Applicant has said is positive. Mr Sale stated that the EA will need to provide response in writing and the main issue is having the mechanism to be consulted at the detailed design stage. The ExA asked the Applicant if this can this be built into the submission. Ms Brodrick stated the Applicant would take this point away given the EA is already being consulted on Requirement 11. The ExA stated it would be helpful to have this in the SoCG and to be resolved by Deadline 7. <i>Post Hearing Note:</i> <i>Please refer to the Applicant's response to Action Point 19 in the Actions Point Table below.</i> In response to comments from Mr Singh on the need for monitoring, Ms Brodrick stated that monitoring is included in the management plans and therefore there is no separate need to have a monitoring obligation on the face of the DCO. The ExA invited the Applicant to explain what assessment has been undertaken to understand and address flood risk at Farleaze Farm, including any assumptions, discussions with Network Rail, and proposed mitigation or management measures. Mr Rigby stated that the Applicant has considered the topography, map surface water pathways and drainage features around the farm. He stated that the existing mapping corresponds to the local low flood point. Mr Rigby confirmed that the Applicant understands there are existing drains and conveyance issues which predate the scheme and that this is an existing issue. He stated that
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	whether the Scheme will have an issue hinges on whether it will increase surface run-off. The Applicant's assessment is that it would not. Mr Rigby stated that the solar fields remain predominantly permeable and vegetated at existing ground level and that drainage pathways exist. Accordingly, as the Applicant's assessment is that the Scheme will not increase surface water runoff from the site, the Scheme is not expected to exacerbate the existing flood risk at Farleaze Farm. Mr Rigby addressed the position with regard to Network Rail and stated that there has been engagement with Network Rail regarding the wider Scheme interface and protective provisions. The Applicant understands that the works currently being undertaken relate to piling and strengthening of the embankment rather than drainage works. The Applicant has sought further information regarding the railway drainage system and relevant drainage assets affecting Farleaze Farm, including the relationship between any culverts, inlets and outlets and the existing conveyance arrangements. Mr Rigby noted that these assets are outside the Order limits but remain relevant to understanding the existing drainage conditions at Farleaze Farm. The ExA noted that this issue is not covered in the SoCG with Network Rail and requested that this be added to the SoCG. Ms Brodrick stated that the Applicant can see if Network Rail will confirm that the current works it is undertaking are not drainage related. She noted that Network Rail would be unlikely to confirm in the SoCG that its infrastructure is the cause of the flooding at Farleaze Farm. The ExA requested that the Applicant try and include some of this matter in the SoCG. <i>Post Hearing Note:</i> <i>Please refer to the Applicant's response to Action 20 in the Actions Response Table below.</i>
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	Mr Singh for Wiltshire Council stated that it is important that for properties directly downstream from the proposed site, flooding is likely to be exacerbated if the Applicant does not have a proper monitoring and verification framework. He stated that the property is in a low-lying area, and if the run-off is uncontrolled it is likely to worsen the existing flooding. Mr Singh suggested that the Applicant identifies similar properties in the low-lying area which receive run-off from the Applicant's site and that the monitoring plan should include such properties. The ExA stated that it understands the Applicant's position is that it is not causing flooding off-site. The ExA noted that if Wiltshire Council thinks the evidence shows something different, it will need to be brought before the hearing. The ExA asked whether Wiltshire Council has anything to add in respect of Farleaze Farm in particular. Mr Singh confirmed not. In response to comments from Mr Skeffington that the Farleaze Farm is built on well-drained Sherbourne series, but the land around is on the soil series which is vulnerable to excess runoff, Mr Rigby stated that the controlling mechanism at Farleaze Farm is the culvert inlet and outlet for a pond during significant rainfall events. He stated that the Applicant saw this when it visited Farleaze Farm. Mr Rigby explained that there is a restriction at a particular point from a culvert, which is why the surface water is retained behind a slightly lower paddock. The ExA requested a post-hearing submission on Farleaze Farm being built on the free-draining soil type and the less porous soil type surrounding it, and the ponding on that land. <i>Post hearing note:</i> <i>Please refer to the Applicant's response to Action 21 in the Actions Response Table below.</i>
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4.4 Impact Management - Hydrological Verification Framework	The ExA suggested that this item could be moved to Thursday and the parties agreed. Ms Brodrick stated that the Applicant is seeking to understand what measures Wiltshire Council is looking for that are not incorporated in the management plans, and that the Applicant would like to deal with specifics. The ExA requested that Wiltshire Council come to the hearing with that information.
4.5 Integration of Sustainable Drainage Systems ("SUDS") and Landscape	The ExA stated that natural flood management has already been discussed, but invited the Applicant to explain how SUDS have been integrated with other aspects of the development such as open space or green infrastructure to ensure an efficient use of the site. The Applicant was also invited to explain how the Design Principles and Parameters respond to paragraph 5.8.15, bullet point 11(6) of the Overarching National Policy Statement for energy (NPS EN-1). Mr Rigby stated that the scheme takes a proportionate approach to SUDS as there are two different drainage conditions across the development. Firstly, the land beneath the solar panels are areas which remain predominantly permeable and vegetated and rainfall is not collected into a conventional sealed drainage network but continues to drain diffusely across the predominantly permeable and vegetated ground. The managed ground therefore continues to provide the source control through diffused drainage, surface roughness and attenuation with infiltration where ground conditions allow. Mr Rigby stated that the Applicant therefore does not propose engineered SUDS across every panel. Mr Rigby further stated that adding basins, pipes or formal drainage beneath the arrays would provide little benefit in those areas and would introduce additional disturbance and infrastructure into the land, which is intended to ultimately return to agricultural use. Secondly, Mr Rigby stated that the second condition is the positively drained infrastructure, principally the substation, BESS and associated hardstanding. He explained that those areas create defined drainage catchments, and the Flood Risk Assessment and Outline Drainage Strategy [REP4-021, REP5-047 to REP5-050, REP6-010, REP5-053 to REP5-060 and REP3-063] commits to formal SUDS and establishes the hydraulic and water quality performance that those systems must

	achieve. Mr Rigby stated that the Applicant cannot sensibly fix now the final size, type and location of each SUDS component, as the final infrastructure layouts, hardstanding areas, contributing drainage catchment, levels and discharge arrangements are not yet known. While the engineering geometry follows a detailed design stage, the final drainage scheme is secured through requirement 11 of the Draft DCO [REP6-005] and must be substantially in accordance with the Outline Drainage Strategy [REP4-021, REP5-047 to REP5-050, REP6-010, REP5-053 to REP5-060 and REP3-063]. Mr Rigby stated that this is when blue-green infrastructure benefit can be maximised. Where practicable, above-ground features such as swales, basins or ponds can provide attenuation and deliver water quality treatment, vegetation, habitat and landscape benefits. The ExA requested confirmation in respect of the Outline Drainage Strategy [REP4-021, REP5-047 to REP5-050, REP6-010, REP5-053 to REP5-060 and REP3-063]. The ExA noted that the Outline Drainage Strategy [REP4-021, REP5-047 to REP5-050, REP6-010, REP5-053 to REP5-060 and REP3-063] explains that SUDS are feasible, but the sketches do not reflect these options and only refer to porous and permeable surfacing. The ExA asked whether the sketches should be reviewed to allow for other options. Mr Rigby stated that the sketch is purely to show what is feasible in that area. The calculation is based on the hard standing area that is contributing to it and the discharge rate at which the Applicant is allowed to discharge from it. Mr Rigby stated that the exact attenuation benefit cannot be known. Mr Rigby further stated that an effective drainage system retains water as close to where it is captured as possible, so the individual pond or swale features accommodate for the entire attenuation requirement. He stated that the sketches are necessarily vague and show an area that could be implemented on the scheme, but the Applicant is constrained by the level of detail available. Mr Rigby stated that if features are shown on the plans which are estimates, that risks the Applicant not being able to achieve the optimal drainage system. The ExA asked for clarification on how those measures are secured through the detailed design.
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	Mr Rigby stated that the detailed drainage scheme is secured through requirement 11 of the Draft DCO [REP6-005], which requires it to be substantially in accordance with the Outline Drainage Strategy and to be approved. The additional measures within the BESS are within the outline battery safety management plan and secured through requirement 6. The ExA noted that in response to EXQ1 [FHW 2.2] (Applicant's Response to the Examining Authority's First Written Questions [REP3-128]) the Applicant stated that rainwater harvesting has been reconsidered as a potential supplementary measure. The ExA asked the Applicant to explain how rainwater will be harvested to support landscape establishment and how this will be secured through the drainage strategy. Mr Rigby stated that rainwater harvesting is not considered an effective attenuation measure because it is designed to fill up a tank with an inlet at the top and an outlet top, to store water for as long as possible until it is used. He stated that the issue with this is that you would want the attenuation tank to be empty at the time of a storm event to provide the attenuation required. A rainwater harvest tank is filled up until the water is used. The drainage strategy at the time considered it as part of the overall strategy to be used. It would be used as and when necessary, when the operator requires water for permissible uses. During landscape establishment, it depends on when the drainage system has been implemented and whether it is required to supplement. Mr Rigby stated that there is no reason it could not be used as soon as it is installed. The ExA asked for clarification on the Applicant's approach to rainwater harvesting following its response to ExQ1. Mr Rigby stated that the Applicant has always considered rainwater harvesting as part of the drainage system. If required during operation, it will be installed. If it is decided there is no use for
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	the water, a discussion will be had with the consenting authority, but the Applicant is not removing it. The ExA asked whether rainwater harvesting should not be referred to in the drainage strategy. Mr Rigby stated that the drainage strategy gives operationality. He stated he would not suggest removing any potential option until the specific operation on that site is known. Mr Rigby stated that this is why the full SUDS hierarchy and measures are provided, so that the SUDS options considered are still there and designers have the option to use them. Mr Rigby stated that the wording in the drainage strategy means rainwater harvesting is not part of the attenuation system. If the Applicant determines it needs to provide a certain amount of storage, it would not use the rainwater storage. He stated that it is not part of the attenuation system, but it is part of the drainage system. The ExA asked the Applicant to update the wording of the drainage strategy. Mr Rigby confirmed that the Applicant will clarify this point in the drainage strategy. <i>Post Hearing Note:</i> <i>Please refer to the Applicant's response to Actions 25 and 26 in the Actions Response Table below.</i> The ExA raised a question regarding the Applicant's discussion with Wiltshire Council on how to apply the betterment rates and calculate the volume of attenuation. Mr Rigby stated that the methodology is well understood. Wiltshire Council requires the Applicant to restrict discharge rates and provide attenuation up to the 1 in 100 year plus climate change rates.
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	Mr Rigby stated that the Applicant is following Wiltshire Council's policies and that this is detailed in the drainage strategies and is secured through the requirement. The ExA asked Wiltshire Council for its comments on SUDS integration and the outline drainage strategies in respect of integration in the landscape. Mr Rigby stated that this point has been discussed and the Applicant has established its position. Given the evidence provided to Wiltshire Council and SLD, the Applicant's position is that the grass sward and management plans will ensure that the surface flood risk will not be exacerbated. Mr Rigby stated that the addition of built SUDS and hard interventions will have a significant impact on the proposed development and on returning it to use post-decommissioning. The ExA asked whether Wiltshire Council will have the opportunity to review the SUDS proposals at the detailed design stage. Ms Brodrick for the Applicant confirmed this and stated that Requirement 11 of the Draft DCO [REP6-005] in terms of the detailed drainage strategy has been approved by Wiltshire Council and to the extent they are integrated drainage systems with other green infrastructure, that is part of the Outline LEMP [REP6-037] which is approved by the planning authority. She stated that there is a limit to the available information at this time and the Applicant does not consider it is necessary for the ExA and the Secretary of State to have that level of detail because the commitments being made will ensure the outcomes are consistent with the EIA. Ms Brodrick stated that the Applicant will take away how it will monitor and ensure the effectiveness of the grass swards. The ExA asked Wiltshire Council to comment on betterment rates. Mr Singh for Wiltshire Council stated that Wiltshire Council's standard position is 30% betterment from developers. He noted that this is normally for conventional developments and that this is a
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	solar park with panelled areas and infrastructure areas. Mr Singh stated that Wiltshire Council would need 30% betterment in Lime Down D and E, but in Lime Down A, B and C, while Wiltshire Council would encourage betterment, that is not part of its policy. Mr Rigby explained that the Applicant has stated Wiltshire Council's policy verbatim in the drainage strategy examples. The Applicant has committed to 30% betterment over the greenfield run-off rates. Mr Rigby stated that the Applicant has committed to applying 30% betterment over greenfield runoff rates within the positively drained areas where this is required by the relevant drainage strategy. Ms Laura Edwards for the EA stated that the EA is aligned with the Applicant's SUDS position, as was written in the EA's Responses to the ExA's first written questions [REP3-146] where the Applicant improved sediment controls. The EA was satisfied with that approach. Ms Edwards noted that the EA is not named in the relevant requirements. She confirmed that the EA is satisfied from a water quality perspective and that from a flood risk perspective the EA defers to Wiltshire Council.
4.6 Water Quality - Water Framework Directive	The ExA requested an update on the water framework directive and invited the EA invited to set out its position regarding the thermal implications of cables on sensitive groundwater receptors. The ExA stated that the discussion will include how to secure a mechanism for the assessment of thermal impacts and micro-siting of the cable route. Ms Susie Bateson for the EA stated that the EA has reviewed the documents submitted at Deadline 6 by the Applicant, including [REP6-029] which is the updated Outline CEMP including the Groundwater Monitoring Plan, and the latest version of ES Volume 1, Chapter 19: Ground Conditions [REP5-026]. Ms Bateson stated that the document provides that the micro-routing of the cables will ensure no potable supplies, meaning the source protection zone one or sensitive groundwater-dependent terrestrial ecosystems, will be within 50 metres of the cables. A hydrogeological risk assessment will be completed if the plan is to locate cables within 50 metres of

	these receptors and if any previously unidentified risk to groundwater receptors emerged during detailed design [REP2-029] in consultation with the EA. Ms Bateson stated that the EA feels this and the groundwater monitoring plan are sufficient to resolve this issue. She noted she is unsure whether the Applicant has seen the EA's responses. Mr Dan Maher for the Applicant stated that the Applicant welcomes the comments from the EA and will ensure the SoCG is updated to reflect the new position. <i>Post Hearing Note:</i> <i>It has been clarified with the Environment Agency that the approach as described in ES Volume 1, Chapter 19: Ground Conditions [REP5-26] and the Outline CEMP [REP6-029] will be to route cables to avoid contact with groundwater within SPZ or within 50m of an abstraction point. This has been agreed and accepted by the EA in a subsequent call.</i> In response to comments from Mr Skeffington and the EA on thermal implications of cabling, Mr Maher confirmed that the potential environmental effects of different cables will be considered and that cable selection will be part of the solution applied. <i>Post Hearing Note:</i> <i>The approach to assessing thermal pollution risks has been agreed with the EA in the SoCG and is secured via the CEMP. The applicant recognises the sensitivity of the groundwater resources within the order limits and has committed to ensuring that no unacceptable impacts to groundwater will occur. Ground investigation will be undertaken to confirm the understanding of the geology and hydrogeological risk assessment undertaken in key locations in order to inform detailed design and cable selection.</i>
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4.7 Horizontal Directional Drilling (“HDD”) Position Between Wiltshire Council and the Applicant	The ExA invited Wiltshire Council and the Applicant to set out their respective positions on the use of HDD, including any outstanding matters concerning assessment, construction methodology, environmental effects or the securing of mitigation. Mr Singh for Wiltshire Council stated that Wiltshire Council broadly supports the use of HDD at environmentally sensitive crossings where it can reduce impacts on watercourses, groundwater, flood risks and ecological receptors compared to open cut methods. He stated that Wiltshire Council's primary interest is ensuring that cross-cutting risks are appropriately assessed. Mr Singh confirmed that Wiltshire Council does not object in principle to HDD but that matters related to detailed implementation and approval would need to be addressed. Mr William Barrett for the Applicant stated that in the SoCG this is referred to at item 3.7.9, which is a summary of what Mr Singh for Wiltshire Council provided. On monitoring and controls, Mr Barrett stated that the Applicant agrees this is an important element of HDD crossings and referred to the monitoring commitments set out in the Outline CEMP [REP6-029]. He noted that another reference relevant to HDD is the preliminary geotechnical risk registers, which takes a closer look at HDD in respect to ground conditions and ground water (Cable Route Avoidance Areas – Preliminary Geotechnical Risk Register [REP1-129]). The ExA stated that further HDD questions will be referred back at the ISH7 hearing with the ecology specialists and requested that EA attend this hearing.
5. Other Matters if required	The ExA stated that in respect of Farleaze Farm, Mr Seymour-Williams should provide his response as soon as possible. The ExA noted that the recording should be published on Friday and that the ExA wants comments from the Applicant by Deadline 7. Ms Brodrick asked that a copy be provided directly to the Applicant by SLD. Ms Reynolds for SLD stated that Mr Seymour-Williams is providing his submission in his own capacity but that SLD can ask him to provide a copy.

	The ExA stated that it is important that Mr Seymour-Williams does so as it is in his interest to make the submission and pass it on to the Applicant as soon as possible. <i>Post Hearing Note:</i> <i>Please refer to the Applicant's response to Action 23 in the Actions Response Table below.</i>
6. Review of the issues and action arising	The ExA confirmed that the deadline for submissions is Deadline 7, 2 October 2026, with the exception of Mr Seymour-Williams.
7. Close of hearing	Post hearing notes and documents required for deadline 7. The ExA thanked the parties for their contributions to the proceedings and closed the hearing at 18:06.

2 List of Actions for the Applicant and Other Parties following Issue Specific Hearing 5

Number	Responsible party	Action	Submission deadline	Applicant's response / commentary
1.	Wiltshire Council, Cotswolds National Landscape Board, Natural England	To provide comments on the Applicant's updated Tranquillity Assessment [REP5-099].	D7	N/A
2.	Natural England	To provide comment on the implications of the modification of the EIA Agriculture Regulations 2006, under article 6(4) of the dDCO [REP6-005] with regards to the wildflower meadows at decommissioning.	D7	N/A
3.	Wiltshire Council, Stop Lime Down	To provide specific details of where sensitivity and/ or magnitude of change has been downplayed in the sequential visual assessment and the	D7	N/A

Number	Responsible party	Action	Submission deadline	Applicant's response / commentary
		implications that this would have on the conclusions on the assessment.		
4.	Applicant	To respond to the detailed comments Ms Tinkler (SLD) made on the sequential visual assessment of the route named SLD Route 2 in the Additional Sequential Visual Assessments [REP6-062].	D7	The Applicant's response to the detailed comments provided by Stop Lime in relation to the sequential visual assessment is set out in Appendix B of this written summary.
5.	Applicant	To update the text of the Additional Sequential Visual Assessment [REP6-062] to cross-reference viewpoint photography and additional photography in appendix 2 of the same document.	D7	The Applicant has updated the Sequential Visual Assessment [EN010168/EXAM/9.71] (Revision 2) to cross-reference the viewpoint photography and additional photography in Appendix 2 of the same document.
6.	Applicant	Continue trying to engage with Badminton Airfield on potential glint and glare impacts on aviation and provide update to ExA.	D7	The Applicant has sought to engage with the Badminton Airfield but at the time of writing has not been able to make contact with the operator to discuss the potential glint and glare impacts on aviation.

Number	Responsible party	Action	Submission deadline	Applicant's response / commentary
				The Applicant will continue to attempt to engage with the Badminton Airfield, and provide an update in the Applicant's Closing Statement, to be submitted at Deadline 8.
7.	Applicant	To review possible alterations to the oCEMP to include additional measures for airfield operators to operationally accommodate the predicted glare effects and a requirement for consultation to take place with the Airfield Operator(s) as part of the approval process.	D7	Table 17 of the Outline CEMP [EN010168/APP/7.12] (Revision 8) has been updated to add a requirement to inform aerodrome operators of predicted 'yellow' glare.
8.	SLD	To provide specific details of the road and rail receptors that SLD consider should be allocated a different sensitivity and whether this would result in a different effect to that determined by the applicant.	D7	N/A

Number	Responsible party	Action	Submission deadline	Applicant's response / commentary
9.	Applicant	To provide a side-by-side comparison of the pager power and forge solar modelling results demonstrating that both models lead to similar results.	D7	A side by side comparison of the Pager Power and Forge Solar modelling is out in Appendix D of this written summary. As demonstrated, the modelling comparison examples show that both models produce substantially similar results, and using an alternative model for the assessment would not affect the report conclusions or mitigation recommendations. As the models were both developed independently of each other, there are minor differences in the modelling assumptions. In some circumstances, this leads to slightly different times and durations of glare, but the results overall remain comparable. As demonstrated in the example charts, the modelling outputs predict glare occurring at a similar time of day and year, demonstrating that using an alternative model would not result in changes to the report conclusions. Overall, it is considered that the comparison demonstrates the substantial similarity in modelling outputs between the Pager Power and Forge Solar models and shows that these two

Number	Responsible party	Action	Submission deadline	Applicant's response / commentary
				models, developed independently, would both produce the same overall conclusions when utilised alongside the methodology of Pager Power's Glint and Glare Guidance.
10.	Applicant, Wiltshire Council, Historic England	Parties to progress discussions on the outline Archaeological Mitigation Strategy (oAMS) and clarify: • The specific detail and measures that need to be included in the oAMS to address outstanding concerns. • Any proposed alterations to the wording of requirement 12.	D7	Meeting with Wiltshire Council requested on the 16.09.26. The Applicant understands a meeting was undertaken between Wiltshire Council and HE on 24.09.26. Following which, Wiltshire Council and HE provided comments on the AMS on the 25.09.26. A meeting was undertaken between Wiltshire Council, HE and the Applicant on the 28.09.26 focused on reviewing comments provided by Wiltshire Council and HE and discussing the need for a DAMs. The Applicant subsequently updated the AMS in line with comments provided and reissued the AMS for review to Wiltshire Council and HE on the 29.09.26. A subsequent meeting was undertaken with the Applicant on the 01.10.26 with HE and Wiltshire Council, following which further amendments were made to the AMS, which was reissued to Wiltshire Council and HE on the 02.10.26. Historic England and Wiltshire Council

Number	Responsible party	Action	Submission deadline	Applicant's response / commentary
				confirmed on the 02.10.26 that they had no further comments on the contents of the AMS. The Applicant understands from discussions held at ISH5 and meetings on the 29 September 2026 and 1 October 2026 that Wiltshire Council are in principle happy with the technical contents of the AMS but disagree with the process proposed by the Applicant (i.e. an Archaeological Mitigation Strategy (AMS) supported by Site Specific Written Schemes of Investigation (SSWSIs), which would be informed by a site wide sampling strategy, produced post-determination of the DCO). As such Wiltshire Council consider the production of the Detailed Archaeological Mitigation Strategy (DAMS) is required as part of Requirement 12 to be in line with the approach they have taken on other DCO schemes (i.e. the A303 road Scheme, which traversed land within a World Heritage Site). The Applicant understands from meetings on the 29 September 2026 and 1 October 2026, noting Historic England were unable to attend ISH5, that Historic England's preference would be for

Number	Responsible party	Action	Submission deadline	Applicant's response / commentary
				the production of a DAMs prior to the production of SSWSIs, as this would follow the same process as other DCOs in the south-west region and ensure sufficient detail relating to research objectives and a Scheme wide sampling strategy is provided in the document. The Applicant is not aware of any solar-based DCOs in this region, noting the application for Beacon Solar in Devon is currently on hold. The approach the Applicant has taken is in line with other consented solar DCO schemes with comparable archaeological mitigation needs. The Applicant has looked to undertake meaningful consultation with both Historic England and Wiltshire Council from the pre-application period through to the examination period. This includes rapid updates to the AMS during the week commencing 28 September 2026 to ensure the AMS provides sufficient technical detail to ensure the best approach is taken to mitigating archaeological remains and mechanisms are in place to ensure any detail not included within the AMS will be included

Number	Responsible party	Action	Submission deadline	Applicant's response / commentary
				within site specific WSIs following detailed design of the Scheme. The Applicant maintains their position that the AMS is sufficient to mitigate any impacts as a result of the Scheme to archaeological remains and is proportionate to the nature of archaeological remains identified and the nature of the proposed development.
11.	Applicant	To submit a rebuttal to SLD's D5 [REP5- 130] report on surface water run-off from solar panels. The Applicant should include commentary on: The percentage of vegetation cover required to successfully address surface water run-off including any potential 'gaps' in ground cover during the installation period to the full establishment of the grass sward	D7	The response to SLD's Deadline 5 submission [REP5-130] is set out in the Applicant's Response to SLD Deadline 6 Submission - Hydrology [REP5-130] [EN010168/EXAM/9.88]. This document addresses the matters raised by the Examining Authority, including the PV-SMaRT assessment and inputs, the existing agricultural baseline, vegetation establishment and management, soil condition and compaction, differences between soil types, the need for any additional temporary or permanent SuDS measures, climate resilience and adaptive management, and the robustness and limitations of SLD's assessment.

Number	Responsible party	Action	Submission deadline	Applicant's response / commentary
		• The timing for review of 80% take of grass sward and an explanation if this needs to be reviewed • The adaptive management details of the grass sward to take account of climate change • Any differences of run-off rates between the various soil types within Lime Down following the full establishment of the grass sward • The need for further SuDS and/ or temporary SuDS to address surface water run-off from the PV panels and achieve the agreed run-off rates. If so, include an explanation of how this will be calculated and addressed in the outline Drainage Strategies		The Applicant's Response to SLD Deadline 6 Submission - Hydrology [REP5-130] [EN010168/EXAM/9.88] also addresses the points raised regarding potential solar PV panel runoff and the sensitivity of Farleaze Farm.

Number	Responsible party	Action	Submission deadline	Applicant's response / commentary
		- How all the relevant management plans will be updated including, but not limited to, oCEMP, oOEMP, oLEMP and outline Drainage Strategies - Include a comment on the robustness of the model used by SLD in their report - Any other matters within the report that the Applicant considers pertinent to respond to.		
12.	Applicant	To respond to Mr Calderbank's D6 submission [REP6-083]	D7	A full response to Mr Calderbank's Deadline 6 submission is contained within the Applicant's Response to Submissions Received at Deadline 6 [EN010168/EXAM/9.70] , at AC-001 to AC-006.
13.	Applicant and the EA	To update their SoCG: To reflect the hearing discussion about the	D7	The Statement of Common Ground with the Environment Agency has been updated to reflect the hearing discussion on the Gauze Brook hydraulic modelling, the Lime Down C1 substation and the position on potential thermal

Number	Responsible party	Action	Submission deadline	Applicant's response / commentary
		hydraulic modelling for the Gauze Brook - To reflect the conversation regarding the location of the substation in Lime Down C1 to ensure that they have a mechanism for the EA to be consulted at design stage - show the progress regarding the thermal implications of cables on sensitive groundwater receptors (Water Framework Directive).		effects from buried cables on sensitive groundwater receptors. The Statement of Common Ground with the Environment Agency will be submitted at Deadline 8 in accordance with the Revised Timetable [PD-018] published on 25 September 2026.
14.	Applicant and Wiltshire Council/ LLFA	To update their SoCG regarding: - Hydraulic modelling for the Gauze Brook - Reflect the hearing conversation regarding the functional floodplain - Reflect the conversation regarding the ordinary	D7	The Statement of Common Ground with Wiltshire Council [EN010168/EXAM/8.2] (Revision 5) has been updated at Deadline 7 to reflect the hearing discussion on the Gauze Brook hydraulic modelling, functional floodplain, the Ordinary Watercourse between Fields D22 and D1, and the application of the LLFA's 30% drainage betterment requirement.

Number	Responsible party	Action	Submission deadline	Applicant's response / commentary
		watercourse between fields D22 and D1 To add an item in the SoCG on betterment rate understanding and agreement		
15.	Applicant	As part of the hydraulic modelling for the Gauze Brook: a) To update Lime Down D Modelling Report [REP5-095], outline Drainage Strategy [REP5-055] and supporting ES figure [REP5-034] to account for the hydraulic modelling for the Gauze Brook b) To consider the Rodbourne Gauge to account for low frequency high intensity events. To explore the	D7	The Lime Down D - Hydraulic Modelling Report [EN010168/EXAM/9.32] (Revision 3), ES Volume 3 Appendix 11-6 Flood Risk Assessment and Drainage Strategy Lime Down D [EN010168/APP/6.3] (Revision 6) and associated flood-risk mapping have been updated to reflect the revised Gauze Brook hydraulic model, including the additional survey information and updated flood levels, depths and extents.

Number	Responsible party	Action	Submission deadline	Applicant's response / commentary
		sensitivity of water levels within scenarios rather than revisiting the hydrology.		
16.	LLFA	To submit a review of the NPS EN-1 policy position, specifically paragraphs 5.8.12, 5.8.15(8) and 5.8.32 on the implementation of Natural Flood Management measures as part of the post hearing submission.	D7	N/A
17.	Applicant	Review the Lime Down D - Natural Flood Management Viability Report [REP5-019] and: a) To present Figures 8 and 9 as water level difference maps, clearly identifying areas that are wet in the baseline but dry with the interventions in place, and vice versa (as raised by the	D7	The Lime Down D - Natural Flood Management Viability Report [EN010168/EXAM/9.66] (Revision 2) has been updated to present the relevant intervention effects as difference mapping and to clarify changes in modelled inundation. The report has also been updated with additional more frequent event assessment with additional figures provided in Appendix B of the report. The conclusion of the report remains that natural flood management does provide a viable

Number	Responsible party	Action	Submission deadline	Applicant's response / commentary
		EA in their submission [REP6-074] b) To review the conclusion of the report that references the level change and reconsider this for smaller, more frequent events.		solution to the flooding experienced in Corston regardless of the scale of flood event.
18.	Applicant	To update the Design Principles and Parameters to include a commitment to place the BESS and all substations outside the mapped Flood Zone 3b.	D7	Tables 2-3 and 2-4 of the Design Principles and Parameters [EN010168/APP/7.4] (Revision 5) have been updated to confirm that the BESS and substations are located wholly within Flood Zone 1 and outside any area identified as Flood Zone 3b, the functional floodplain.
19.	Applicant	To confirm if consultation with the EA at design stage regarding the location of the substation in Lime Down C1 can be included in the control documents.	D7	ES Volume 3, Appendix 11-1 Flood Risk Assessment and Drainage Strategy - Lime Down Covering Report [EN010168/APP/6.3] (Revision 5) has been updated to clarify the detailed-design assessment required for the Lime Down C1 substation, including consideration of mapped surface water flow paths, flood levels and any necessary mitigation.

Number	Responsible party	Action	Submission deadline	Applicant's response / commentary
				The Design Principles and Parameters [EN010168/APP/7.4] (Revision 5) have also been updated at Deadline 7 to require Works 3A and 3B to be located entirely within Flood Zone 1, and to be excluded from Flood Zone 3B. The detailed design, including the location of the substation in Lime Down C1 will need to be approved by Wiltshire Council under Requirement 5. Noting that the LLFA is also Wiltshire Council, and the responsible body for managing surface water flood risk, it will be open to Wiltshire Council to consult with the LLFA as part of the discharge of Requirement 5, or indeed the EA. On the basis of these changes, it is not considered that a specific consultation requirement with the EA is necessary, however it is not prevented should Wiltshire Council choose to consult with the EA as part of the discharge of requirement process.
20.	Applicant	To add an item in the SoCG with Network Rail regarding drainage	D7	N/A

Number	Responsible party	Action	Submission deadline	Applicant's response / commentary
		works and flood risk to Farleaze Farm.		
21.	Applicant	To include a rebuttal to Professor Skeffington's comment about the potential impact of PV panel run-off contributing to the ponding around Farleaze Farm.	D7	The hydrology matters raised regarding potential PV panel runoff and the sensitivity of Farleaze Farm is addressed in the Applicant's Response to SLD Deadline 6 Submission - Hydrology [REP5-130] [EN010168/EXAM/9.88] .
22.	Mr Seymour-Williams	To submit his representation following the hearing to both PINS and the Applicant no later than 24 September 2026.	No later than 24 September 2026	N/A
23.	Applicant	To respond to Mr Seymour-Williams' submission.	D7	The Applicant has provided a response to the representation submitted by Mr Seymour Williams in Tables 5-1 and 5-2 in the Applicant's Response to Deadline 6 submissions [EN010168/EXAM/9.79] .
24.	The EA	To provide their comments regarding Professor Skeffington's points on the thermal implications of the cable route corridor in its hearing statement.	D7	N/A

Number	Responsible party	Action	Submission deadline	Applicant's response / commentary
25.	Applicant	To update all outline Drainage Strategies to reflect discussion regarding rainwater harvesting both within the text and in Table 3: SuDS Options for Proposed Development.	D7	Appendices 11-2 to 11-8: Flood Risk Assessment and Outline Drainage Strategies [EN010168/APP/6.3] (Rev 5 and 6) have been updated to clarify that rainwater harvesting may be incorporated at detailed design for operational water use, including potable use where appropriate and subject to the necessary treatment and water-quality requirements. It is not relied upon for attenuation or flood storage, with the required attenuation and discharge controls provided independently.
26.	Applicant	To update all outline Drainage Strategies and surface water maps ensuring consistency across documents: - Show the indicative dimensions of the PV panels in the Fluvial and Surface Water Flood Risk Maps - Review the access tracks to the substations in the	D7	ES Volume 3, Appendices 11-2 to 11-8: Flood Risk Assessment and Outline Drainage Strategies [EN010168/APP/6.3] (Revisions 5 and 6) have been reviewed and updated for consistency, including panel dimensions, access tracks, watercourse presentation, Conversion Unit numbers, everyday rainfall and attenuation storage, references to Outline Drainage Sketches, attenuation volumes and references to Natural Flood Management where relevant.

Number	Responsible party	Action	Submission deadline	Applicant's response / commentary
		maps (specifically those for substation in parcel D18 as it appears to be outside the red line) - Review the way of showing wet ditches in the maps as they can be confused with contour lines - Review the conversion unit numbers in maps and strategies - Review the tables for the Conversion Unit/ 33kV Distribution Switch Room - Everyday Rainfall and Attenuation Storage within the outline - Drainage Strategies - Review references to the outline Drainage Sketch within the text to ensure that they are included in the		

Number	Responsible party	Action	Submission deadline	Applicant's response / commentary
		strategies that have one - Ensure that the attenuation volumes are explained in volume metrics (m³) within the outline Drainage Sketches. - To include references to Natural Flood Management in all outline Drainage Strategies to reflect the hearing discussion and address NPS EN-1 paragraphs		

Appendix A Green Hill – Natural England's Response to the Secretary of State's Consultation

Date: 10 September 2026
Our ref: 557860
Your ref: EN010170-001868-Green Hill



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BY EMAIL ONLY greenhill@planninginspectorate.gov.uk

Dear ██████████

Green Hill Solar – Request for Information

Thank you for your email of 2 September 2026 notifying Natural England of the letter from the Secretary of State, dated 28 August 2026, requesting further information from Natural England.

Natural England is a non-departmental public body. Our statutory purpose is to ensure that the natural environment is conserved, enhanced, and managed for the benefit of present and future generations, thereby contributing to sustainable development.

We note the Secretary of State's specific question to Natural England as follows:

Changes to the draft Development Consent Order 8.

In response to the Secretary of State's most recent request for information, the Applicant produced an updated Schedule of Changes to the Draft Development Consent Order [C1-014]. In this, the Applicant included a proposed update to Article 6 (Disapplication and modification of legislation, etc.) in response to comments made by Natural England during the Examination of the Lime Down Solar Project (EN010168). Natural England is invited to comment on the wording of this requirement, and the suitability of adding this requirement into this Development Consent Order.

Natural England has reviewed the proposed update to Article 6 ((Disapplication and modification of legislation, etc.) and is satisfied with the wording as set out. We have no concerns around adding this requirement into the Development Consent Order.

I hope the above is helpful. Please direct any further planning related consultations or queries to consultations@naturalengland.org.uk

Yours sincerely

██████████
Senior Officer – West Anglia Sustainable Development
Natural England

Appendix B Applicant's Response to Ms Tinkler (SLD) comments on the Sequential Visual Assessment

Appendix B

This note provides the Applicant's response to comments made by Stop Lime Down (SLD) on the **Additional Sequential Visual Assessments [REP6-062]**, submitted by the Applicant at Deadline 6. SLD referred to its intended response to the Additional Sequential Visual Assessments during Issue Specific Hearing 5 (ISH5) and subsequently provided the Applicant with a draft of its response, dated 25 September 2026, outside the formal Examination process.

The Methodology for the Cumulative Assessment was agreed as part of the **LVIA Methodology [REP5-067]** with Wiltshire Council, within which the Methodology sets out that those Cumulative Development Sites to be included within the assessment of cumulative effects would include those that were of a similar nature to that of the Lime Down Solar Project. These being renewable projects identified from the 'Short List', as set out in paragraph 2.3.5 of the LVIA Methodology in **ES Volume 3, Appendix 8-1 Landscape and Visual Impact Assessment Methodology [REP5-067]**. As such, the Applicant undertook the Additional Sequential Visual Assessments based on the included CD Sites in Table 8-31 of the LVIA in **ES Volume 1 Chapter 8: Landscape and Visual [REP3-025]**.

Consideration of the cumulative effects have been assessed 'In Combination' and 'In Succession' (Succession being sequentially), in accordance with the **LVIA Methodology in ES Volume 3, Appendix 8-1 Landscape and Visual Impact Assessment Methodology [REP5-067]**.

The Applicant makes the following general comments in response to the comments received from SLD:

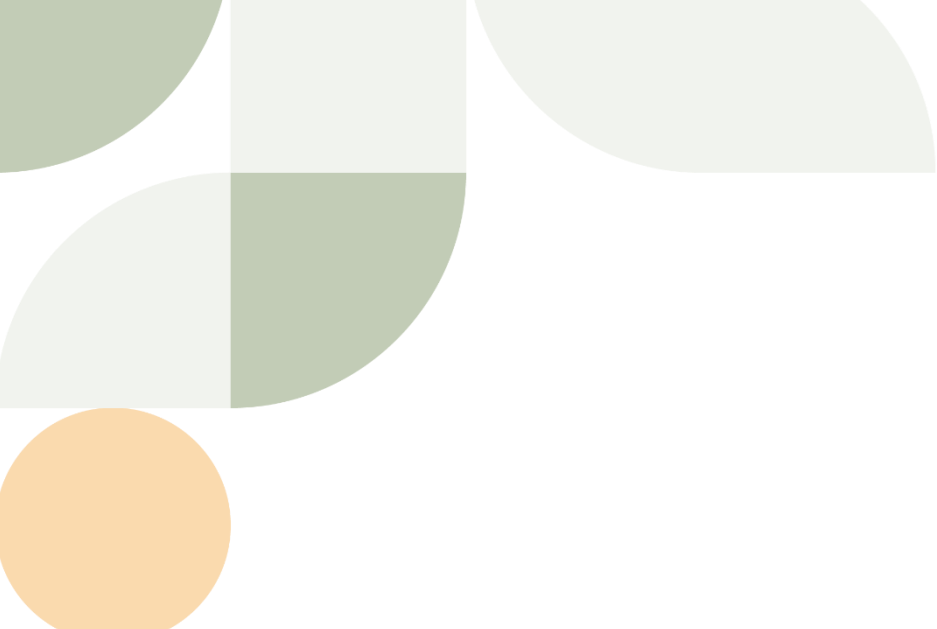
1. The Applicant considers the layers of existing vegetation as well as proposed mitigation planting within the Scheme (which is detailed in the **Outline LEMP [REP6-037]** and which will be secured through Requirement 7 in Schedule 2 of the **Draft DCO [REP6-005]**) can be relied upon to screen the development.
2. With reference to SLD Route 2, CD Site 221 was considered in the assessment initially but was scoped out of the assessment due to distance and intervening vegetation resulting in no visibility from the route. For clarity, the Applicant considers the presence of this development does not increase the levels of adverse cumulative sequential visual effects on the route because there is no visibility.
3. Significant Adverse effects are recorded in the **Additional Sequential Visual Assessments [REP6-062]** where proposed solar infrastructure is clearly visible in views from the routes assessed. These effects are all as a result of the Lime Down Scheme and are highlighted in the tables for each route. There are a few occasions where there are some views to the wider Lime

Down sites usually at a greater distance. In these instances, the increase in the magnitude of change in views is not sufficient to increase the level of significance assessed. For example, from SLD Route 2 passing through Lime Down Site A, there are near distance views to infrastructure in Fields A9 and A10 as well as more distant views to infrastructure in Field C22.

4. ZTV mapping (Zone of Theoretical Visibility) are an aid to site assessment work in the field and as noted in GLVIA at paragraph 6.10, *"it is the desk study component of the visibility analysis. In reality many factors other than terrain will influence actual visibility"*. Information contained in ZTVs are theoretical and cannot be relied upon to confirm visibility. ZTVs are more helpful in determining where there is no visibility (due to the topography and intervening features) and are not a substitute for undertaking fieldwork to verify actual visibility
5. The Applicant recognises that glint and glare is a consideration of cumulative visual assessment. However, as there is no intervisibility between the Scheme and any of CD Sites, the effects of glint and glare are therefore as assessed for the Scheme in **ES Volume 3, Appendix 20-4 Solar Photovoltaic Glint and Glare Study [APP-261]**.

In conclusion, the Applicant considers that the **Additional Sequential Assessment [REP6-062]** and updated for Deadline 7 provides an accurate assessment of the intra and inter sequential effects of the Scheme on the routes assessed.

**Appendix C Pager Power's Solar Photovoltaic and
Building Development – Glint and Glare Guidance Fourth
Edition (September 2022)**



Lime Down

Solar Park

Appendix C: Solar Photovoltaic and Building Development – Glint and Glare Guidance

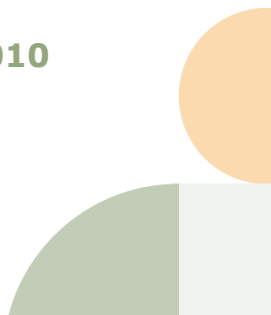
October 2026

Revision 1

Planning Inspectorate Reference: EN010168

Document Reference: EXAM/9.80

The Infrastructure Planning (Examination Procedure) Rules 2010



Solar Photovoltaic and Building Development – Glint and Glare Guidance

Fourth Edition

September 2022

PLANNING SOLUTIONS FOR:

- Solar
- Defence
- Airports
- Telecoms
- Buildings
- Radar
- Railways
- Wind
- Mitigation

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ADMINISTRATION PAGE

Reference:	Solar Photovoltaic Glint and Glare Guidance
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Revision History		
Issue	Date	Detail of Changes
1	April, 2017	First edition.
2	October, 2018	Second edition. This revision adds a methodology for the assessment of helipad operations whilst adding clarity to the previously presented methodologies through the experience gained in the time between edition 1 and 2. The methodologies have not changed significantly. High-level comments regarding the impact of building developments, particularly façades capable of producing specular reflections, is included within the foreword, which is also a new addition.

Revision History		
Issue	Date	Detail of Changes
3	December, 2020	Third edition. Updated Pager Power details. Updated Literature Review section. Updated significance flow charts for determining the impact of solar reflections for road and dwelling receptors. Further comments on common considerations from railway stakeholders for glint and glare assessments including building and solar photovoltaic developments. Additional details regarding aviation assessments for building developments and the safeguarding of non-typical aviation receptors.
3.1	April, 2021	Update to the impact significance flow charts for road and dwelling receptors.
4	September, 2022	Updated guidance section. Updated glint and glare overall significance flow chart. Updates to impact classifications for roads, dwellings, railways and aviation within the significance flow charts. Further details surrounding aviation receptors following assessment experience and stakeholder responses.

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FOREWORD

Introduction and Background

The number, size and scale of solar photovoltaic (PV) developments continues to rise, with glint and glare assessments often required within the UK, South Africa, USA, Australia, India and elsewhere in the world. The requirement for a glint and glare assessment now extends to building developments with reflective façades. Rapid deployment of PV in the UK between 2010-2015 lead to a knowledge gap in the area of glint and glare, with assessments often required without definition of what constitutes a significant impact. Pager Power has been at the forefront of this planning issue with over 250 assessments completed at the time of the publication of first edition of the guidance. Now going into the fourth edition, over 900 international glint and glare assessments have been completed by Pager Power.

The original aim of the glint and glare guidance was to produce a standardised methodology for PV developers, planners and stakeholders to follow. This was well received, adding clarity to a previously unfamiliar planning issue. The second edition, produced over a year and a half later, did not reinvent the assessment methodology for PV, it merely refined and added detail where required based on the experience gained subsequently. The requirement for glint and glare assessments of building developments, specifically those with large reflective façades, had also grown between the first and second edition and therefore further additional information regarding the methodology for assessment was provided.

The third edition refined the guidance and added additional guidance for building developments, specifically in the vicinity of airports and railway infrastructure. The focus remained on the guidance for PV panels, however where required, additional information was presented for building developments. The fourth edition has added a further guidance update and improvements to the way effects are determined, and how the significance of impacts are classified.

This guidance document presents the methodology recommended by Pager Power through assessment experience. It should be used for reference and ideally, the methodology should be agreed with the relevant stakeholder where an assessment is required. There may be cases where the assessment scenario does not match the guidance criteria, in this situation, a pragmatic approach is recommended.

It is understood that this guidance document has now been referred to internationally.

Guidance Basis

Prepared for:

Developers, planners and stakeholders.

Aim:

To provide guidance for assessing the impact of glint and glare from solar photovoltaic (PV) panels and building developments with large reflective façades upon surrounding receptors.

Receptors:

Dwellings (residential amenity), Roads (safety), Rail (safety) and Aviation (safety).

EXECUTIVE SUMMARY

Overview and Purpose

The purpose of this guidance document is to provide solar photovoltaic (PV) and building developers, planners and stakeholders with an assessment process for determining the effects of glint and glare (solar reflections) upon receptors surrounding a proposed solar PV and building development.

Throughout the document, the focus remains on the guidance for PV panels, however where required, additional information is presented for building developments. If a building development is not specifically mentioned, then assume the guidance is not applicable or relevant.

Formal guidance around glint and glare remains somewhat lacking in many cases. This guidance document has therefore been produced to bridge this knowledge gap pertaining to the assessment of glint and glare. The aim is to produce a standardised assessment process for developers, planners and stakeholders to reduce the element of risk associated with glint and glare.

The guidance presented is based on the following:

- Reviews of existing guidance in a variety of areas;
- Glint and glare assessment experience and industry knowledge;
- An overview of available solar reflection studies.

This guidance document is based on knowledge initially gained through analysis within the UK and Irish markets however the methodologies are deemed applicable, and have been used, for worldwide solar PV development and building development.

Key Receptors

Glint and glare can significantly affect nearby receptors under particular conditions. The key receptors with respect to glint and glare are residents in surrounding dwellings, road users, train infrastructure (including train drivers), and aviation infrastructure (including pilots and air traffic controllers). Other receptors do exist, however this guidance considers the four most common receptor types unless otherwise stated.

Modelling Requirements

A geometric glint and glare assessment model must include the following:

- The Earth's orbit around the Sun;
- The Earth's rotation;
- The Earth's orientation;

- The location of the solar PV development or building development including the reflector (solar panel or façade) area;
- The reflector's 3D orientation including azimuth angle of the solar panel or façade (the orientation of the reflectors relative to north and the reflector elevation angle);
- Local topography including receptor and panel or façade heights above mean sea level.

For increased accuracy, the model could account for the following:

- Terrain at the visible horizon;
- Local time zone and daylight savings times;
- Consideration of sunrise and sunset times;
- Determine which solar panels create the solar reflection within the solar PV development;
- Determine what area of the façade create the solar reflection from the building development;
- Azimuth range of the Sun¹ when a solar reflection is geometrically possible;
- Vertical elevation range of the Sun when a solar reflection is geometrically possible;
- High-resolution analysis i.e. undertaking multiple geometric calculations within the given solar PV development or façade area. For example, at intervals of between 1 and 20 metres;
- Consideration of the effect of non-specular reflective surfaces e.g. masonry between glass façades;
- The intensity² of any solar reflection produced.

Assessment Inputs – Receptors

The following paragraphs set out the key distances for identifying receptors and the height data which should be included.

Dwellings within approximately 1km of a proposed solar PV development that may have a view of the PV panels should be assessed. Terrain heights and an additional height to account for the solar panel and eye level within the relevant floor of the dwelling should also be considered. Dwellings are not typically assessed for building developments.

National roads, or those with greater significance, within approximately 1km of a proposed solar PV development that may have a view of the PV panels should be assessed. Terrain heights and

¹ The azimuth range is the angle between the Sun and North, measured clockwise around the receptor's horizon. The Sun azimuth range shows the location of the Sun when a geometric solar reflection is possible. Therefore, it is possible to determine whether the Sun and the solar reflection are both likely to be visible to a receptor.

² In W/cm² at the retina, for example.

an additional height to account for the solar panel and eye level of a road user should also be considered. Roads are not typically assessed for building developments.

Where railway infrastructure is located within approximately 100m of a proposed solar PV or building development that may have a view of the PV panels, an assessment should be undertaken. Train drivers out to 500m should be assessed. Any signals, crossings or vital railway infrastructure within 500m that could be affected by glare should be assessed especially where railway signal utilises incandescent bulb³ technology and/or where no hood is attached. Terrain heights and an additional height to account for the solar panel/façade and eye level of a train driver or the height of a railway signal should also be considered.

Aviation receptors out to 30km⁴ from a proposed PV development should be considered to determine the requirement for assessment, if any. A full technical assessment is usually undertaken for those developments located within 10km of an aerodrome or if specifically requested by the aerodrome safeguarding team. The typical receptors include the Air Traffic Control (ATC) tower and a 2-mile approach path for the relevant runway approaches. Additional receptors may be included where a solar reflection may be deemed a hazard to safety e.g. helipad approaches and the visual manoeuvring area (VMA). Aviation receptors for building developments are the same.

Assessment Significance

Determining the significance of a solar reflection varies for each receptor type. In general, the significance criteria for glint and glare effects are as follows:

- No Impact – A solar reflection is not geometrically possible or will not be visible from the assessed receptor. No mitigation required;
- Low – A solar reflection is geometrically possible however any impact is considered to be small such that mitigation is not recommended e.g. intervening screening will limit the view of the reflecting solar panels significantly or the glare time per year is considered negligible. No mitigation recommended;
- Moderate – A solar reflection is geometrically possible and visible however it occurs under conditions that do not represent a worst-case scenario e.g. a solar reflection originates from a less sensitive location. Mitigation recommended;
- High – A solar reflection is geometrically possible and visible under conditions that will produce a significant impact. Mitigation will be required if the proposed development is to proceed.

There may be instances where the solar reflection scenario does not fall accurately within the significance categories. Where this occurs, detailed consideration of the receptors and the modelling results should be undertaken.

³ Non-LED.

⁴ Aviation stakeholders can and have requested a glint and glare assessment beyond 30km.

See the following sections where the process for determining the significance of a solar reflection is described for each receptor type:

- Section 6 – Dwellings;
- Section 7 – Road infrastructure;
- Section 8 – Railway infrastructure;
- Section 9 – Aviation infrastructure.

In each section, the process for determining the significance of a solar reflection is described comprehensively.

Guidance Conclusions

This guidance should be followed to ensure comprehensive assessment of solar PV and building developments with respect to glint and glare. This guidance is applicable for solar PV and building development anywhere in the world.

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GLOSSARY

Term	Definition
Aerodrome	A defined area on land or water (including any buildings, installations, and equipment) intended to be used either wholly or in part for the arrival, departure, and surface movement of aircraft ⁵ .
Approach Path	The descent path of an aircraft as it comes in for landing.
ATC Tower	Air Traffic Control tower – used by air traffic controllers to observe and direct aviation activity at or near to an aerodrome.
Azimuth Angle	The angle the solar panel faces relative to north (0/360 degrees).
CAA	Civil Aviation Authority.
Diffuse Reflection	The reflection of light from a surface such that the incident light is reflected at many angles rather than at just one angle.
Elevation Angle	The angle of the solar panel relative to 0 degrees (the horizontal or flat).
FAA	Federal Aviation Administration.
Façade	The reflective surface of a building development
Glare	A continuous source of bright light.
Glint	A momentary flash of bright light.
Glint and Glare	As above. Interchangeably used with the term ‘solar reflection’ where the specific type of reflection is not necessary.
IAA	Irish Aviation Authority.
Incandescent Light Bulb	An incandescent light bulb is an electric light with a wire filament heated to a high temperature. An electric current is passed through it until it glows with visible light.

⁵ International Civil Aviation Organization (ICAO) Documents, Aerodrome Standards, Aerodrome Design and Operations. Annex 14 to The Convention on International Civil Aviation (Chicago Convention), Volume I- Aerodrome Design and Operations under Definitions.

Term	Definition
Incident Solar Reflection	The solar reflection from the solar panel appears visible and close to the location of the Sun, such that both the solar reflection and the Sun originate and are visible from a receptor's viewpoint simultaneously. The angle between the reflected light and the perpendicular (or normal) to the surface (solar panel) is the angle of incidence.
LED	A light-emitting diode (LED). It is a semiconductor diode, which glows when a voltage is applied. LED signals are brighter and more efficient than incandescent bulbs and normally do not have a reflective mirror.
Level Crossing	A crossing where (typically) a road passes over a railway line.
Level Crossing Warning Lights (LCWL)	The system of lights located next to a level crossing on a railway line, used to warn road users from crossing.
National Roads: Typically A Roads (UK) or N Roads (Ireland)	Typically a road with a one or more carriageways with a maximum speed limit of up to 60mph or 70mph (UK A Road) or 100kph (Ireland N Road). These roads typically have fast moving vehicles with moderate to busy traffic density. Other road designations or maximum speed limits may apply internationally.
Major National Roads: Typically a motorway	Typically a road with a minimum of two carriageways with a maximum speed limit of up to 70mph (UK) or 120kph (Ireland). These roads typically have fast moving vehicles with busy traffic. Other road designation or maximum speed limits may apply internationally.
Local Roads	Typically roads and lanes with the lowest traffic densities. Speed limits vary.
Normal	The mathematical term used to define the line at right angles to a reflector i.e. a solar panel.
Potential for temporary after-image	The likelihood of a solar reflection continuing to appear in one's vision after the exposure to the original image has ceased.
Railway Signal	A light or physical signalling system located beside a railway line. Used to indicate to a train driver a particular order.

Term	Definition
Receptor	A potential viewer of glint and glare effects. They may be located in a dwelling, as a pilot in a plane, as a road user, train operator etc..
Regional Roads B Roads (UK) or R Roads (Ireland)	Typically a single carriageway with a maximum speed limit of up to 60mph (UK B Road) or 80kph (Ireland R Road). The speed of vehicles will vary with a typical traffic density of low to moderate. Other road designations or maximum speed limits may apply internationally.
Runway Threshold	The beginning of the physical runway surface.
SGHAT	Solar Glare Hazard Analysis Tool - solar glint and glare model designed by Sandia National Laboratory, specifically for aviation and recommended by the FAA.
Signal Hood	A signal hood is located on a lit railway signal to screen the light from direct sunlight.
Shadow Flicker	Refers to the sunlight flickering effect caused when rotating wind turbine blades periodically cast shadows over neighbouring properties through small openings such as windows.
Solar Reflection	Also referred to as glint or glare. Used interchangeably to describe glint or glare where the type of solar reflection is not necessary.
Specular Reflection	The mirror-like reflection of light from a surface, in which light from a single incoming direction is reflected into a single outgoing direction.

Glossary

PAGER POWER COMPANY PROFILE

Company Background

Pager Power is a dedicated consultancy company based in Suffolk, UK. The company has undertaken projects in 54 countries within Europe, Africa, America, Asia and Australia.

The company comprises a team of experts to provide technical expertise and guidance on a range of planning issues for large and small developments.

Pager Power was established in 1997. Initially the company focus was on modelling the impact of wind turbines on radar systems.

Over the years, the company has expanded into numerous fields including:

- Renewable energy projects.
- Building developments.
- Aviation and telecommunication systems.

Pager Power prides itself on providing comprehensive, understandable and accurate assessments of complex issues in line with national and international standards. This is underpinned by its custom software, longstanding relationships with stakeholders and active role in conferences and research efforts around the world.

Pager Power's assessments withstand legal scrutiny and the company can provide support for a project at any stage.

Pager Power's Experience

Pager Power has undertaken over 900 Glint and Glare Assessments in the United Kingdom and internationally.

The studies have included assessment of civil and military aerodromes, railway infrastructure and other ground-based receptors including roads and dwellings.

1 OVERVIEW

Introduction

1.1 Glint and glare is a planning consideration brought about through the rise and rapid deployment of solar photovoltaic (PV) development. There has been a lack of official guidance documents for developers, planners or stakeholders to follow and therefore Pager Power has produced this document to assist with this planning consideration.

1.2 The requirement for a glint and glare assessment has now extended to new building developments, or indeed any project which has the potential to produce significant glare through a specular solar reflection.

1.3 Whilst general planning guidance for solar PV development has been established, there is no specific planning guidance, in the UK and Ireland, for assessing the effects of glint and glare on surrounding receptors. There also remains no standardised guidance in regard to glare from building developments.

1.4 This guidance document has specific focus on the UK and Irish markets however the methodologies are deemed applicable for worldwide solar PV or building development.

Purpose

1.5 This guidance has been produced for developers, planners and stakeholders.

1.6 The aims of this guidance are as follows:

- To bridge the knowledge gap for all stakeholders regarding glint and glare (solar reflections) from solar PV and building developments;
- To produce a standardised and universally agreed methodology for assessing the impact of glint and glare upon receptors surrounding a proposed solar PV and building development;
- To ensure the proper and safe development of renewable energy schemes and building projects in the UK, Ireland and internationally with respect to glint and glare.

1.7 A standardised process will reduce risk for all stakeholders of a proposed solar PV or building development.

1.8 The guidance is based on industry knowledge, consultation and experience.

Scope

1.9 Glint and glare is referenced within guidance documents⁶ throughout the UK and Internationally, however a specific methodology for assessing, contextualising and determining the impact of solar glint and glare are not provided for many receptor types. Aviation is covered within Federal Aviation Administration (FAA) guidance from the USA, however this is not strictly applicable outside of the USA (though many aviation authorities do refer to it).

1.10 This guidance document aims to present a standardised methodology for assessing glint and glare for surrounding receptors, this includes:

- Residents in surrounding dwellings;
- Road users on surrounding roads;
- Railway infrastructure (including train drivers);
- Aviation infrastructure (including pilots and air traffic controllers).

Glint and Glare Definition

1.11 The reflective properties of solar PV panels vary from different manufacturers. Whilst solar panels vary in their reflectivity with some claiming 'anti-glare' properties, no solar panel absorbs 100% of the incoming light. Therefore, any solar PV panel has the potential to produce a solar reflection. The relative absorptive properties of a solar panel should be considered on a case-by-case basis.

1.12 The reflective properties of glass are similar to PV panels, with both producing reflections of similar intensities.

1.13 The definition of glint and glare⁷ is as follows:

- Glint – a momentary flash of bright light;
- Glare – a continuous source of bright light.

1.14 In context, glint will be witnessed by moderate to fast moving receptors whilst glare would be encountered by static or slow moving receptors with respect to a solar farm. The term 'solar reflection' is used to refer to both reflection types i.e. glint and glare.

⁶ Overview of the associated guidance is presented in Section 3.

⁷ These definitions are aligned with the Draft National Policy Statement for Renewable Energy Infrastructure (in the UK) and the Federal Aviation Administration (FAA) in the United States of America.

2 CONSULTATION

Consultation Overview

Consultation with key stakeholders is essential to ensure any concerns are suitably addressed. A list of some of the key stakeholders pertaining to safety related glint and glare issues is presented in Table 1 below.

Party	Comment
UK Civil Aviation Authority (CAA)	Key stakeholders pertaining to safety.
UK Ministry of Defence (MOD)	
Irish Department of Defence (DOD)	
Irish Aviation Authority (IAA)	
Network Rail	
Irish Rail	
Relevant Highways Agencies including: • Highways England; • Transport Infrastructure Ireland.	

Table 1 Stakeholder consultation

3 LITERATURE REVIEW

Overview

3.1 A review of the available guidance and studies pertaining to solar PV developments and glint and glare is presented in this section.

Planning Guidance

UK Planning Practice Guidance

3.2 There is guidance from other nations within the UK. The following relates to English guidance only. In many instances the guidance is similar both within the UK and internationally, with no specific methodology defined.

3.3 English Planning Practice Guidance dictates that a glint and glare assessment is required in some instances. The guidance for 'Renewable and low carbon energy'⁸ dictates the following with respect to glint and glare. Note only the relevant information is presented.

The deployment of large-scale solar farms can have a negative impact on the rural environment, particularly in undulating landscapes. However, the visual impact of a well-planned and well-screened solar farm can be properly addressed within the landscape if planned sensitively.

Particular factors a local planning authority will need to consider include:

- *the proposal's visual impact, the effect on landscape of glint and glare (see guidance on landscape assessment) and on neighbouring uses and aircraft safety;*
- *the extent to which there may be additional impacts if solar arrays follow the daily movement of the sun;*
- *great care should be taken to ensure heritage assets are conserved in a manner appropriate to their significance, including the impact of proposals on views important to their setting. As the significance of a heritage asset derives not only from its physical presence, but also from its setting, careful consideration should be given to the impact of large scale solar farms on such assets. Depending on their scale, design and prominence, a large scale solar farm within the setting of a heritage asset may cause substantial harm to the significance of the asset;*
- *the potential to mitigate landscape and visual impacts through, for example, screening with native hedges.*
- *The approach to assessing cumulative landscape and visual impact of large scale solar farms is likely to be the same as assessing the impact of wind turbines. However, in the*

⁸ UK Planning Practice Guidance, 2015. Renewable and low carbon energy - What are the particular planning considerations that relate to large scale ground-mounted solar photovoltaic Farms? Last accessed 01.07.2020.

case of ground-mounted solar panels it should be noted that with effective screening and appropriate land topography the area of a zone of visual influence could be zero.

3.4 The UK planning guidance does not provide a specific methodology for assessing the impact of glint and glare.

Draft National Policy Statement for Renewable Energy Infrastructure

3.5 The Draft National Policy Statement for Renewable Energy Infrastructure (EN-3)⁹ sets out the primary policy for decisions by the Secretary of State for nationally significant renewable energy infrastructure. Section 2.52 states:

‘2.52.1 Solar panels may reflect the sun’s rays, causing glint and glare. Glint is defined as a momentary flash of light that may be produced as a direct reflection of the sun in the solar panel. Glare is a continuous source of excessive brightness experienced by a stationary observer located in the path of reflected sunlight from the face of the panel. The effect occurs when the solar panel is stationed between or at an angle of the sun and the receptor.

2.52.2 In some instances, it may be necessary to seek a glint and glare assessment as part of the application. This may need to account for ‘tracking’ panels if they are proposed as these may cause differential diurnal and/or seasonal impacts. The potential for solar PV panels, frames and supports to have a combined reflective quality should be assessed. This assessment needs to consider the likely reflective capacity of all of the materials used¹⁰ in the construction of the solar PV farm.

2.52.3 Applicants should consider using, and in some cases the Secretary of State may require, solar panels to be of a non-glare/ non-reflective type and the front face of the panels to comprise of (or be covered) with a non-reflective coating for the lifetime of the permission.

2.52.4 Solar PV panels are designed to absorb, not reflect, irradiation. However, the Secretary of State should assess the potential impact of glint and glare on nearby homes and motorists.

2.52.5 There is no evidence that glint and glare from solar farms interferes in any way with aviation navigation or pilot and aircraft visibility or safety. Therefore, the Secretary of State is unlikely to have to give any weight to claims of aviation interference as a result of glint and glare from solar farms.’

3.6 Consultation to determine whether EN-3 provides a suitable framework to support decision making for nationally significant energy infrastructure ended in November 2021. Pager Power is aware that aviation stakeholders were not consulted prior to the publication of the draft

⁹ Draft National Policy Statement for Renewable Energy Infrastructure (EN-3), Department for Business, Energy & Industrial Strategy, date: September 2021, accessed on: 01/11/2021.

¹⁰ In Pager Power’s experience, the solar panels themselves are the overriding source of specular reflections which have the potential to cause significant impacts upon safety or amenity.

policy and understands that they will still request a glint and glare assessment on the basis that glare may lead to impact upon aviation safety. It is possible that the draft policy will change in light of the consultation responses from aviation stakeholders.

3.7 Finally, it should be noted that the EN-3 relates solely to nationally significant renewable energy infrastructure and therefore does not apply to all planning applications for solar developments.

Road Safety Guidance

UK Highway Code

3.8 Information relating to solar glare and general guidelines for safer driving is presented in the UK's Highway Code¹¹. Each country will have their own guidance with respect to road safety. The relevant information is presented below for reference. Note only the relevant information is presented.

93 Slow down, and if necessary stop, if you are dazzled by bright sunlight.

125 The speed limit is the absolute maximum and does not mean it is safe to drive at that speed irrespective of conditions. Driving at speeds too fast for the road and traffic conditions is dangerous. You should always reduce your speed when:

- *the road layout or condition presents hazards, such as bends;*
- *sharing the road with pedestrians, cyclists and horse riders, particularly children, and motorcyclists;*
- *weather conditions make it safer to do so;*
- *driving at night as it is more difficult to see other road users.*

146 Adapt your driving to the appropriate type and condition of road you are on. In particular:

- *do not treat speed limits as a target. It is often not appropriate or safe to drive at the maximum speed limit;*
- *take the road and traffic conditions into account. Be prepared for unexpected or difficult situations, for example, the road being blocked beyond a blind bend. Be prepared to adjust your speed as a precaution;*
- *where there are junctions, be prepared for road users emerging;*
- *in side roads and country lanes look out for unmarked junctions where nobody has priority;*
- *be prepared to stop at traffic control systems, road works, pedestrian crossings or traffic lights as necessary;*
- *try to anticipate what pedestrians and cyclists might do. If pedestrians, particularly children, are looking the other way, they may step out into the road without seeing you.*

¹¹ The Highway Code, 2016. Department of Transport, UK Government. Last accessed 01.07.2020.

3.9 Different countries have various highway standards that must be followed. The UK Highway Code states that a driver should be aware of particular hazards such as glare from the Sun, and should adjust their driving style appropriately. Solar panels reflect sunlight producing solar reflections under specific conditions, therefore it is advised that this guidance is considered.

Railway Guidance

3.10 It is understood that that railway guidance with respect to signalling has changed¹². The following historical guidance is therefore presented for reference only.

UK Network Rail Guidance

3.11 This section provides an overview of the relevant railway guidance with respect to the siting of signals on railway lines. Network Rail is the stakeholder of the UK's railway infrastructure¹³. Generally, a railway operator's concerns would likely to relate to the following:

- The development producing a solar reflection that affects train drivers;
- The development producing a solar reflection towards level crossing warning lights (LCWL) or level crossings; and
- The development producing a solar reflection that affects railway signals.

3.12 The railway guidelines are presented below. The extract is taken from section 3.2 of the 'Guidance on Signal Positioning and Visibility' which details the visibility of signals, train drivers' field of vision and the implications with regard to signal positioning. Note only the relevant information is presented.

3.2 The visibility of signals

3.2.1 Overview

The effectiveness of an observer's visual system in detecting the existence of a target will depend upon the object's position in the observer's visual field, its contrast with its background, its luminance properties, and the observer's adaptation to the illumination level of the environment. It is also influenced by the processes relating to colour vision, visual accommodation, and visual acuity. Each of these issues is described below.

3.2.2 Field of vision

The field of vision, or visual field, is the area of the visual environment that is registered by the eyes when both eyes and head are held still. The normal extent of the visual field is approximately 135 degrees in the vertical plane and 200 degrees in the horizontal plane.

The visual field is normally divided into central and peripheral regions: the central field being the area that provides detailed information. This extends from the central point (0 degrees) to

¹² Known to Pager Power as of August 2020.

¹³ Guidance on Signal Positioning and Visibility, December 2003. Railway Group Guidance Note. Last accessed 28.03.2017.

approximately 30 degrees at each eye. The peripheral field extends from 30 degrees out to the edge of the visual field.

Objects are seen more quickly and identified more accurately if they are positioned towards the centre of the observer's field of vision, as this is where our sensitivity to contrast is highest. Peripheral vision is particularly sensitive to movement and light.

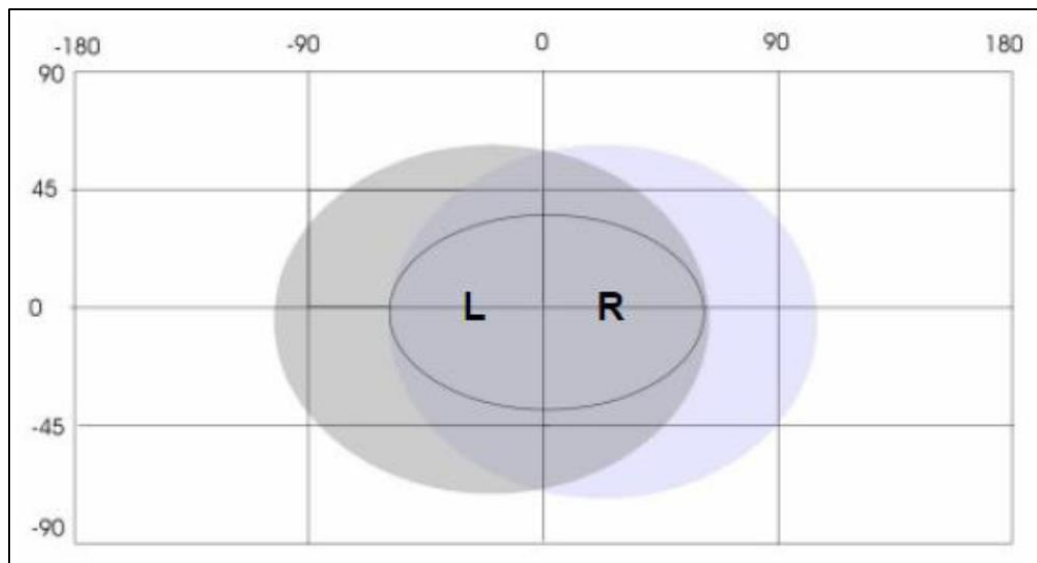


Figure 1 Field of view

In the diagram above, the two shaded regions represent the view from the left eye (L) and the right eye (R) respectively. The darker shaded region represents the region of binocular overlap. The oval in the centre represents the central field of vision.

Research has shown that vehicle drivers search for signs/signals towards the centre of the field of vision. As approach speed increases, drivers demonstrate a tunnel vision effect and focus only on objects in a field of $+ 8^\circ$ from the direction of travel

3.2.2.1 Field of vision

Drivers become increasingly dependent on central vision for signal detection at increasing train speeds, and even minor distractions can reduce the visibility of the signal if it is viewed towards the peripheral field of vision. (D I)

Because of our sensitivity to movement in the peripheral field, the presence of clutter to the sides of the running line, for example, fence posts, lamp-posts, traffic, or non-signal lights, such as house, factory or security lights, can be highly distracting. (D I)

3.2.2.2 Implications

Signals should be at a height and distance from the running line that permits them to be viewed towards the centre of the field of vision. (D)

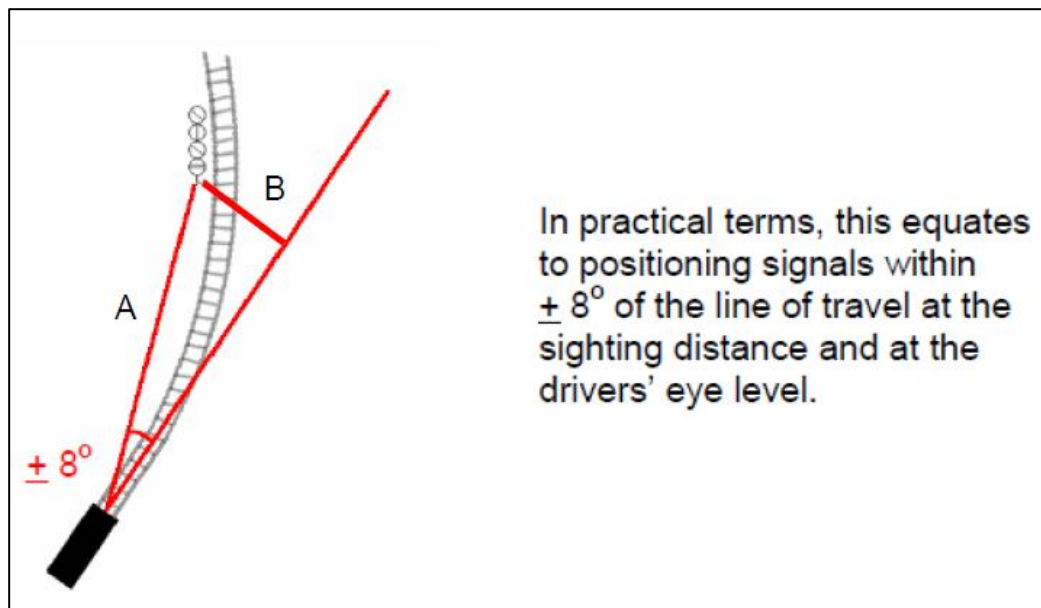


Figure 2 Signal positioning

'Car stop' signs should be positioned such that, if practicable, platform starting signals and 'OFF' indicators can be seen in the driver's central field of vision. (D)

If possible, clutter and non-signal lights in a driver's field of view should be screened off or removed so that they do not cause distraction. (D I)

The distance at which the 8° cone along the track is initiated is dependent on the minimum reading time and distance which is associated to the speed of trains along the track. The extract below is taken from section B5 (pages 8-9) of the guidance which details the required minimum reading time for a train driver when approaching a signal. Note only the relevant information is presented.

'B5.2.2 Determining the assessed minimum reading time

GE/RT8037

The assessed minimum reading time shall be no less than eight seconds travelling time before the signal.

The assessed minimum reading time shall be greater than eight seconds where there is an increased likelihood of misread or failure to observe. Circumstances where this applies include, but are not necessarily limited to, the following:

- a) the time taken to identify the signal is longer (for example, because the signal being viewed is one of a number of signals on a gantry, or because the signal is viewed against a complex background)
- b) the time taken to interpret the information presented by the signal is longer (for example, because the signal is capable of presenting route information for a complex layout ahead)

c) there is a risk that the need to perform other duties could cause distraction from viewing the signal correctly (for example, the observance of lineside signs, a station stop between the caution and stop signals, or DOO (P) duties)

d) the control of the train speed is influenced by other factors (for example, anticipation of the signal aspect changing).

The assessed minimum reading time shall be determined using a structured format approved by the infrastructure controller.

3.13 Network Rail guidance does not specifically reference the effect of glint and glare from solar PV developments on railway infrastructure. Nonetheless, the guidance references the importance of signal visibility and driver awareness, hence the guidance has merit when determining whether glint and glare will have a significant impact on railway safety.

Aviation Guidance

UK CAA Guidance

3.14 The UK Civil Aviation Authority (CAA) issued interim guidance relating to Solar Photovoltaic Systems (SPV) on 17 December 2010 and was subject to a CAA information alert 2010/53. The formal policy was cancelled on September 7th, 2012¹⁴ however it remains the most recent and comprehensive CAA guidance produced to date. The CAA guidance is presented in the section below. Note only the relevant information is presented.

Interim CAA Guidance - Solar Photovoltaic Systems

BACKGROUND

1 Airport interest in solar energy is growing rapidly as a way to reduce operating costs and to demonstrate a commitment to renewable energy and sustainable development. In response, the CAA is seeking to develop its policy on the installation of Solar Photovoltaic (SPV) Systems and their impact on aviation. In doing so, it is reviewing the results of research having been carried out in the United States by the Federal Aviation Administration (FAA) culminating in the publication of Technical Guidance for Evaluating Solar Technologies on Airports¹⁵ and also reviewing guidance issued by other National Aviation Safety Administrations and Authorities on this subject.

2 On completion of the review, the CAA, together with the assistance of other aviation stakeholders, will develop a policy and provide formal guidance material on the installation of SPV, principally on or in the vicinity¹⁶ of licensed aerodromes but will also include guidance on installations away from aerodromes (or 'en-route'¹⁷). This document therefore constitutes interim CAA guidance until a formal policy has been developed.

DISCUSSION

3 At present the key safety issue is perceived to be the potential for reflection from SPV to cause glare, dazzling pilots or leading them to confuse reflections with aeronautical lights. Whilst permission is not required from the CAA for any individual or group to shine or reflect a light or lights into the sky, SPV developers should be aware of the requirements to comply with the Air Navigation Order (ANO) 2009. In particular, developers and Local Planning Authorities (LPA) should be cognisant of the following articles of the ANO with respect to any SPV development regardless of location:

- Article 137 – Endangering safety of an aircraft.

¹⁴ CAA, 2010. Interim CAA Guidance - Solar Photovoltaic Systems. Last accessed 28.03.2017.

¹⁵ Discussed in the following section.

¹⁶ 'In this context, the term "in the vicinity" refers to officially safeguarded aerodromes noted in the Planning Circulars (see Paragraph 10) and a distance of up to 15km from the 'Aerodrome Reference Point' or the centre of the longest runway.'

¹⁷ 'SPV installations proposed further than 15km from an aerodrome are considered "en-route" developments, and may still require consultation with the CAA for an assessment on the impact, if any, to CNS equipment.'

- Article 221 – Lights liable to endanger.
- Article 222 – Lights which dazzle or distract.

4 The potential for SPV installations to cause electromagnetic or other interference with aeronautical Communications Navigational and Surveillance equipment (CNS) must be considered by the SPV developer, in coordination with the CAA, the aerodrome Air Traffic Service provider (ATS), the Air Navigation Service Provider (ANSP) and/or NATS and the MoD, as required.

5 Where SPV systems are installed on structures that, for example, extend above the roofline of tall buildings (either on, or 'off-aerodrome'), or where they are installed in the vertical plane (on plinths or towers), then there may be the potential for creating an obstacle hazard to aircraft and - in addition to the potential for creating turbulence hazard to aircraft - any infringement of the aerodrome Obstacle Limitation Surfaces (OLS) shall also need to be considered by the Aerodrome Licence Holder (ALH).

6 For all planned SPV installations it is best practice for the developer to consult with the operators of nearby aerodromes before any construction is initiated.

7 An ALH, in agreement with their LPA, may wish to initiate procedures so that it is only consulted on SPV planning applications at shorter distances from the aerodrome (for example within a 5 km radius), or at distances that would limit SPV development from within the aircraft operating visual circuit; however, this is at the discretion of the ALH and no CAA approval or endorsement of this decision is necessary.

RECOMMENDATIONS

8. It is recommended that, as part of a planning application, the SPV developer provide safety assurance documentation (including risk assessment) regarding the full potential impact of the SPV installation on aviation interests.

9. Guidance on safeguarding procedures at CAA licensed aerodromes is published within CAP 738 Safeguarding of Aerodromes and advice for unlicensed aerodromes is contained within CAP 793 Safe Operating Practices at Unlicensed Aerodromes.

10. Where proposed developments in the vicinity of aerodromes require an application for planning permission the relevant LPA normally consults aerodrome operators or NATS when aeronautical interests might be affected. This consultation procedure is a statutory obligation in the case of certain major airports, and may include military establishments and certain air traffic surveillance technical sites. These arrangements are explained in Department for Transport Circular 1/2003 and for Scotland, Scottish Government Circular 2/2003.

11. In the event of SPV developments proposed under the Electricity Act, the relevant government department should routinely consult with the CAA. There is therefore no requirement for the CAA to be separately consulted for such proposed SPV installations or developments.

12. If an installation of SPV systems is planned on-aerodrome (i.e. within its licensed boundary) then it is recommended that data on the reflectivity of the solar panel material should be included in any assessment before installation approval can be granted. Although approval for installation is the responsibility of the ALH, as part of a condition of a CAA Aerodrome Licence, the ALH is required to obtain prior consent from CAA Aerodrome Standards Department before any work is begun or approval to the developer or LPA is granted, in accordance with the procedures set out in CAP 791 Procedures for Changes to Aerodrome Infrastructure.

13. During the installation and associated construction of SPV systems there may also be a need to liaise with nearby aerodromes if cranes are to be used; CAA notification and permission is not required.

14. The CAA aims to replace this informal guidance with formal policy in due course and reserves the right to cancel, amend or alter the guidance provided in this document at its discretion upon receipt of new information.

15. Further guidance may be obtained from CAA's Aerodrome Standards Department via aerodromes@caa.co.uk.

3.15 CAP 738¹⁸ Safeguarding of Aerodromes is a later CAA document which details more on the specifics of safeguarding against solar developments. Key excerpts from the guidance are presented in the section below.

Safeguarding Scope

...

Who:

6. Aerodromes holding a certificate based on European Union (EU) regulation or a licence based on UK regulation are required by the CAA to ensure they have a system in place to safeguard their aerodrome against the growth of obstacles; or activities that may present a hazard to aircraft operations (e.g encourage wildlife, glare, lighting, building induced turbulence, etc). Responsibility for all safeguarding activities at these aerodromes' rests with the aerodrome operator. Government advice is that non-licensed sites are also encouraged to have a system of safeguarding in place with their Local Planning Authority (LPA).

...

What is Aerodrome Safeguarding

1.1 Safeguarding is the process by which the Aerodrome Operator can, in consultation with the Local Planning Authority (LPA) and within their capability, protect the environment surrounding the Aerodrome from developments and activities that have the potential to impact on the

¹⁸ CAA, CAP 738 Safeguarding of Aerodromes - 2020. Last accessed 15.08.2022.

aerodrome's safe operation. Aerodrome safeguarding covers several aspects. Its purpose is to protect:

...

h) aircraft from the risk from glint and glare, e.g. solar panels.

...

3. Calculated height of the transitional surface at that point is 33.7m, therefore giving a clearance of 4.7m between the height of the structure and the height of the transitional surface. There are no safeguarding objections, but consider a crane condition, lighting condition (including glint and glare) and landscaping condition in the response to the Planning Authority, as well as the likelihood of building induced turbulence due to the shape and location of the structure.

...

APPENDIX C

Solar Photovoltaic Cells Policy

1. In 2010 the CAA published interim guidance on Solar Photovoltaic Cells (SPCs). At that time, it was agreed that we would review our policy based on research carried out by the Federal Aviation Authorities (FAA) in the United States, in addition to reviewing guidance issued by other National Aviation Authorities. New information and field experience, particularly with respect to compatibility and glare, has resulted in the FAA reviewing its original document 'Technical Guidance for Evaluating Selected Solar Technologies on Airports', which is likely to be subject to change, see link;

<https://www.federalregister.gov/documents/2013/10/23/2013-24729/interimpolicy-faa-review-of-solar-energy-system-projects-on-federally-obligated-airports>

2. In the United Kingdom there has been a further increase in SPV cells, including some located close to aerodrome boundaries; to date the CAA has not received any detrimental comments or issues of glare at these established sites. Whilst this early indication is encouraging, those responsible for safeguarding should remain vigilant to the possibility.

3.16 The CAA Guidance does not provide a methodology for assessing the effects of glint and glare on aviation infrastructure. Many aviation stakeholders under the umbrella of the CAA in the UK utilise the US Federal Aviation Administration (FAA) guidance presented on the following page. It is known that other countries internationally recommend the FAA guidance and it remains the most detailed methodology for assessing glint and glare internationally. The FAA guidance is presented in the following subsection.

US FAA Guidance

3.17 The most comprehensive guidelines available for the assessment of solar PV developments near aerodromes were produced initially in November 2010 by the United States FAA and updated in 2013.

3.18 The 2010 document is entitled 'Technical Guidance for Evaluating Selected Solar Technologies on Airports'¹⁹.

3.19 The 2013 version is entitled 'Interim Policy, FAA Review of Solar Energy System Projects on Federally Obligated Airports'²⁰.

3.20 The 2018 version is entitled 'Technical Guidance for Evaluating Selected Solar Technologies on Airports'²¹ and is version 1.1 of the 2013 edition. The key changes are as follows:

Version 1.1 (April 2018):

o Updated Section 3.1.2, Reflectivity, to incorporate the latest information about evaluating solar glint and glare.

o Updated corresponding references to glare throughout the document.

o Clarified the relationship between solar energy and the FAA's Voluntary Airport Low Emissions (VALE) program in Section 5.3.2.

o Added information about the FAA's Airport Energy Efficiency Program to Section 5.3.3.

o Updated FAA Contact information on Appendix A (where appropriate).

3.21 A final policy entitled 'Federal Aviation Administration Policy: Review of Solar Energy System Projects on Federally-Obligated Airports'²² was released in 2021, which superseded the all previous guidance.

3.22 Key excerpts²³ from the FAA guidance produced in 2018 are presented in the following section.

16. Abstract

Airport interest in solar energy is growing rapidly as a way to reduce airport operating costs and to demonstrate a commitment to sustainable development. In response, the Federal Aviation Administration (FAA) has prepared Technical Guidance for Evaluating Selected Solar

¹⁹ FAA, 2010. Technical Guidance for Evaluating Selected Solar Technologies on Airports. Last accessed 28.03.2017.

²⁰ FAA, 2013. Interim Policy, FAA Review of Solar Energy System Projects on Federally Obligated Airports. Last accessed 28.03.2017.

²¹ FAA, 2018. Technical Guidance for Evaluating Selected Solar Technologies on Airports. Last accessed 06.07.2020.

²² FAA, 2021. Federal Aviation Administration Policy: Review of Solar Energy System Projects on Federally-Obligated Airports. Last accessed 08/12/2021.

²³ Edited to include only key information with respect to assessing glint and glare from solar PV developments.

Technologies on Airports to meet the regulatory and informational needs of the FAA Airports organization and airport sponsors.

For airports with favorable solar access and economics, this report provides a checklist of FAA procedures to ensure that proposed photovoltaic or solar thermal hot water systems are safe and pose no risk to pilots, air traffic controllers, or airport operations. Case studies of operating airport solar facilities are provided, including Denver International, Fresno Yosemite International, and Albuquerque International Sunport.

...

Preface

Over 15 airports around the country are operating solar facilities and airport interest in solar energy is growing rapidly. In response, the Federal Aviation Administration (FAA) has prepared this report, Technical Guidance for Evaluating Selected Solar Technologies on Airports, to meet the regulatory and information needs of FAA personnel and airport sponsors in evaluating airport solar projects.

The guidance is intended to provide a readily usable reference for FAA technical staff who review proposed airport solar projects and for airport sponsors that may be considering a solar installation. It addresses a wide range of topics including solar technology, electric grid infrastructure, FAA safety regulations, financing alternatives, and incentives.

Airport sponsors are interested in solar energy for many reasons. Solar technology has matured and is now a reliable way to reduce airport operating costs. Environmentally, solar energy shows a commitment to environmental stewardship, especially when the panels are visible to the traveling public. Among the environmental benefits are cleaner air and fewer greenhouse gases that contribute to climate change. Solar use also facilitates small business development and U.S. energy independence.

While offering benefits, solar energy introduces some new and unforeseen issues, like possible reflectivity and communication systems interference. The guidance discusses these issues and offers new information that can facilitate FAA project reviews, including a flow chart of FAA procedures to ensure that proposed systems are safe and pose no risks to pilots, air traffic controllers, or airport operations.

The guidance includes case studies of operating solar projects at Denver International, Fresno Yosemite International, Metropolitan Oakland International, Meadows Field (Bakersfield), and Albuquerque International Sunport. Each case study highlights a particular area of interest such as the selected technology, siting considerations, financing, and regulatory requirements.

...

1 AIRPORTS AND SOLAR ENERGY: CHARTING A COURSE

Though solar energy has been evolving since the early 1990's as a mainstream form of renewable energy generation, the expansion in the industry over the past 10 years and corresponding decrease in prices has only recently made it a practical consideration for airports.

Solar energy presents itself as an opportunity for FAA and airports to produce on-site electricity and to reduce long-term electricity use and energy costs. While solar energy has many benefits, it does introduce some new and unforeseen issues, like possible glare (also referred to as reflectivity) and communication systems interference, which have complicated FAA review and approval of this technology. This guide discusses such issues and how FAA reviews for solar projects can be streamlined and standardized to a greater extent.

...

3.1.2 Reflectivity

Reflectivity refers to light that is reflected off surfaces. The potential effects of reflectivity are glint (a momentary flash of bright light) and glare (a continuous source of bright light). These two effects are referred to hereinafter as “glare,” which can cause a brief loss of vision, also known as flash blindness.

FAA Order 7400.2, *Procedures for Handling Airspace Matters*, defines flash blindness as “generally, a temporary visual interference effect that persists after the source of illumination has ceased.”

The amount of light reflected off a solar panel surface depends on the amount of sunlight hitting the surface, its surface reflectivity, geographic location, time of year, cloud cover, and solar panel orientation. As illustrated on Figure 16²⁴, flat, smooth surfaces reflect a more concentrated amount of sunlight back to the receiver, which is referred to as specular reflection. The more a surface is polished, the more it shines. Rough or uneven surfaces reflect light in a diffused or scattered manner and, therefore, the light will not be received as bright.

CSP systems use mirrors to maximize reflection and focus the reflected sunlight and associated heat on a design point to produce steam, which generates electricity. About 90 percent of sunlight is reflected. However, because the reflected sunlight is controlled and focused on the heat collecting element (HCE) of the system, it generally does not reflect back to other sensitive receptors. Another source of reflection in a CSP system is the light that contacts the back of the HCE and never reaches the mirror. Parts of the metal frame can also reflect sunlight. In central receiver (or power tower) applications, the receiver can receive concentrated sunlight that is up to a thousand times the sun’s normal irradiance. Reflections from a central receiver, although approximately 90% absorptive, can still reflect a great deal of sunlight.

Solar PV and SHW panels are constructed of dark, light-absorbing materials and covered with an anti-reflective coating designed to maximize absorption and minimize reflection. However, the glass surfaces of solar PV and SHW systems also reflect sunlight to varying degrees throughout the day and year. The amount of reflected sunlight is based on the incidence angle of the sun relative to the light-sensitive receptor (e.g., a pilot or air traffic tower controller). The

²⁴ Shown as Figure 3 on the following page in this report.

amount of reflection increases with lower incidence angles. In some situations, 100% of the sun's energy can be reflected from solar PV and SHW panels.

Because solar energy systems introduce new visual surfaces to an airport setting where reflectivity could result in glare that can cause flash blindness to those that require clear, unobstructed vision, project proponents should evaluate reflectivity during project siting and design.

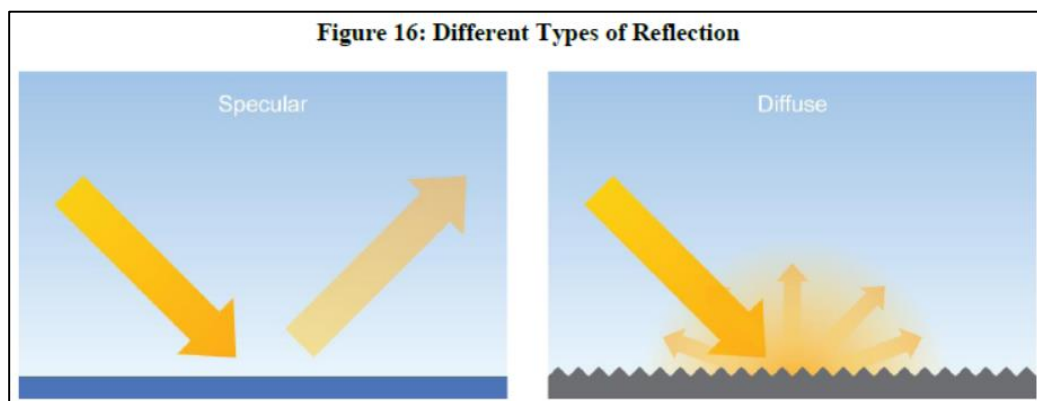


Figure 3 Specular versus diffuse reflections

Completing an Individual Glare Analysis

Evaluating glare for a specific project should be an iterative process that looks at one or more of the methodologies described below. Airport sponsors should coordinate closely with the FAA's Office of Airports to evaluate the potential for glint and glare for solar projects on airport property. These data should include a review of existing airport conditions and a comparison with existing sources of glare, as well as related information obtained from other airports with experience operating solar projects.

Because the FAA has no specific standards for airport solar facilities and potential glare, the type of glare analysis may vary. Depending on site specifics (e.g., existing land uses, location and size of the project) an acceptable evaluation could involve one or more of the following levels of assessment:

- (1) A qualitative analysis of potential impact in consultation with the Air Traffic Control Tower, pilots, and airport officials
- (2) A demonstration field test with solar panels at the proposed site in coordination with Air Traffic Control Tower personnel
- (3) A geometric analysis to determine days and times when there may be an ocular impact.

The FAA should be consulted after completing each of the following steps to determine if potential reflectivity issues have been adequately considered and addressed.

The extent of reflectivity analysis required to assess potential impacts will depend on the specific project site and system design.

1. Assessing Baseline Reflectivity Conditions

Reflection in the form of glare is present in current aviation operations. The existing sources of glare come from glass windows, auto surface parking, rooftops, and water bodies. At airports, existing reflecting surfaces may include hangar roofs, surface parking, and glassy office buildings. To minimize unexpected glare, windows of air traffic control towers and airplane cockpits are coated with anti-reflective glazing. Operators also wear polarized eye wear. Potential glare from solar panels should be viewed in this context. Any airport considering a solar PV project should first review existing sources of glare at the airport and the effectiveness of measures used to mitigate that glare.

2. Tests in the Field

Potential glare from solar panels can easily be viewed at the airport through a field test. A few airports have coordinated these tests with FAA Air Traffic Controllers to assess the significance of glare impacts. To conduct such a test, a sponsor can take a solar panel out to proposed location of the solar project, and tilt the panel in different directions to evaluate the potential for glare onto the air traffic control tower. For the two known cases where a field test was conducted, tower personnel determined the glare was not significant. If there is a significant glare impact, the project can be modified by ensuring panels are not directed in that direction.

3. Geometric Analysis

Geometric studies are the most technical approach for reflectivity issues. They are conducted when glare is difficult to assess through other methods. Studies of glare can employ geometry and the known path of the sun to predict when sunlight will reflect off of a fixed surface (like a solar panel) and contact a fixed receptor (e.g., control tower). At any given site, the sun moves across the sky every day and its path in the sky changes throughout year. This in turn alters the destination of the resultant reflections since the angle of reflection for the solar panels will be the same as the angle at which the sun hits the panels. The larger the reflective surface, the greater the likelihood of glare impacts. Figure 17 provides an example of such a geometric analysis (not shown).

Facilities placed in remote locations, like the desert, will be far from receptors and therefore potential impacts are limited to passing aircraft. Because the intensity of the light reflected from the solar panel decreases with increasing distance, an appropriate question is how far you need to be from a solar reflected surface to avoid flash blindness. It is known that this distance is directly proportional to the size of the array in question but still requires further research to definitively answer.

The FAA Airport Facilities Terminal Integration Laboratory (AFTIL), located at the William J. Hughes Technical Center at Atlantic City International Airport, provides system capabilities to evaluate control tower interior design and layout, site selection and orientation, height determination studies, and the transition of equipment into the airport traffic control tower environment. AFTIL regularly conducts computer assessments of potential penetrations of airspace for proposed airport design projects and has modeled the potential characteristics of

glare sources, though not for solar projects. AFTIL may be a resource for regional FAA officials and sponsors who seek to evaluate the potential effects of glare from proposed solar projects.

Experiences of Existing Airport Solar Projects

Solar installations are presently operating at a number of airports, including megawatt-sized solar facilities covering multiple acres. Air traffic control towers have expressed concern about glint and glare from a small number of solar installations. These were often instances when solar installations were sited between the tower and airfield, or for installations with inadequate or no reflectivity analysis. Adequate reflectivity analysis and alternative siting addressed initial issues at those installations

3.23 Key excerpts²⁵ from the final FAA guidance produced in 2021 are presented in the following section.

Initially, FAA believed that solar energy systems could introduce a novel glint and glare effect to pilots on final approach. FAA has subsequently concluded that in most cases, the glint and glare from solar energy systems to pilots on final approach is similar to glint and glare pilots routinely experience from water bodies, glass-façade buildings, parking lots, and similar features. However, FAA has continued to receive reports of potential glint and glare from on-airport solar energy systems on personnel working in ATCT cabs. Therefore, FAA has determined the scope of agency policy should be focused on the impact of on-airport solar energy systems to federally-obligated towered airports, specifically the airport's ATCT cab.

The policy in this document updates and replaces the previous policy by encouraging airport sponsors to conduct an ocular analysis of potential impacts to ATCT cabs prior to submittal of a Notice of Proposed Construction or Alteration Form 7460-1 (hereinafter Form 7460-1). Airport sponsors are no longer required to submit the results of an ocular analysis to FAA. Instead, to demonstrate compliance with 14 CFR 77.5(c), FAA will rely on the submittal of Form 7460-1 in which the sponsor confirms that it has analyzed the potential for glint and glare and determined there is no potential for ocular impact to the airport's ATCT cab. This process will enable FAA to evaluate the solar energy system project, with assurance that the system will not impact the ATCT cab.

FAA encourages airport sponsors of federally-obligated towered airports to conduct a sufficient analysis to support their assertion that a proposed solar energy system will not result in ocular impacts. There are several tools available on the open market to airport sponsors that can analyze potential glint and glare to an ATCT cab. For proposed systems that will clearly not impact ATCT cabs (e.g., on-airport solar energy systems that are blocked from the ATCT cab's view by another structure), the use of such tools may not be necessary to support the assertion that a proposed solar energy system will not result in ocular impacts.

²⁵ Edited to include only key information with respect to assessing glint and glare from solar PV developments.

The excerpt above states where a solar PV development is to be located on a federally obligated aerodrome with an ATC Tower, it will require a glint and glare assessment to accompany its application. It states that pilots on approach are no longer a specific assessment requirement due to effects from solar energy systems being similar to glint and glare pilots routinely experience from water bodies, glass-façade buildings, parking lots, and similar features. Ultimately it comes down to the specific aerodrome to ensure it is adequately safeguarded, and it is on this basis that glint and glare assessments are routinely still requested.

The policy also states that several different tools and methodologies can be used to assess the impacts of glint and glare, which was previously required to be undertaken by the Solar Glare Hazard Analysis Tool (SGHAT) using the Sandia National Laboratories methodology.

In 2018, the FAA released the latest version (Version 1.1) of the 'Technical Guidance for Evaluating Selected Solar Technologies on Airports'. Whilst the 2021 final policy also supersedes this guidance, many of the points are still relevant because aerodromes are still safeguarding against glint and glare irrespective of the FAA guidance. The key points are presented below for reference:

- Reflectivity refers to light that is reflected off surfaces. The potential effects of reflectivity are glint (a momentary flash of bright light) and glare (a continuous source of bright light). These two effects are referred to hereinafter as “glare,” which can cause a brief loss of vision, also known as flash blindness²⁶.
- The amount of light reflected off a solar panel surface depends on the amount of sunlight hitting the surface, its surface reflectivity, geographic location, time of year, cloud cover, and solar panel orientation.
- As illustrated on Figure 16²⁷, flat, smooth surfaces reflect a more concentrated amount of sunlight back to the receiver, which is referred to as specular reflection. The more a surface is polished, the more it shines. Rough or uneven surfaces reflect light in a diffused or scattered manner and, therefore, the light will not be received as bright.
- Because the FAA has no specific standards for airport solar facilities and potential glare, the type of glare analysis may vary. Depending on site specifics (e.g., existing land uses, location and size of the project) an acceptable evaluation could involve one or more of the following levels of assessment:
 - A qualitative analysis of potential impact in consultation with the Control Tower, pilots and airport officials;

²⁶ Flash Blindness, as described in the FAA guidelines, can be described as a temporary visual interference effect that persists after the source of illumination has ceased. This occurs from many reflective materials in the ambient environment.

²⁷ Figure 3 above.

- A demonstration field test with solar panels at the proposed site in coordination with FAA Tower personnel;
- A geometric analysis to determine days and times when an impact is predicted.
- The extent of reflectivity analysis required to assess potential impacts will depend on the specific project site and system design.
- **1. Assessing Baseline Reflectivity Conditions** – Reflection in the form of glare is present in current aviation operations. The existing sources of glare come from glass windows, auto surface parking, rooftops, and water bodies. At airports, existing reflecting surfaces may include hangar roofs, surface parking, and glassy office buildings. To minimize unexpected glare, windows of air traffic control towers and airplane cockpits are coated with anti-reflective glazing. Operators also wear polarized eye wear. Potential glare from solar panels should be viewed in this context. Any airport considering a solar PV project should first review existing sources of glare at the airport and the effectiveness of measures used to mitigate that glare.
- **2. Tests in the Field** – Potential glare from solar panels can easily be viewed at the airport through a field test. A few airports have coordinated these tests with FAA Air Traffic Controllers to assess the significance of glare impacts. To conduct such a test, a sponsor can take a solar panel out to proposed location of the solar project, and tilt the panel in different directions to evaluate the potential for glare onto the air traffic control tower. For the two known cases where a field test was conducted, tower personnel determined the glare was not significant. If there is a significant glare impact, the project can be modified by ensuring panels are not directed in that direction.
- **3. Geometric Analysis** – Geometric studies are the most technical approach for reflectivity issues. They are conducted when glare is difficult to assess through other methods. Studies of glare can employ geometry and the known path of the sun to predict when sunlight will reflect off of a fixed surface (like a solar panel) and contact a fixed receptor (e.g., control tower). At any given site, the sun moves across the sky every day and its path in the sky changes throughout year. This in turn alters the destination of the resultant reflections since the angle of reflection for the solar panels will be the same as the angle at which the sun hits the panels. The larger the reflective surface, the greater the likelihood of glare impacts.
- Facilities placed in remote locations, like the desert, will be far from receptors and therefore potential impacts are limited to passing aircraft. Because the intensity of the light reflected from the solar panel decreases with increasing distance, an appropriate question is how far you need to be from a solar reflected surface to avoid flash blindness.

It is known that this distance is directly proportional to the size of the array in question²⁸ but still requires further research to definitively answer.

- **Experiences of Existing Airport Solar Projects** – Solar installations are presently operating at a number of airports, including megawatt-sized solar facilities covering multiple acres. Air traffic control towers have expressed concern about glint and glare from a small number of solar installations. These were often instances when solar installations were sited between the tower and airfield, or for installations with inadequate or no reflectivity analysis. Adequate reflectivity analysis and alternative siting addressed initial issues at those installations.

3.24 The previous 2018 guidance offered three assessment options however, where a proposed solar development is located where a risk to aviation safety is possible, geometric analysis, as per the 2013 guidance, was likely to be required to alleviate concerns. The 2021 final policy has taken a step back and allowed aerodromes to safeguard as they see fit, with no longer a recommendation for any given glare model. The current precedence set by aerodromes in the UK and internationally is to safeguard against glint and glare as per the 2018 guidance based on the aerodrome's operations.

²⁸ Ho, Clifford, Cheryl Ghanbari, and Richard Diver. 2009. Hazard Analysis of Glint and Glare From Concentrating Solar Power Plants. SolarPACES 2009, Berlin Germany. Sandia National Laboratories.

The Air Navigation Order

3.25 The Air Navigation Order (ANO) from 2016²⁹ contains general aviation legislation with respect to aviation safety. Key points relating to general safety and light as a hazard are presented below. Note only the relevant information is presented.

The Air Navigation Order 2009

Lights liable to endanger

224. (1) A person must not exhibit in the United Kingdom any light which—

(a) by reason of its glare is liable to endanger aircraft taking off from or landing at an aerodrome; or

(b) by reason of its liability to be mistaken for an aeronautical ground light is liable to endanger aircraft.

(2) If any light which appears to the CAA to be a light described in paragraph (1) is exhibited, the CAA may direct the person who is the occupier of the place where the light is exhibited or who has charge of the light, to take such steps within a reasonable time as are specified in the direction—

(a) to extinguish or screen the light; and

(b) to prevent in the future the exhibition of any other light which may similarly endanger aircraft.

(3) The direction may be served either personally or by post, or by affixing it in some conspicuous place near to the light to which it relates.

(4) In the case of a light which is or may be visible from any waters within the area of a general lighthouse authority, the power of the CAA under this article must not be exercised except with the consent of that authority.

Lights which dazzle or distract

225. A person must not in the United Kingdom direct or shine any light at any aircraft in flight so as to dazzle or distract the pilot of the aircraft.'

The document states that no 'light', 'dazzle' or 'glare' should be produced which will create a detrimental impact upon aircraft safety.

Endangering safety of an aircraft

240. A person must not recklessly or negligently act in a manner likely to endanger an aircraft, or any person in an aircraft.

²⁹ The Air Navigation Order, 2016. No. 3015. Last accessed 15.08.2022.

Endangering safety of any person or property

241. A person must not recklessly or negligently cause or permit an aircraft to endanger any person or property.

3.26 The document states that no 'light', 'dazzle' or 'glare' should be produced which would produce a detrimental impact to aircraft safety. This guidance is referenced within the CAA guidance.

4 MODELLING PARAMETER REQUIREMENTS

Overview

4.1 A glint and glare assessment requires a geometric model to accurately predict whether a solar reflection is geometrically possible towards a receptor. The following sections set out the modelling requirements.

Geometric Modelling Requirements

4.2 The requirements for a geometric model are presented below. Failure to include the parameters below is likely to result an over-simplified output that would not be considered reliable in the context of predicted impact. The calculations are three dimensional and complex, and must account for the following:

- The Earth's orbit around the Sun;
- The Earth's rotation;
- The Earth's orientation;
- The location of the solar PV development or building development including the reflector (solar panel or façade) area;
- The reflector's 3D orientation including azimuth angle of the solar panel or façade (the orientation of the reflectors relative to north and the reflector elevation angle;
- Local topography including receptor and reflector (panel or façade) heights above mean sea level.

4.3 For increased accuracy, the model could account for the following:

- Terrain at the visible horizon;
- Local time zone and daylight savings times;
- Consideration of sunrise and sunset times;
- Determine which solar panels create the solar reflection within the solar PV development;
- Determine what area of the façade create the solar reflection from the building development;
- Azimuth range of the Sun³⁰ when a solar reflection is geometrically possible;
- Vertical elevation range of the Sun when a solar reflection is geometrically possible;

³⁰ The azimuth range is the angle between the Sun and North, measured clockwise around the receptor's horizon. The Sun azimuth range shows the location of the Sun when a geometric solar reflection is possible. Therefore, it is possible to determine whether the Sun and the solar reflection are both likely to be visible to a receptor.

- High-resolution analysis i.e. undertaking multiple geometric calculations within the given solar PV development or façade area. For example, at intervals of between 1 and 20 metres;
- Consideration of the effect of non-specular reflective surfaces e.g. masonry between glass façades;
- The intensity³¹ of any solar reflection produced.

Geometric Modelling Overview

4.4 Solar reflections from a solar panel or a façade made of glass are specular meaning that a high percentage of incoming light is reflected in a particular direction. The direction of a specular solar reflection from a flat reflector is calculated by considering the normal. The normal is an imaginary line perpendicular to the reflective surface and originates from the point the incoming light intercepts the face of the reflector. Figure 4 and Figure 5 below and on the following page may be used to aid understanding of the reflection calculation process.

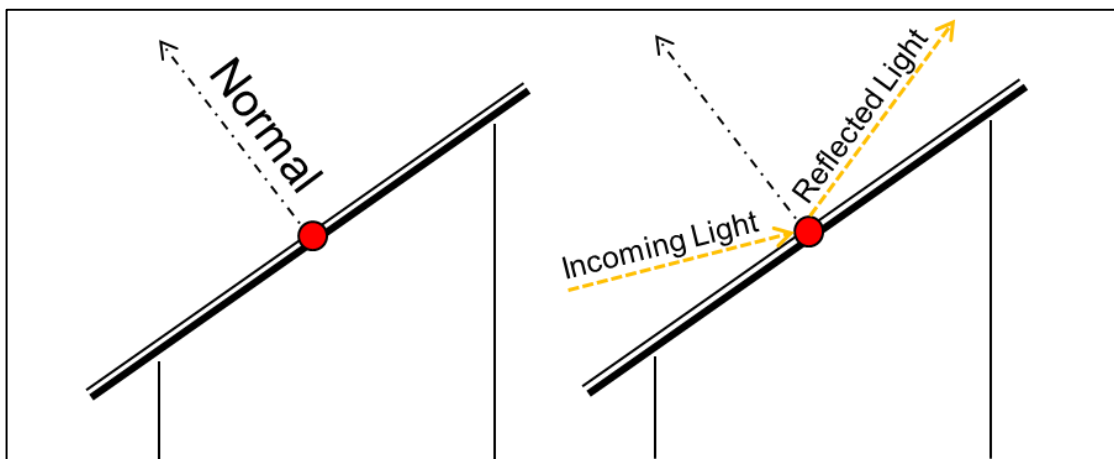


Figure 4 Illustration showing normal and solar reflection from a solar panel (side on).

³¹ In W/cm² at the retina, for example.

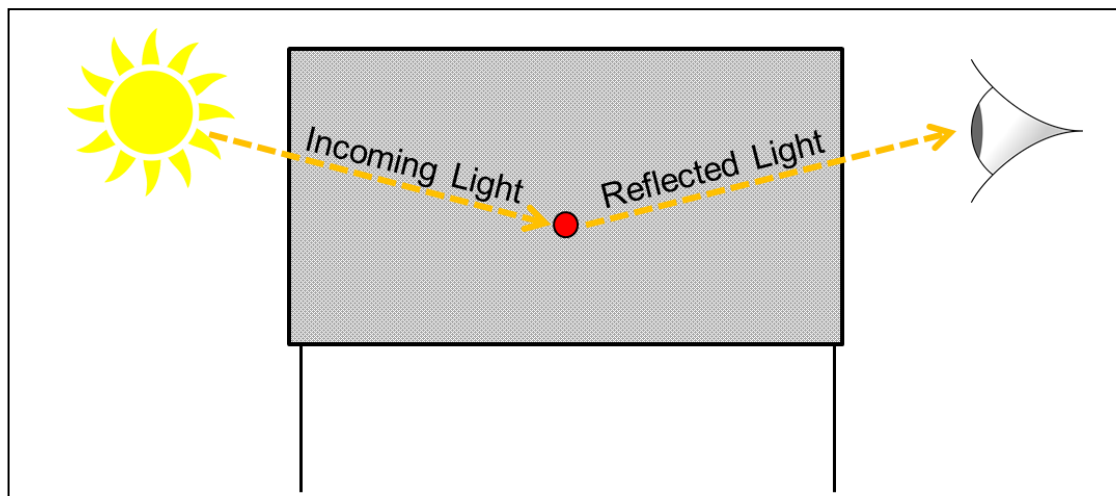


Figure 5 Illustration showing solar reflection from a solar panel (top down).

4.5 The direction of a solar reflection is also dependent on the elevation angle and the azimuth angle of a solar panel. The solar panel elevation angle and azimuth angle are illustrated in Figure 6 below.

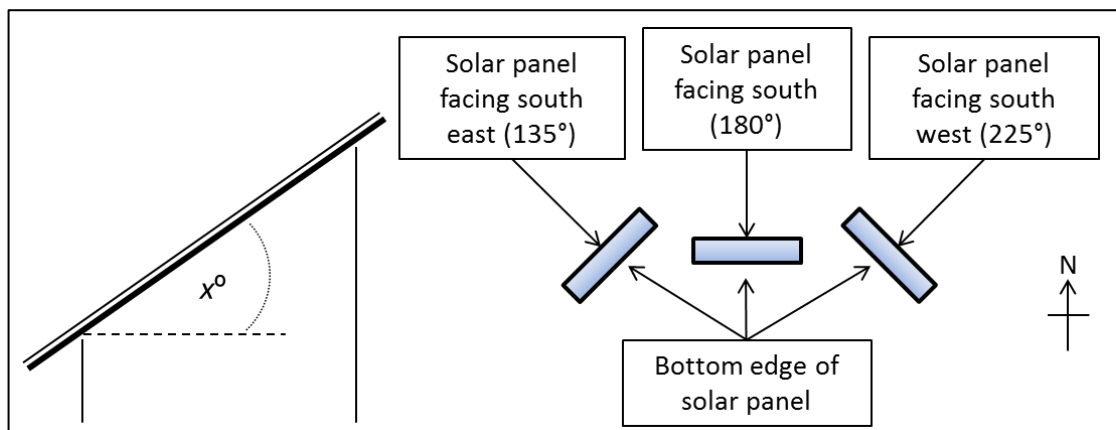


Figure 6 Illustration showing panel elevation angle (side-on) and panel azimuth angle (top down)

4.6 The left image in Figure 6 shows the panel elevation angle. A typical panel elevation angle value for x in the UK and Ireland is 15° - 35° . The right image shows the panel azimuth angle viewed from a top down perspective. A typical panel azimuth angle in the UK and Ireland is 180° (facing south towards the equator – with north facing panels typical in the southern hemisphere). Building façades are typically at 90 degrees to the horizontal, however some buildings, such as the Shard in London (UK), do not have façades that are perpendicular to the ground.

Geometric Modelling Methodology Overview

4.7 A geometric solar reflection model needs to consider a number of factors when determining whether a solar reflection is geometrically possible towards a surrounding receptors, and if so, the duration throughout the year. The following information is required for a complete geometric solar reflection model:

- A model of the Sun's path throughout the sky for an entire selected year;
- For calculating a solar reflection:
 - The 3D angle between the source and the normal;
 - The azimuth and elevation of the solar reflection, by verifying the following:
 - That the angle between source (the Sun) and normal (relative to the reflector, considering its elevation and azimuth angle) is equal to the angle between the normal and solar reflection;
 - That the source, normal and solar reflection are in the same plane;
 - A model of the path of the Sun relative to the reflector area based on the reflector's latitude and longitude;
 - The assessed receptor location's latitude and longitude relative to the above.

- The model must then be run to determine whether the Sun is ever in a position within the sky to create a solar reflection from the reflectors towards the assessed receptor. This must consider the relative heights of the reflectors and receptors. Where a solar reflection is geometrically possible, a date time graph is a suitable representational format.

4.8 The process outlined above does not describe the full methodology for undertaking a detailed geometric glint and glare assessment however, it presents the key criteria that must be considered within a model.

Modelling Parameter Requirement Conclusions

4.9 Various modelling methodologies can be used to model solar reflections from the Sun. The process outlined provides general guidance for the parameters that should be built into a geometric solar reflection model.

5 GLINT AND GLARE IMPACT SIGNIFICANCE

Overview

5.1 The significance of glint and glare will vary for different receptors. This section presents a general overview of the significance criteria with respect to experiencing a solar reflection.

Impact Significance Definition

5.2 For each glint and glare assessment, an overall conclusion should be made with reference to the requirement for mitigation for each assessed receptor. Table 2 below presents the recommended definition of 'impact significance' in glint and glare terms and the requirement for mitigation under each.

Impact Significance	Definition	Mitigation Requirement
No Impact	A solar reflection is not geometrically possible or will not be visible from the assessed receptor.	No mitigation required.
Low	A solar reflection is geometrically possible however any impact is considered to be small such that mitigation is not required e.g. intervening screening will limit the view of the reflecting solar panels significantly.	No mitigation recommended.
Moderate	A solar reflection is geometrically possible and visible however it occurs under conditions that do not represent a worst-case given individual receptor criteria.	Mitigation recommended.
High	A solar reflection is geometrically possible and visible under worst-case conditions that will produce a significant impact given individual receptor criteria	Mitigation will be required if the proposed development is to proceed.

Table 2 *Impact significance definition*

5.3 Figure 7 on the following page highlights the general conditions under which a solar reflection may be possible. These are key considerations when determining whether a solar reflection is to be considered significant and whether mitigation should be implemented.

General Overview – Determining Significant Glint and Glare Effects

5.4 The following six conditions should be considered when determining whether a predicted solar reflection will produce an impact (low to high) for the assessed receptors. These conditions are illustrated in Figure 7 to the right. Each one is explained further below.

1. The reflector can be seen by the receptor i.e. there is line of sight between the observer (receptor) and the reflector;
2. The location of the receptor relative to the solar reflection. The significance of a solar reflection may be dependent on its location of origin relative to the location of the receptor;
3. The time of day when the Sun is in the position to produce a solar reflection from a reflector towards an assessed receptor³². Some times of day may be more significant than others for some receptors;
4. The path between the Sun and reflector is clear of obstruction i.e. there is a line of sight between the Sun and the reflector when the Sun is at a location in the sky where it can produce a solar reflection;
5. The solar reflection is not coming from the same direction as the Sun. A solar reflection is less significant when a receptor is already facing directly at the Sun;
6. A momentary exposure is less significant than a prolonged one. Therefore, the duration of the solar reflection should be considered for static receptors i.e. dwellings or ATC Towers.

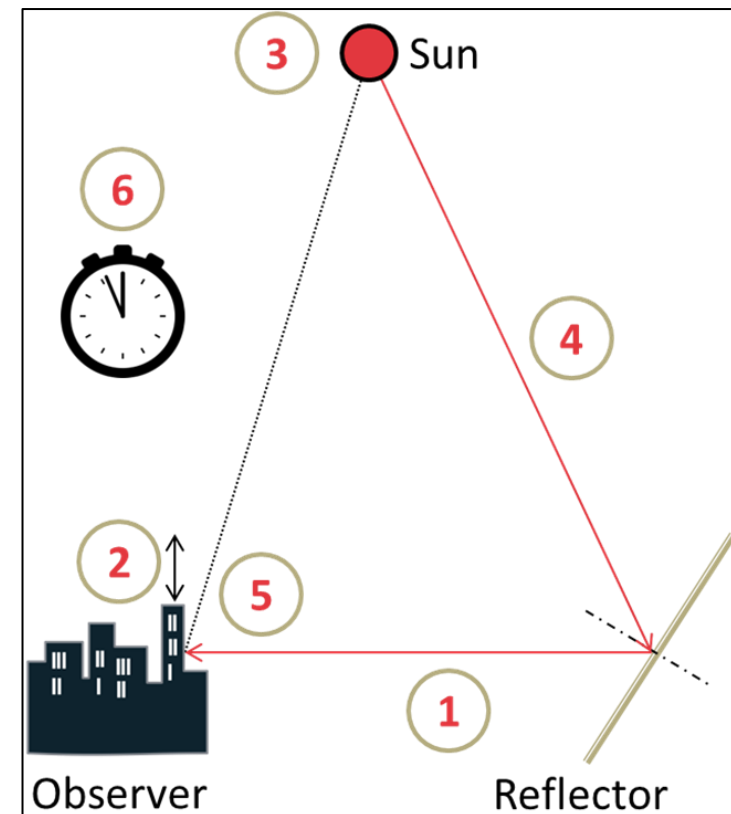


Figure 7 Conditions for determining significant glint and glare

³² Not specifically referenced within the significance criteria for each assessed receptor (dwellings, road, rail and aviation) however in some instance the time of day may warrant consideration.

5.5 Figure 8 below shows the general process for determining the significance of glint and glare.

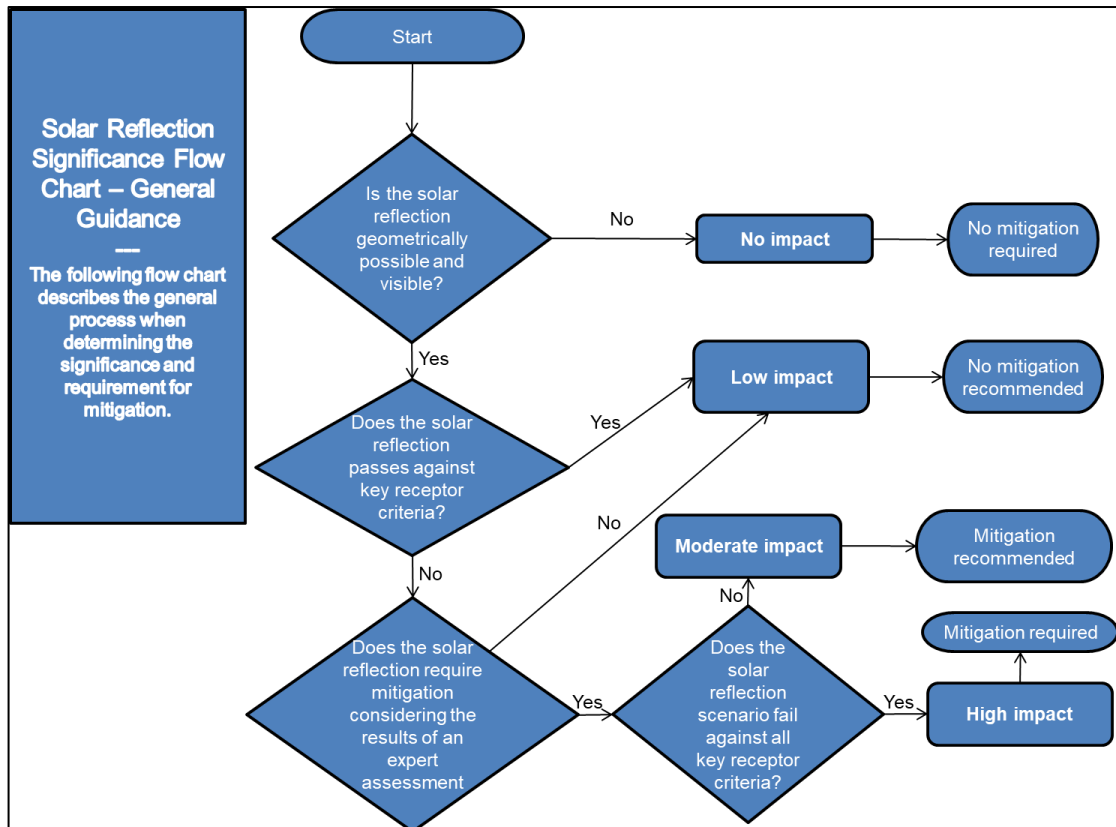


Figure 8 General process for determining the significance of glint and glare

5.6 Key receptor criteria refer to how aspects of the glare scenario may affect receptors differently e.g. field of view for a road user not being relevant to a resident in a local dwelling, or how the intensity of reflection being relevant for aviation only.

5.7 The specific methodologies for each receptor (dwellings, road, railway and aviation) are presented in Sections 6-9.

6 ASSESSING THE IMPACT UPON SURROUNDING DWELLINGS

Overview

6.1 Local residents are a key stakeholder within the local environment when proposing a solar PV development. This is because residents will be living in close proximity to the solar PV development whilst also potentially having views of the solar panels for its lifetime. Where a view of the solar panel exists, a solar reflection may be possible which may impact upon residential amenity. The following guidance has therefore been produced to determine in what instances, a solar reflection becomes significant and mitigation should be implemented. The effects of glint and glare from building developments is not typically considered however, if required, the general methodology can be applied.

Key Considerations

6.2 A list of key considerations for assessing glint and glare with respect to surrounding dwellings and residential amenity is presented below:

- Surrounding dwellings may have views of a solar PV development. Where a view of the solar panel exists, a solar reflection may be possible;
- A view of a solar panel however does not guarantee that a solar reflection is possible;
- There is no technical limit (distance) within which solar reflections is possible for a surrounding dwelling receptor however, the significance of a reflection decreases with distance. This is because the proportion of an observer's field of vision that is taken up by the reflecting area diminishes as the separation distance increases;
- Seasonal variations or additional developments may change the view from a dwelling towards the solar panels over time;
- Terrain and shielding by vegetation are also more likely to obstruct an observer's view at longer distances;
- In general, the geometry of the relationship between typical ground mounted solar panels and the movement of the Sun in the northern hemisphere means that dwellings due east and west of the panels are most likely to view a solar reflection for south facing arrays panels. Dwellings that are north or south of the panels are unlikely to experience a solar reflection under typical conditions. In the southern hemisphere, this is reversed;
- For solar PV developments that have solar panels orientated at an azimuth angle other than south, solar reflections may be directed in alternate directions.

6.3 The following subsections present the recommended methodology for assessing the impact upon residential amenity.

Identifying Receptors

6.4 The following process should be used for identifying dwelling receptors:

1. Identify dwellings in the immediate surrounding area (out to approximately 1km from the solar PV development boundary) that may have visual line of sight to the solar panels. Figure 9 below shows the receptor identification process;
2. If visual line of sight exists between the proposed solar PV development and a dwelling, then a solar reflection could be experienced if it is geometrically possible. If there is no line of sight, then a reflection cannot be experienced;
3. An additional height should be added to the ground level at a dwelling to represent a viewing height;
4. For dwellings, a recommended additional height of 1.8 metres above ground level should be added to account for eye level on the ground floor, with additional floors being assessed as required. Additional heights should be considered where a receptor is higher than a first floor. Modelling is recommended for ground floor receptors because it is typically the most occupied during daylight hours;
5. Use the height and location data within the geometric solar reflection model.

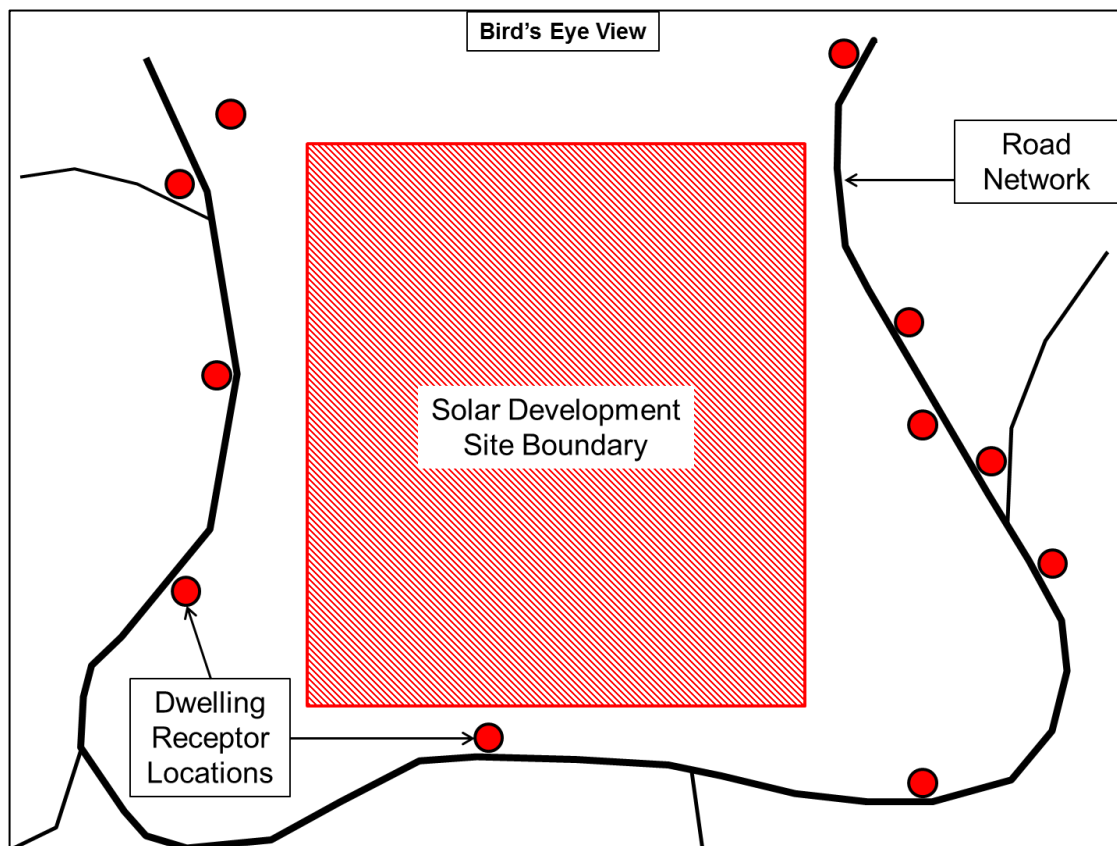


Figure 9 Illustration showing receptor identification process – dwellings

Assessment Process

6.5 The following process should be used for modelling glint and glare for the identified dwelling receptors:

1. Define the solar PV development panel area;
2. Undertake geometric calculations, as outlined within Section 4 of this guidance;
3. Produce a solar reflection chart to determine whether a solar reflection is geometrically possible, and if so at what time/duration;
4. Assess the results of the geometric glint and glare assessment in the context of the following:
 - a. Sun location relative to the solar panels;
 - b. Location of the reflecting solar panels relative to the dwelling;
 - c. Existing screening;
 - d. Proposed screening;
5. Determine whether a solar reflection is significant;
6. Consider mitigation, if required.

Discussion of Significant Effects

6.6 There are many solar PV developments where solar reflections are geometrically possible and visible from surrounding dwellings. Experiencing a solar reflection does not, however, guarantee a significant effect requiring mitigation will occur. Assuming the solar PV development is visible from a window of a room occupied during daylight hours, the duration of time for which a solar reflection could last is the most significant characteristic.

6.7 Other factors that could be considered when determining whether a solar reflection is significant include:

- Whether the solar reflection is incident to direct sunlight and the location;
- Whether the dwelling has a window facing the solar PV development;
- The room or floor within the dwelling from which a solar reflection may be visible i.e. is it occupied for a long period during daylight hours e.g. a living room;
- Whether views from a window are oblique;
- The time of day/year when a solar reflection is geometrically possible.

6.8 The duration of time for which a solar reflection is possible is the main defining characteristic when determining whether mitigation is required. Defining a minimum duration for effects to become significant is, however, subjective. For static receptors, the length of time for which a solar reflection is geometrically possible and visible will determine its significance upon residential amenity. Therefore, it is appropriate to choose a duration beyond which solar reflections become significant and where mitigation is required. Applying a strictly scientific approach is difficult however because:

- Most models generally show a worst-case scenario of glint and glare, often predicting solar reflections for a much greater length of time than will be experienced in reality;
- The scenario in which glint and glare occurs will vary for each dwelling;
- The effects of glint and glare are subjective and the significance will vary from person to person.

6.9 To quantify and determine where a significant impact is expected, previous glint and glare assessment experience has been drawn upon as well as a review of existing guidance with respect to light based environmental impacts, these include:

- Previous glint and glare assessment experience;
- Shadow flicker guidance for wind turbines³³. Guidance has been produced which sets durations beyond which a significant impact on residential amenity is expected and mitigation is required.

Previous Experience of Glint and Glare Dwelling Assessments

6.10 It is common for dwellings to be located within 1km of a proposed solar PV development. Assessment experience means that typical results for proposed ground mounted solar PV developments³⁴ are known. It is common for solar reflections to be possible in the mid-morning (~06:00-08:00 GMT) and again in the early evening (~17:00-19:00 GMT). There are many examples of dwellings located where a solar reflection is geometrically possible however, a solar reflection could only ever be significant where the solar reflection is visible from the dwelling. Assuming a solar reflection is geometrically possible, and the reflecting solar panels are visible, a solar reflection would be experienced when the following conditions are met:

1. An observer is located at a point within the dwelling where a solar reflection is possible e.g. located at a kitchen window at the time of the day when a solar reflection is geometrically possible;
2. The weather at the particular time of the day when a solar reflection is geometrically possible is clear and sunny;
3. There are clear unobstructed views from this window towards the reflecting solar panel area

6.11 The likelihood of these conditions being met varies both person to person and geographically based on local climate conditions. However, it illustrates that a predicted geometric solar reflection does not guarantee a visible solar reflection when considering real world conditions.

³³ Shadow flicker, like glint and glare, is considered a detrimental effect created through the manipulation of sunlight. Therefore the guidance has been used for comparative purposes.

³⁴ At typical solar panel azimuth and inclinations. Defined as panel elevation angle 15-30 degrees and south facing in the UK and Ireland.

Shadow Flicker Guidance

6.12 “Shadow flicker” refers to the sunlight flickering effect caused when rotating wind turbine blades periodically cast shadows over neighbouring dwellings through small openings such as windows. This can cause a significant detrimental impact upon residential amenity under certain conditions.

6.13 A review of the shadow flicker guidance has been undertaken, with specific reference to the guidance where time limits have been stated for the maximum acceptable duration of shadow flicker, beyond which mitigation is required. The guidance states the following:

1. Shadow flicker is possible at dwellings within 10 rotor diameters³⁵. A typical rotor diameter for a large-scale wind turbine is 90m, making the potential shadow flicker zone out to 900m from the wind turbine location³⁶;
2. The following must all apply:
 - a. Shadow flicker is only possible when the wind turbine is rotating; and
 - b. Shadow flicker is only possible where the Sun passes behind the rotating wind turbine relative to the assessed dwelling; and
 - c. Shadow flicker is possible within rooms where windows have a clear view of the rotating wind turbine.
3. Shadow flicker is deemed significant where it lasts for longer than 30 minutes per day and for more than 30 hours of the year within 500m of the turbine³⁷ in some European countries. Beyond this distance no maximum acceptable time is stated;
4. Mitigation is required if all of the above are satisfied.

Determination of Significant Effects

6.14 The effects of glint and glare differ to shadow flicker for a number of reasons, and could be considered less significant because:

- A solar panel produces a solar reflection and therefore the light reflected is less intense than direct sunlight because a percentage of the light is absorbed by the solar panel. Shadow flicker is the effect of the varying light levels directly from the Sun;
- Shadow flicker produces significant variations to light levels within a room. An observer does not have to be looking at the wind turbine directly to observe the effect. For glint and glare effects to be experienced, an observer has to view the solar panels directly;

³⁵ Onshore Wind Energy Planning Conditions Guidance Note, Renewables Advisory Board and BERR (2007). Last accessed 02/11/2016.

³⁶ The search radius for dwellings is within 1km from a proposed solar development for glint and glare effects. This search area is for glint and glare effects is therefore expected to be larger than the area for shadow flicker for the majority of large-scale onshore wind turbines.

³⁷ Draft PPS18: Renewable Energy Annex 1 Wind Energy Planning Issues: Shadow Flicker and Reflected Light, Planning Portal Northern Ireland (the shadow flicker recommendations are based on research by Predac, a European Union sponsored organisation promoting best practice in energy use and supply which draws on experience from Belgium, Denmark, France, the Netherlands and Germany). Last accessed 02/11/2016.

- A solar reflection from a solar panel will appear static, whereas the effect of shadow flicker will inherently flicker in time with 1/3 the frequency of the rotating blades (assuming three blades);
- The presence of shadow flicker would be a new effect experienced at a dwelling. Solar panels produce solar reflections of similar intensity to those from still water or glass for example, both common reflective sources next to dwellings.

6.15 Shadow flicker guidance states that effects for more than 30 minutes per day, over 30 hours of the year, is significant and requires mitigation. Considering the information presented within Section 6.5 and the above, it is deemed appropriate to consider the effects of glint and glare less significant than shadow flicker. Therefore, the duration beyond which mitigation should be required for glint and glare is longer than for shadow flicker.

6.16 Therefore the recommendation within this guidance is:

- If visible glint and glare is predicted for a surrounding dwelling for longer than 60 minutes per day, for three or more months of the year, then the impact should be considered significant with respect to residential amenity. In this scenario, mitigation should be implemented.

6.17 The process outlined in the following flow chart (Figure 10 below) is recommended when determining whether a solar reflection should be deemed significant and mitigation implemented.

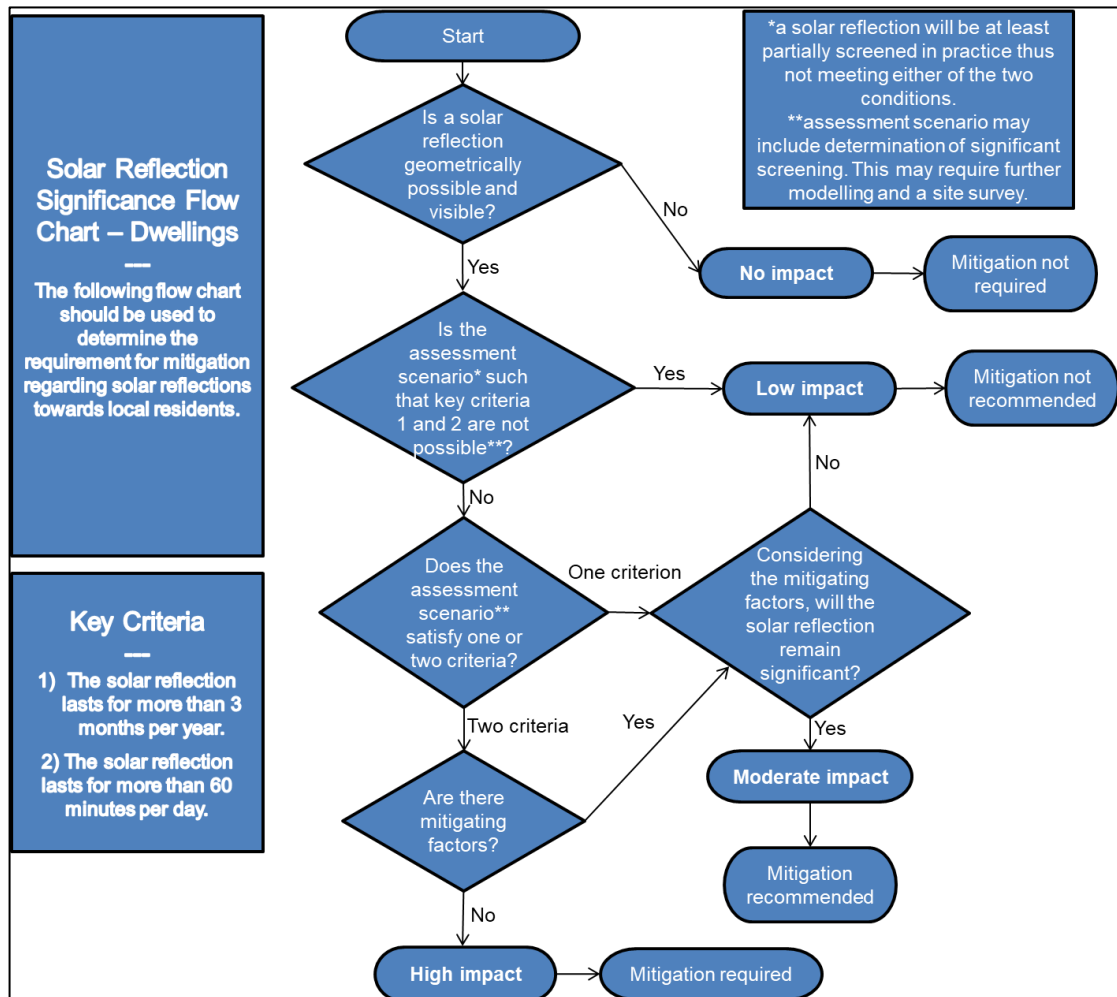


Figure 10 Dwelling impact significance flow chart

6.18 There may be instances where the solar reflection scenario does not fall accurately within the significance categories. Where this occurs, detailed consideration of the receptors and the modelling results should be undertaken.

6.19 'Significant screening' with respect to visibility of reflecting solar panels implies that the observer's view is impeded to the extent that the presence of the solar panels cannot be easily discerned at first glance. For example, a hedgerow that contains small gaps that facilitate partial visibility of the panel face(s) would provide 'significant screening'. Figure 11 on the following page illustrates this.

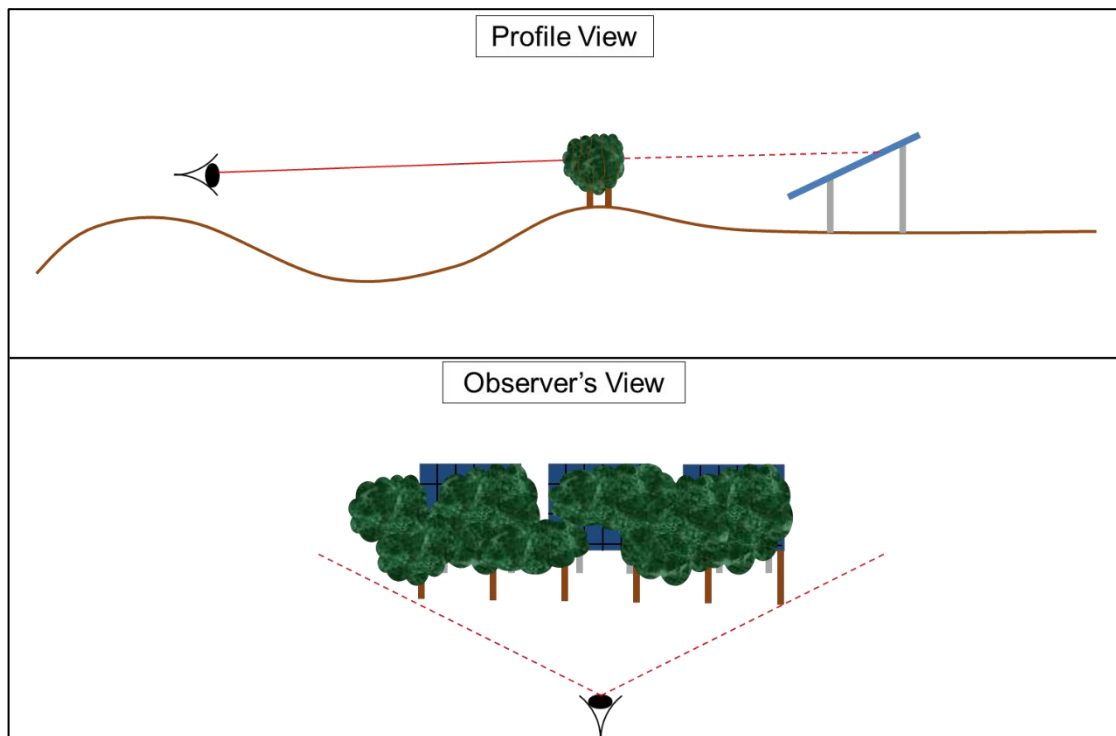


Figure 11 Illustration of 'significant screening'

Conclusions

6.20 The size of the solar panel area and visibility of the reflecting solar panels relative to the assessed dwelling will determine the duration of the solar reflection. Where solar reflections persist beyond 60 minutes per day for three or more months per year, solar reflections are considered significant and mitigation should be implemented. Consultation is recommended where there is a requirement for mitigation.

7 ASSESSING THE IMPACT UPON ROAD USERS

Overview

7.1 Locating a solar PV development next to a road is often essential due to access requirements. The possibility of glint and glare effects from the proposed solar PV development can however lead to concerns with respect to the possible impact upon road safety especially if the solar PV development is to be located next to a road with fast moving and/ or busy traffic. Therefore, a glint and glare assessment may be requested by the relevant stakeholders so that the possible effects can be understood. The effects of glint and glare from building developments is not typically considered however, if required, the general methodology can be applied.

Key Considerations

7.2 A list of key considerations for assessing glint and glare with respect to road safety is presented below:

- A road user may have views of a solar PV development. Where a view of the solar panel exists, a solar reflection may be possible;
- A view of a solar panel does not however guarantee that a solar reflection is possible;
- Where the solar reflection originates from relative to a road user is a key criterion. Pager Power considers a solar reflection to be potentially significant if it originates within 50 degrees of the direction of travel³⁸;
- There is no technical limit (distance) within which a solar reflection is possible for a surrounding road user however, the significance of a reflection decreases with distance. This is because the proportion of an observer's field of vision that is taken up by the reflecting area diminishes as the separation distance increases;
- Seasonal variations to vegetation or new additional development may change the view from a road user towards the solar panels over time;
- Terrain and shielding by vegetation are also more likely to obstruct an observer's view over longer distances;
- In general, the geometry of the relationship between typical ground mounted solar panels and the movement of the Sun in the northern hemisphere means that roads due east and west of the panels are most likely to view a solar reflection for south facing arrays panels. Roads that are north or south of the panels are very unlikely to experience a solar reflection;
- For solar PV developments that have solar panels orientated at an azimuth angle other than south, solar reflections may be directed in alternate directions.

³⁸ As per Pager Power's white paper investigating the field of view for a road user. available [here](#).

7.3 The following subsections present the recommended methodology for assessing the impact upon road safety.

Identifying Receptors

7.4 The following process should be used for identifying road receptors:

1. Identify roads in the immediate surrounding area (out to approximately 1km from the solar PV development boundary) that may have visual line of sight to the solar panels;
2. If visual line of sight exists between the proposed solar PV development and the road, then a solar reflection could be experienced if it is geometrically possible;
3. If there is no line of sight, then a reflection cannot be experienced;
4. Assess a length of road, choosing individual receptor locations no more than 200 metres apart. This is shown in Figure 12 on the following page;
5. An additional height should be added to the ground level height to represent the typical viewing height from a road user. For road users, a height of 1.5 metres is recommended;
6. Use the height and location data within the geometric solar reflection model.

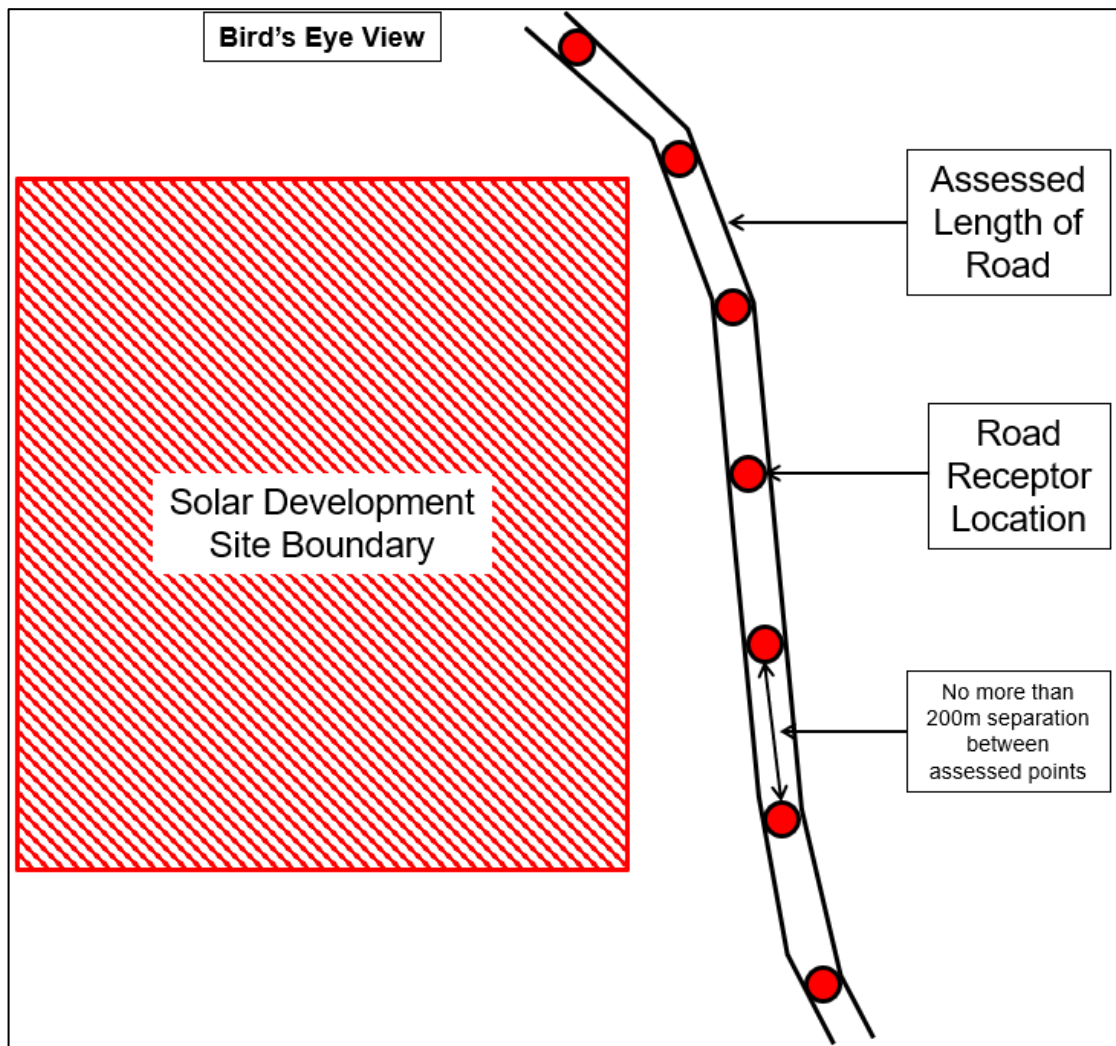


Figure 12 Illustration showing receptor identification process – roads

Assessment Process

7.5 The following process should be used for modelling glint and glare for the identified road user receptors:

1. Define the solar PV development solar panel area;
2. Undertake geometric calculations, as outlined within Section 4 of this guidance;
3. Produce a solar reflection chart to determine whether a solar reflection is geometrically possible;
4. Assess the results of the geometric glint and glare assessment in the context of the following:
 - a. Sun location relative to the solar panels;
 - b. Location of the reflecting solar panels relative to the road and direction of travel;
 - c. Consideration of existing screening;

- d. Consideration of proposed screening;
5. Determine whether a solar reflection is significant;
6. Consider mitigation, if required.

Determination of Significant Effects

7.6 A road user travelling on surrounding roads where a solar reflection is geometrically possible would experience a solar reflection that is fleeting in nature. This is because the road user is typically moving at speeds anywhere up to 70mph or 120kph. This means that the duration of a predicted solar reflection is mostly dependent on the speed of the road user travelling past the solar farm at the time when a solar reflection is geometrically possible. Therefore, the location of origin of the solar reflection is more significant than its duration because the receptor is moving.

7.7 There are many solar PV developments where solar reflections are geometrically possible towards roads. Experiencing a solar reflection does not guarantee a significant effect requiring mitigation and there are criteria that should be considered when determining the significance of a solar reflection, these are:

- Is the solar reflection incident to direct sunlight?
- What type of road is affected? Major National, National, Regional or Local roads?
- Does the solar reflection appear in-line with, or close to, the direction of travel (up to 50 degrees either side of the direction of travel)?
- What is the length of road that may experience a solar reflection?

7.8 For south facing solar panels at standard inclinations³⁹ it is likely that the Sun will be incident to the solar reflections in the UK and Ireland. Whether the solar reflection appears in-line with, or close to, the direction of travel depends on the geographic location of the surrounding road relative to the solar PV development. This, along with the size of the proposed solar PV development, determines the length of road that may be affected.

7.9 Because the length of time a solar reflection can last is mostly dependent on the road user's speed rather than the solar PV development, the length of time that a solar reflection is not considered when determining its significance. Instead, the location of origination of the solar reflection and road type are considered.

³⁹ Defined as 15-35 degrees in the UK and Ireland.

7.10 The process outlined in the flow chart below (Figure 13) is recommended when determining whether a solar reflection should be deemed significant, and mitigation implemented.

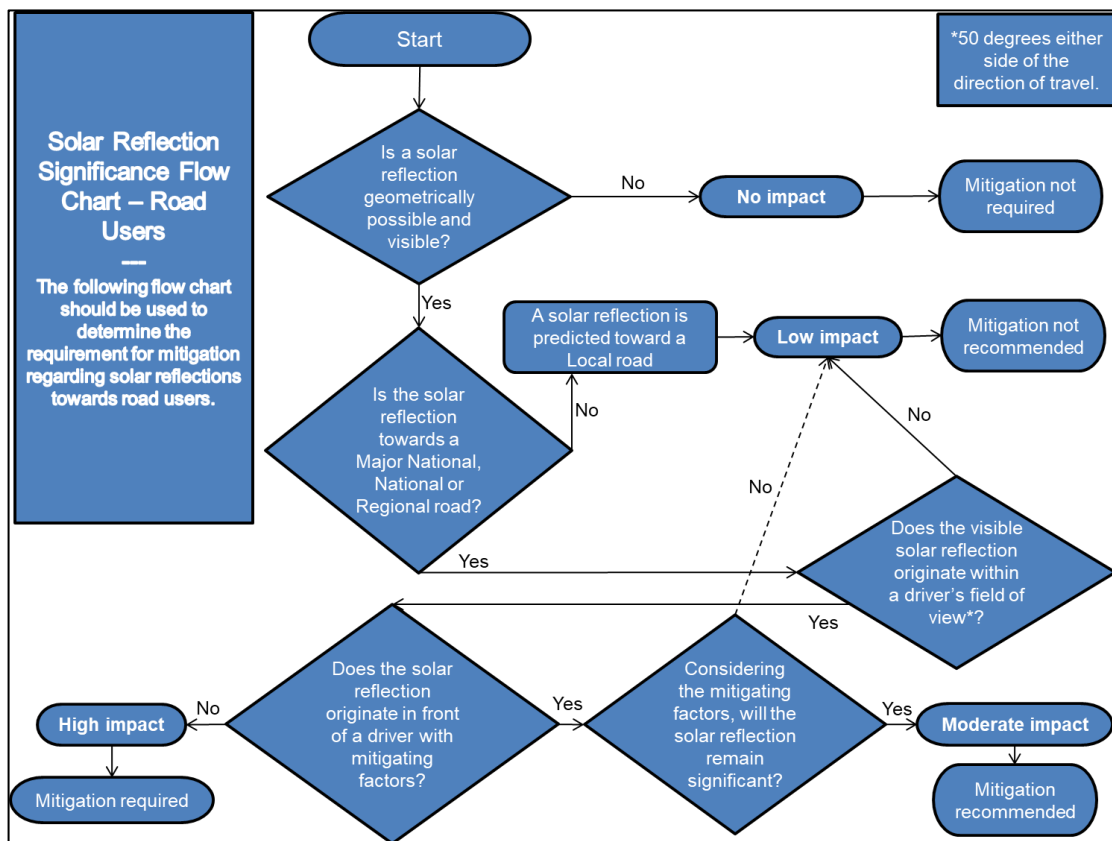


Figure 13 Road user impact significance flow chart

7.11 There may be instances where the solar reflection scenario does not fall accurately within the significance categories. Where this occurs, detailed consideration of the receptors and the modelling results should be undertaken.

7.12 Regional, National and Major National roads are the most important in the majority of instances. Local roads may, under particular conditions, prove to be vital to the surrounding road network. Therefore, consultation with the local highway authority is recommended to ascertain the significance of a surrounding road where it is unknown.

7.13 The road classifications are based on typical UK roads, however what constitutes a regional road (for example) may vary in different countries. Therefore, alongside road classification, the road size, speed limit, surface, traffic volume and traffic speed should also be considered when applying impact significance with road classification.

Conclusions

7.14 The visibility and size of the reflecting solar panel area from an assessed road will in part, determine the duration of a solar reflection. In most scenarios, the speed of the vehicle will be the overall determining factor which determines the duration of the solar reflection. The type of road affected and location of origin of the solar reflection with respect to the direction of road travel will determine the requirement for mitigation. Consultation with the local highway authority is recommended where mitigation is required.

8 ASSESSING THE IMPACT UPON RAILWAY OPERATIONS

Overview

8.1 Solar PV and building developments can be located adjacent to railway lines. Indeed there are already a number of operational solar PV developments in these locations present in the UK^{40,41}. A consideration of a railway stakeholder may be the safety implications of glint and glare effects from a proposed solar PV or building development. It is therefore important to set a specific and standardised assessment methodology so that all proposals are assessed in the same way.

Key Considerations

8.2 A list of key considerations for assessing glint and glare with respect to rail safety is presented below:

- A train driver may have views of a solar PV or building development. Where a view of the solar panel or façade exists, a solar reflection may be possible;
- A view of the reflector does not however guarantee that a solar reflection is possible;
- There is no technical limit (distance) to which a solar reflection is possible towards a surrounding railway line however, the significance of a reflection decreases with distance. This is because the proportion of an observer's field of vision that is taken up by the reflecting area diminishes as the separation distance increases;
- Seasonal variations or additional development may change the view from a receptor location towards the solar panels or building development over time;
- Terrain and shielding by vegetation are also more likely to obstruct an observer's view at longer distances;
- In general, the geometry of the relationship between typical ground mounted solar panels and the movement of the Sun in the northern hemisphere means that railways due east and west of the panels are most likely to view a solar reflection for traditional south facing arrays panels. Railways that are north or south of the panels are very unlikely to experience a solar reflection;
- For building developments and for solar developments that have solar panels orientated at azimuth angles other than south, solar reflections may be directed in alternate directions;

⁴⁰ Hadlow Solar Farm, Off Sherenden Road, Tudeley, Kent, England.

⁴¹ Tower Hayes Solar Farm, near Stanton under Bardon, Leicestershire, England.

8.3 The following subsections present the recommended methodology for assessing the impact upon railway safety.

Identifying Receptors – Railway Infrastructure

8.4 The following process should be used for identifying receptors⁴²:

1. Identify whether a railway line or railway infrastructure is present within 100m of the solar or building development ;
2. If visual line of sight exists between the proposed solar or building development and the railway line, then a solar reflection could be experienced if it is geometrically possible. If there is no line of sight, then a reflection cannot be experienced;
3. Assess a length of railway line, choosing individual receptor locations no more than 200 metres apart out to up to 500m from the development location. This is shown in Figure 14 on the following page with reference to a solar development;
4. An additional height should be added to the ground level height to represent the typical viewing height of a train driver. For train drivers, a height of 2.75 metres is recommended;
5. Identify any other railway infrastructure that may be present within 500m of the proposed development. This includes railway signals and crossings;
6. Use the height and location data for feeding into the geometric solar reflection model.

⁴² Railway signals are discussed separately, beginning paragraph 8.13.

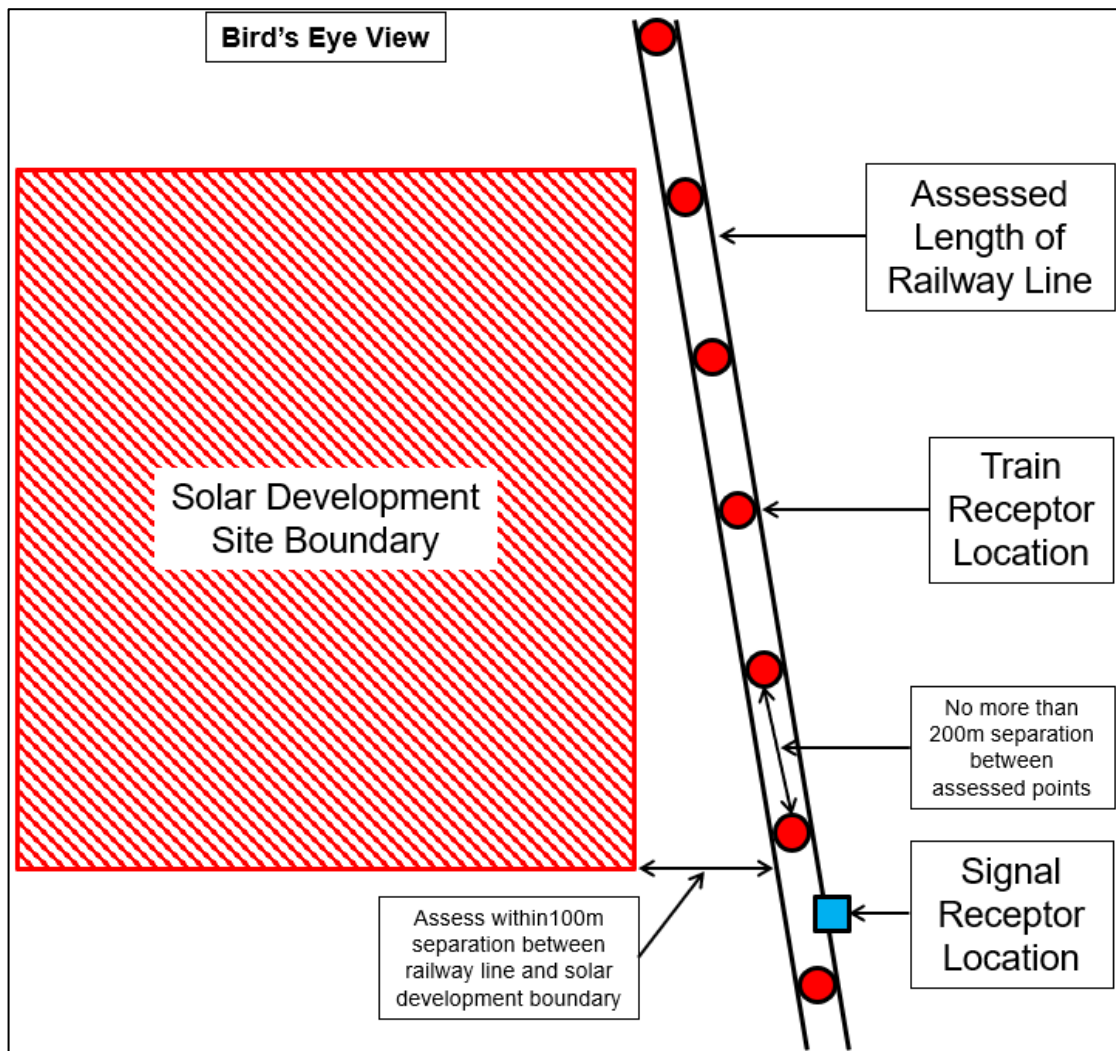


Figure 14 Illustration showing receptor identification process – train drivers and signals

Assessment Process

- 8.5 The following process should be used for modelling glint and glare for a railway line:
1. Define the solar PV development solar panel area or building façade;
 2. Undertake geometric calculations for train drivers and any other railway infrastructure, as outlined within Section 4 of this guidance;
 3. Produce a solar reflection chart to determine whether a solar reflection is geometrically possible;
 4. Assess the results of the geometric glint and glare assessment in the context of the following:
 - a. Sun location relative to the solar panels or façade;
 - b. Location of the reflecting solar panels or façade relative to the railway line, direction of trains and key infrastructure, such as railway signals;
 - c. Existing screening;

- d. Proposed screening;
5. Consider train driver workload;
6. Assess the intensity of the solar reflection, if appropriate;
7. Determine whether a solar reflection is significant;
8. Consider mitigation, if required.

Determination of Significant Effects

8.6 A train driver travelling on a section of railway line where a solar reflection is geometrically possible would experience a solar reflection that is fleeting in nature. This is because a train will typically be moving at speeds anywhere up to 120mph (~190kph). This means that the duration of a predicted solar reflection is mostly dependent on the speed of the train travelling past the solar PV or building development at the time when a solar reflection is geometrically possible. Therefore, the location of origin of the solar reflection is more significant than its duration because the receptor is moving.

8.7 There are examples of solar PV and building developments where solar reflections are geometrically possible towards an adjacent railway line. Experiencing a solar reflection does not necessarily mean there is a significant effect requiring mitigation. The following criteria should be considered when determining the significance of a solar reflection towards a train driver or train infrastructure:

- Is the solar reflection incident to direct sunlight?
- Does the affected length of railway have a signal, crossing or switch/set of points?
- Does the solar reflection appear in line with, or close to, the direction of travel?
- What is the length of railway that may experience a solar reflection?
- What is the intensity of the solar reflection?⁴³

8.8 For south facing solar panels at standard inclinations⁴⁴ it is likely that the Sun will be incident to the solar reflections in the UK and Ireland. Whether the solar reflection appears in line with, or close to, the direction of travel depends on the geographic location of the surrounding railway relative to the solar PV development. This, along with the size of the proposed solar PV development, determines the length of railway line that may be affected.

8.9 For building developments, the scenarios in which solar reflections can occur can vary significantly.

⁴³ The intensity of any calculated solar reflection may be requested by the railway stakeholder. An assessment methodology aligned with the methodology produced for aviation receptors can be utilised (Section 9).

⁴⁴ Typically 15-35 degrees in the UK and Ireland

8.10 Because the length of time a solar reflection can last is mostly dependent on a train's speed rather than the solar PV or building development, the length of time that a solar reflection can last is not considered when determining its significance. Instead, the location of origination of the solar reflection, length of railway and infrastructure present on the assessed railway line are considered.

8.11 The process outlined in the flow chart below (Figure 15) is recommended when determining whether a solar reflection should be deemed significant and mitigation implemented.

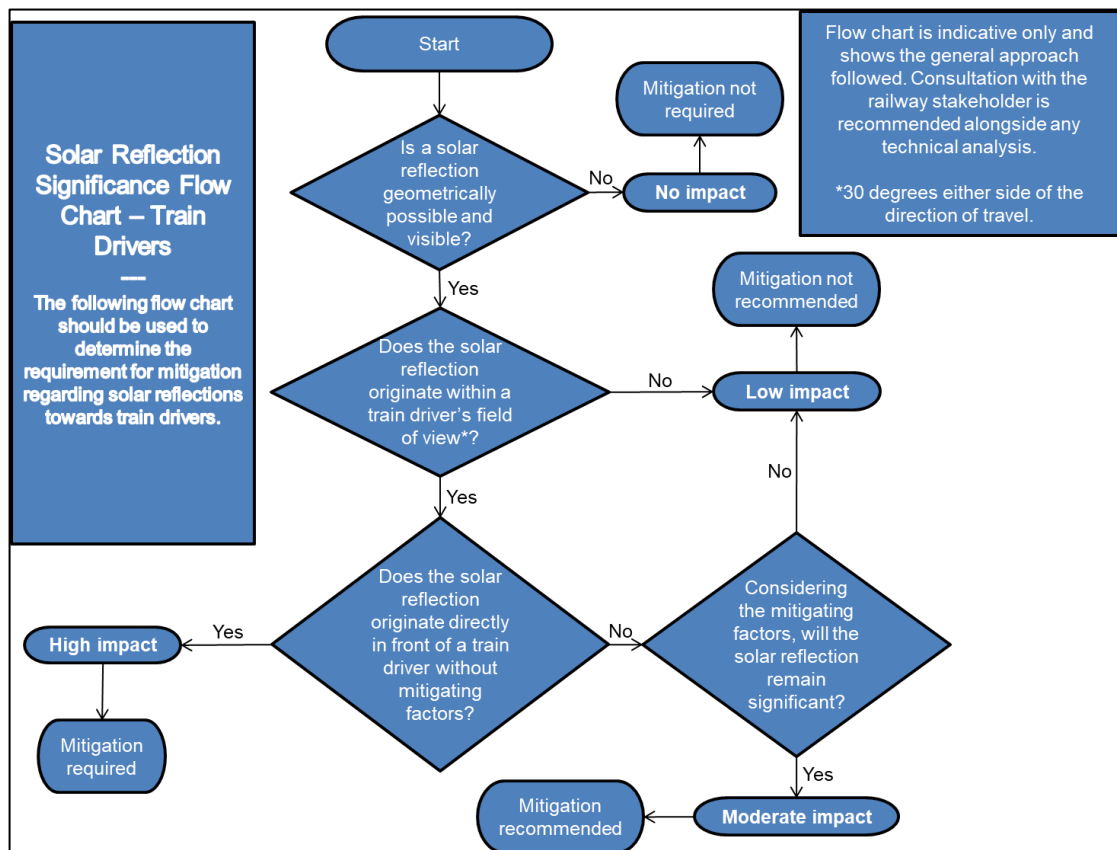


Figure 15 Train driver impact significance flow chart

8.12 There may be instances where the solar reflection scenario does not fall accurately within the significance categories. Where this occurs, detailed consideration of the receptors and the modelling results should be undertaken.

Other considerations

Railway Signals

8.13 Railway signal lights are located immediately adjacent to or above a railway line and are used to direct trains on the lines. In some instances, signals may be difficult to identify and therefore consultation with the railway stakeholder may be beneficial to identify their location and specification. An assessment may be required because of the potential for a phantom aspect illusion occurring. The definition of phantom aspect is presented below.

'Light emitted from a Signal lens assembly that has originated from an external source (usually the Sun) and has been internally reflected within the Signal Head in such a way that the lens assembly gives the appearance of being lit⁴⁵.'

8.14 A phantom aspect is caused when the incoming light is of an intensity which causes a light signal to appear illuminated when it is not switched on. This is a particular problem for filament bulbs with a reflective mirror incorporated into the bulb design.

8.15 No known studies have shown that a phantom aspect illusion is possible due to a solar reflection from a solar panel or glass. Furthermore, modern LED signals are designed to reduce or completely eliminate the likelihood of a phantom aspect illusion occurring and many have hoods attached to reduce the risk of incoming direct light illuminating the signal lens directly. Nevertheless, following consultation with railway operators, it is recommended that an assessment of all signal lights be undertaken. A railway signal location should also be considered where there may be solar reflections towards a train driver on the railway line where the signal is present. This is because a train driver's workload may be higher where signals are present,

⁴⁵ Glossary of Signalling Terms, Railway Group Guidance Note GK/GN0802. Issue One. Date April 2004.

increasing the potential impact as a result of the solar reflection. If the assessed reflectors are not in line of sight to the signal lens, then no phantom aspect illusion is possible.

8.16 The process outlined in the flow chart below (Figure 16Figure 15) is recommended when determining whether a solar reflection should be deemed significant and mitigation implemented.

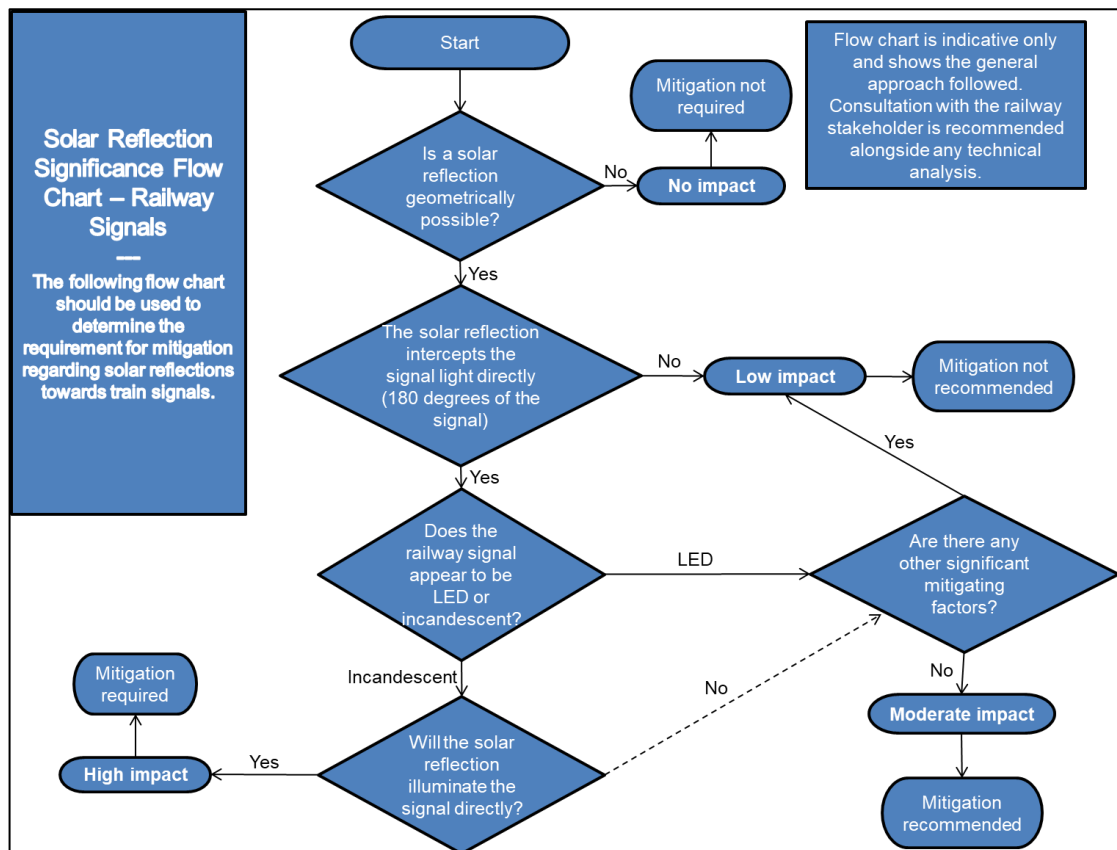


Figure 16 Railway signal impact significance flow chart

8.17 There may be instances where the solar reflection scenario does not fall accurately within the significance categories. Where this occurs, detailed consideration of the receptors and the modelling results should be undertaken.

Level Crossings and Level Crossing Warning Lights (LCWL)

8.18 For determining the impact of glint and glare upon level crossings with respect to road users, follow the 'road users' assessment methodology presented in Section 7. For LCWLs, follow the assessment of railway signals as presented in Section 8.16 above. In both instances, consultation with the railway and/or road stakeholder is advised.

Switches/Set of Points

8.19 Switches and sets of points are present on sections of track where a train may cross from one section of a railway line to another. Where this occurs, a train driver's workload may be increased, and the effect of a solar reflection may increase the significance of a solar reflection.

Conclusions

8.20 The size of the reflector area and visibility of the reflectors relative to static infrastructure (such as signals) will determine the duration of the solar reflection. For moving trains, their speed will be the overall determining factor with regard to the duration of the solar reflection. Consultation with the railway stakeholder is recommended to determine the requirement for assessment, identify particular receptors and determine whether mitigation is required.

9 ASSESSING THE IMPACT UPON AVIATION OPERATIONS

Overview

9.1 Solar PV developments and aviation activity can safely co-exist and there is a growing number of examples of both on-aerodrome and near aerodrome solar PV developments. Safeguarding an aerodrome and its aviation activity is essential, and glint and glare effects may cause a safety concern under certain conditions. Therefore a glint and glare assessment of a proposed solar PV development is essential when it is to be sited in the vicinity of an aerodrome.

9.2 More recently, the effect of solar reflections from building developments with surfaces capable of producing specular solar reflections has been raised as a potential concern at a number of UK airports.

9.3 This section presents a recommended assessment approach, based on previous guidance and experience within the UK and internationally for on and off-aerodrome developments.

Key Considerations

9.4 The two main receptors that require consideration within an aviation glint and glare assessment are pilots in aircraft and air traffic controllers in the Air Traffic Control (ATC) Tower. Helipads and alternate aviation receptors are considered separately within this sector.

9.5 Whilst a proposed solar PV development may be located such that air traffic controllers have no view of the solar panels, pilots navigating the airspace above will almost certainly have a view of the solar panels. Where a view of the solar panel exists, a solar reflection may be possible. A view of a solar panel does not however guarantee that a solar reflection is possible.

9.6 There is no technical limit (distance) within which a solar reflection is possible towards the ATC Tower or pilots, however the significance of a reflection decreases with distance. This is because the proportion of an observer's field of vision that is taken up by the reflecting area diminishes as the separation distance increases.

9.7 On-aerodrome reflections may be considered more significant than those that originate outside of the aerodrome's boundary, particularly at greater distances.

9.8 Seasonal variations or additional development may change the view from the ATC tower towards the solar panels over time.

9.9 Terrain and shielding by vegetation are also more likely to obstruct an air traffic controller's view at longer distances.

9.10 In general, the geometry of the relationship between typical ground mounted solar panels and the movement of the Sun in the northern hemisphere means that ATC towers due east and west of the panels are most likely to view a solar reflection for south facing arrays panels. ATC towers north or south of the panels are very unlikely to experience a solar reflection unless the solar PV development and ATC Tower are in close proximity i.e. an on-aerodrome development.

Pilots may experience solar reflection from a greater number of locations because of the changing location and altitude of the aircraft.

9.11 For building developments and for solar developments that have solar panels orientated at azimuth angles other than south, solar reflections may be directed in alternate directions.

9.12 The key considerations listed in the sections above are broadly the same for both solar and building developments.

Identifying Receptors – Aerodromes

9.13 The following process should be used for identifying the requirement for assessment:

1. Identify aerodromes within 30km of the proposed solar PV development. Complete the following depending on proximity;
 - a. Within 5km: consult with the aerodrome, complete a glint and glare assessment;
 - b. Within 5-10km: consult with the aerodrome, the aerodrome is likely to request a glint and glare assessment;
 - c. 10km-30km: consider consultation with certified and licensed aerodromes, the aerodrome may request a glint and glare assessment;
 - d. 30km+: consultation and assessment not considered a requirement, however requests for assessment have been requested beyond 30km.
2. Solar developments are becoming greater in scale, where appropriate, it may be prudent to extend the lower limits and conduct detailed analysis for licensed aerodromes.

9.14 If a glint and glare assessment is to be completed, follow the process outlined below for identifying receptors:

1. Identify any existing or proposed ATC Towers (if there is one) and approach routes for all existing or proposed runways;
2. If visual line of sight exists between the proposed solar PV development and the ATC Tower, then a solar reflection could be experienced if it is geometrically possible;
3. If there is no line of sight, then a reflection cannot be experienced;
4. Assess a 2-mile⁴⁶ approach path towards the runways using the following criteria;
 - a. Starting point taken at 50 feet (15.2m) above the runway threshold;
 - b. Measure out to 2 miles from the runway threshold using a 3 degree descent path (unless requested otherwise or as per the published aeronautical approach procedures);

⁴⁶ A statute mile (1.61km).

- c. Take reference aircraft locations at no more than $\frac{1}{4}$ mile intervals (minimum of nine points over 2-miles);
5. An additional height should be added to the ground level height to represent the viewing height of an air traffic controller within the ATC Tower;
6. Use the height and location data for feeding into the geometric solar reflection model. Figure 17 below shows the process for identifying aviation receptors.

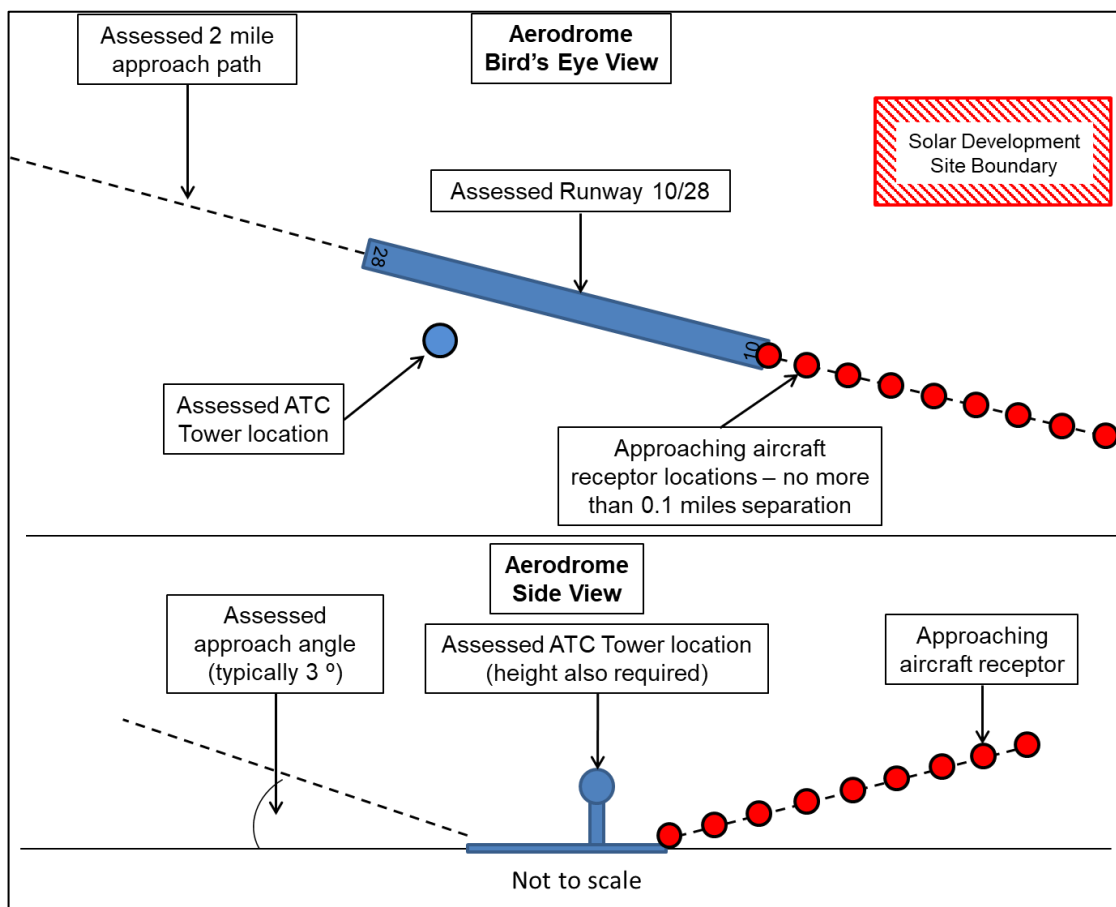


Figure 17 Illustration showing receptor identification process – aviation

Assessment Process

9.15 The following process should be used for modelling glint and glare effect for aviation activity:

1. Define the solar PV development solar panel area;
2. Undertake geometric calculations, as outlined within Section 4 of this guidance;
3. Produce a solar reflection chart to determine whether a solar reflection is geometrically possible;
4. Assess the results of the geometric glint and glare assessment in the context of the following:
 - a. Sun location relative to the solar panels;

- b. Location of the reflecting solar panels relative to the ATC Tower and/or aircraft location;
- c. Consideration of existing screening (ATC Tower only);
- d. Consideration of proposed screening (ATC Tower only);
- 5. Determine whether a solar reflection is significant;
- 6. Consider mitigation, if required.

Building Developments

9.16 The process for assessing reflective façades on building developments is similar to those for solar panels however the FAA guidance was never strictly applicable to reflective surfaces other than solar panels and therefore the significance of a reflection, as per the sections below, can be considered for reference from a technical perspective but should not be the sole determining factor in assigning an impact significance.

Determination of significant effects

Air Traffic Control

9.17 An air traffic controller uses the visual control room to monitor and direct aircraft on the ground, approaching and departing the aerodrome. It is essential that air traffic controllers have a clear unobstructed view of the aviation activity. The key areas on an aerodrome are the views toward the runway thresholds, taxiways and aircraft bays.

9.18 Whilst the FAA guidance has since been updated, the previous 2013 FAA guidance states that no solar reflection towards the ATC tower should be produced by a proposed solar PV development, and it is this guidance that many aerodromes still refer to:

'1. No potential for glint or glare in the existing or planned Airport Traffic Control Tower (ATCT) cab...'

9.19 However, it is recommended that any predicted solar reflection should be assessed pragmatically. Therefore, the following should be considered when determining whether a solar reflection is significant:

- 1. The predicted intensity of the solar reflection;
- 2. Location of origin of the solar reflection relative to the ATC Tower;
- 3. Distance between the reflecting surfaces and the ATC Tower;
- 4. Solar reflection duration per day;
- 5. Number of days a solar reflection is geometrically possible per year;
- 6. The time of day when a solar reflection is geometrically possible.

9.20 Determining a period of time and location from which a predicted solar reflection is considered significant will depend on the operations at a particular aerodrome.

9.21 The process outlined within the flow chart on the following page (Figure 18) is recommended when determining whether a solar reflection should be deemed significant and mitigation implemented.

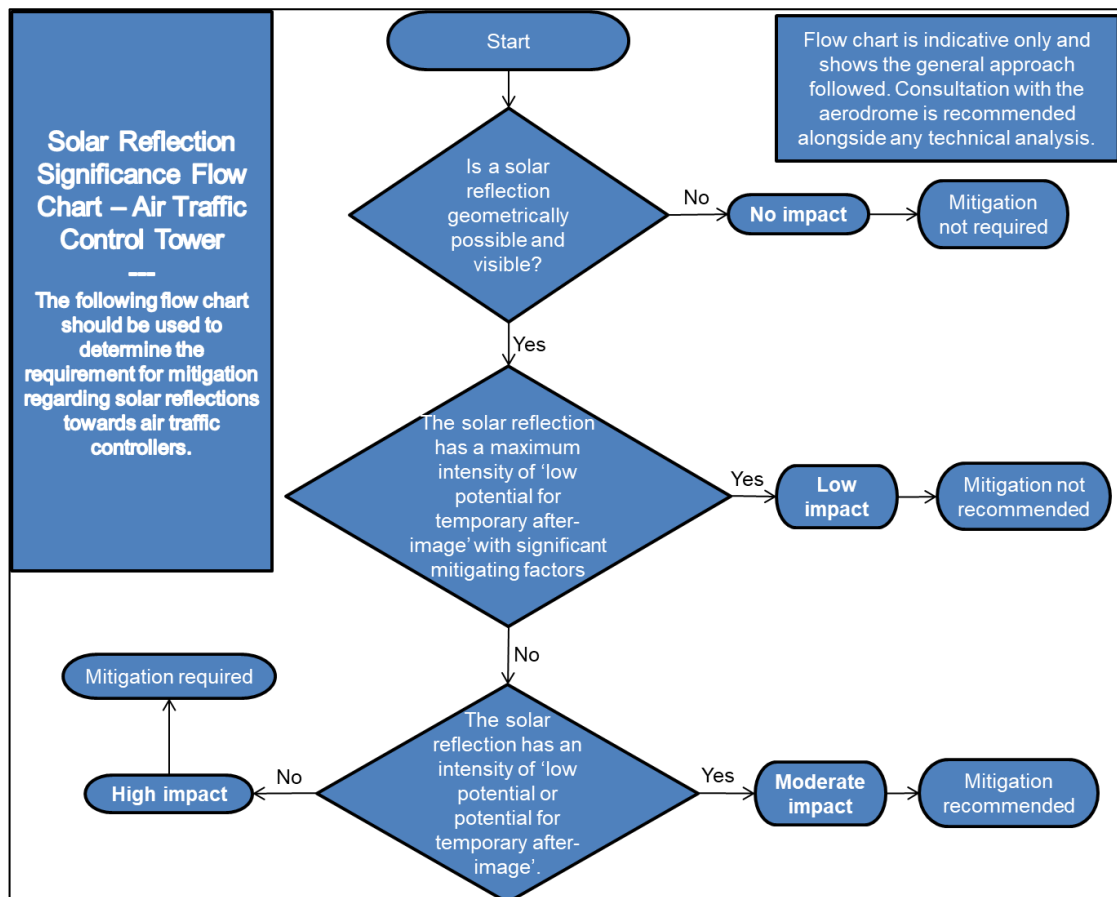


Figure 18 ATC tower impact significance flow chart

9.22 There may be instances where the solar reflection scenario does not fall accurately within the significance categories. Where this occurs, detailed consideration of the receptors and the modelling results should be undertaken.

Approaching Aircraft

9.23 A pilot flying a 2-mile final approach path where a solar reflection is geometrically possible would experience a fleeting solar reflection as the aircraft travels through the solar reflection zone. This means that the duration of a predicted solar reflection is dependent on the speed of the aircraft above the solar PV development at the time when a solar reflection is geometrically possible. Therefore, the location of origin of the solar reflection is more significant than its

duration because it is a fast-moving receptor. The time at which the solar reflection may occur should however be considered.

9.24 There are examples of solar PV developments where solar reflections are geometrically possible towards approaching aircraft. Experiencing a solar reflection does not guarantee a significant effect requiring mitigation, however there are criteria that should be considered when determining the significance of a solar reflection and mitigation requirements, these are:

- Is the solar reflection incident to direct sunlight?
- Does the solar reflection originate from near to a runway threshold or other location of operational significance?
- What is the length of approach path that can experience a solar reflection?
- Does the solar reflection occur at a significant time?
- Does the solar reflection occur for a significant period of time?
- What is the intensity of the solar reflection?

9.25 Further comments regarding the solar reflection intensity and its effect on the significance is presented in the following sub-section.

Solar Reflection Intensity

9.26 Many UK and international aviation stakeholders have adopted the FAA guidance (2013-2018) with respect to glint glare. Along with the initial guidance, Sandia National Laboratories developed the Solar Glare Hazard Analysis Tool (SGHAT) model which is no longer freely available. This model can be used to determine the intensity of a solar reflection which is significant when determining the impact upon approaching aircraft.

9.27 The FAA 2013 guidance stated:

2. No potential for glare or “low potential for after-image” (shown in green in Figure 1) along the final approach path for any existing landing threshold or future landing thresholds (including any planned interim phases of the landing thresholds) as shown on the current FAA-approved Airport Layout Plan (ALP). The final approach path is defined as two (2) miles from fifty (50) feet above the landing threshold using a standard three (3) degree glide path.

9.28 Whilst the FAA stance has since changed (2021), it is still recommended that the previous 2013-2018 FAA guidance is used as a basis for assessment, along with a pragmatic approach to determining whether a predicted solar reflection may indeed be a hazard to aviation safety.

9.29 The process outlined within the flow chart (Figure 19) on the following page is recommended when determining whether a solar reflection should be deemed significant and mitigation implemented.

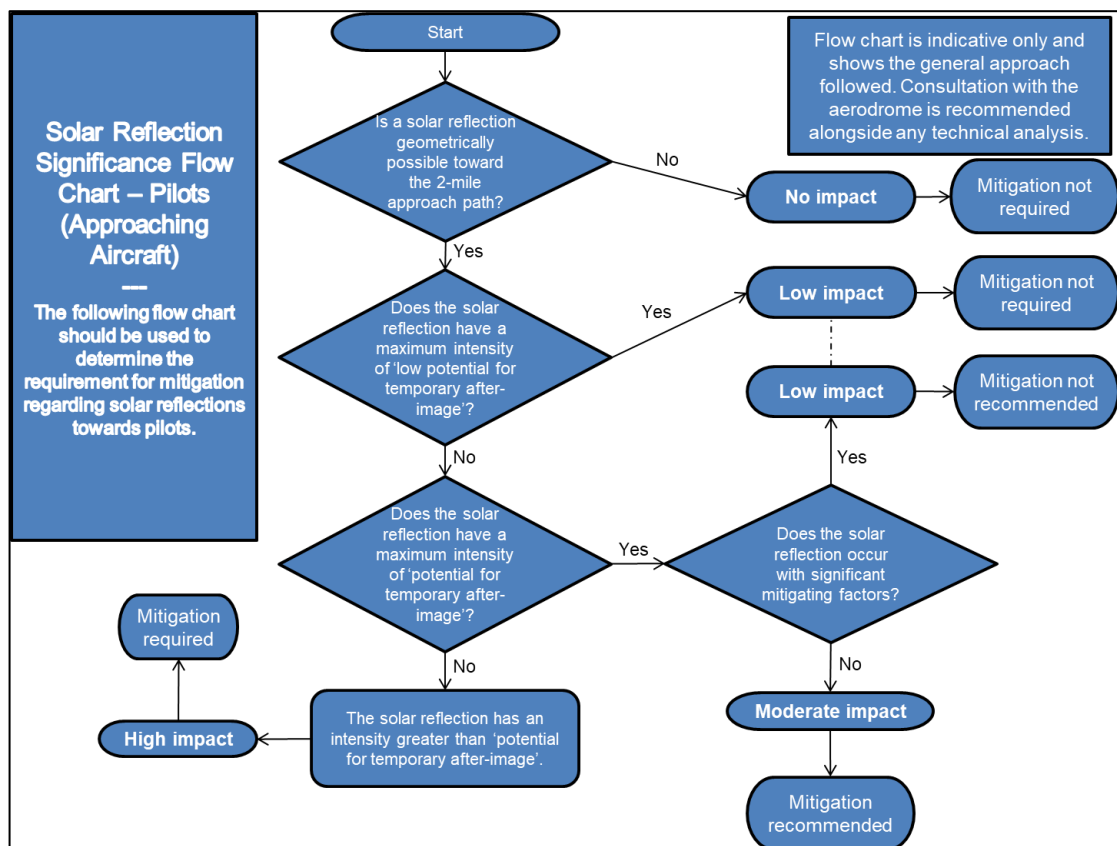


Figure 19 Pilots (approaching aircraft) impact significance flow chart

9.30 There may be instances where the solar reflection scenario does not fall accurately within the significance categories. Where this occurs, detailed consideration of the receptors and the modelling results should be undertaken.

Helipads

9.31 Where helipads are present, a glint and glare assessment may be required. Therefore, Pager Power's has developed a standard methodology to determine the significance of a solar reflection towards a helicopter pilot on approach towards a helipad. The approach paths are assessed within the glint and glare assessment because they are considered to be the most critical stage of the flight.

9.32 In the absence of (or in addition to) the provision of specific helicopter approach routes, the Pager Power approach for determining helicopter approach paths is to select locations along each bearing (spaced at maximum of 10 degrees) based on the centre point of the helipad out to a distance of 2 miles, spaced every 0.1 mile. All possible approach paths are assessed unless specified or requested otherwise. The altitude of the aircraft is based on a 10 degree descent⁴⁷

⁴⁷ Normal helicopter descent angle on approach.

path referenced to 2m above the helipad centre point (approximate eye level of a helicopter pilot).

9.33 Similarly, to the assessment for fixed wing aircraft on approach, the location, duration, time and intensity of the solar reflection are considered to determine whether an impact may be significant. The flow chart presented in Figure 17 can therefore be followed to determine the impact significance. Results should be considered on a case-by-case basis.

Other Considerations

Circling Aircraft, Visual Manoeuvring Areas, Visual Circuits and En-Route Aircraft

9.34 Some aerodromes may request that circling aircraft, visual manoeuvring areas, visual circuits and en-route aircraft be assessed. If requested, the requirements of the assessment should be considered on a case-by-case basis and through consultation with the aerodrome. A typical assessment for aircraft in the Visual Manoeuvring Area (VMA) is as follows:

- Glint and glare calculations are undertaken for points spaced at regular intervals across a 10km radius circle centred above the airport at an altitude of 1500 feet above mean sea level⁴⁸;
- For each point where glint and glare is possible, the glare is classified in accordance with FAA standards;
- Where glint and glare is predicted to have 'potential for temporary after-image' or greater, the following should be completed:
 - The results will be overlaid on the published ICAO⁴⁹ Visual Approach Chart for the airport or similar;
 - An operational assessment should be undertaken using the overlaid Visual Approach Chart, considering the following:
 - Visual Holding Patterns;
 - Visual Reporting Points;
 - Aircraft joining approach from Visual Hold;
 - Other Visual Approach Chart features.
- Considering all of the above, it should be determined whether a significant impact is expected;
- Where glint and glare is not predicted or predicted to have a 'low-potential for temporary after-image', there will be no significant impact.

⁴⁸ Specific request may vary from an aerodrome depending on its operations.

⁴⁹ International Civil Aviation Organisation – ICAO. Chart usually available from the relevant national aviation stakeholder or aerodrome.

Conclusions

9.35 The size of the solar panel area and visibility of the reflecting solar panels relative to static infrastructure (such as the ATC Tower) will determine the duration of the solar reflection. The same is true for a reflective façade on a building development. For moving aircraft, its speed will be the overall determining factor with regard to the duration of the solar reflection. Consultation with the aviation stakeholder is essential to determine the requirement for assessment. It is recommended to consider aerodromes within 30km, though a detailed assessment may not be required.

10 OVERALL CONCLUSIONS

Overview

10.1 The purpose of this guidance document is to provide solar PV and building developers, planners and stakeholders with an assessment process for determining the effect of glint and glare (solar reflections) upon receptors surrounding a proposed solar PV or building development.

10.2 Formal guidance around glint and glare remains somewhat lacking in many cases. This guidance document has been produced to bridge this knowledge gap pertaining to the assessment of glint and glare from solar PV panels and reflective façades on building developments. The aim is to standardise an assessment process for developers, planners or stakeholders to follow.

10.3 The guidance presented within this document is based on the following:

- Reviews of existing guidance in a variety of areas;
- Glint and glare assessment experience and industry knowledge;
- Overview of available solar reflection studies.

10.4 The methodologies presented are deemed applicable for worldwide solar PV and building development.

Modelling Requirements

10.5 A geometric glint and glare assessment model must include the following:

- The Earth's orbit around the Sun;
- The Earth's rotation;
- The Earth's orientation;
- The location of the solar PV development or building development including the reflector (solar panel or façade) area;
- The reflector's 3D orientation including azimuth angle of the solar panel or façade (the orientation of the reflectors relative to north and the reflector elevation angle);
- Local topography including receptor and panel or façade heights above mean sea level.

10.6 For increased accuracy, the model could account for the following:

- Terrain at the visible horizon;
- Local time zone and daylight savings times;
- Consideration of sunrise and sunset times;
- Determine which solar panels create the solar reflection within the solar PV development;

- Determine what area of the façade create the solar reflection from the building development;
- Azimuth range of the Sun⁵⁰ when a solar reflection is geometrically possible;
- Vertical elevation range of the Sun when a solar reflection is geometrically possible;
- High-resolution analysis i.e. undertaking multiple geometric calculations within the given solar PV development or façade area. For example, at intervals of between 1 and 20 metres;
- Consideration of the effect of non-specular reflective surfaces e.g. masonry between glass façades;
- The intensity⁵¹ of any solar reflection produced.

Assessment Inputs – Receptors

10.7 The following paragraphs set out the key distances for identifying receptors and the height data which should be included.

10.8 Dwellings within approximately 1km of a proposed solar PV development that may have a view of the PV panels should be assessed. Terrain heights and an additional height to account for the solar panel and eye level within the relevant floor of the dwelling should also be considered. Dwellings are not typically assessed for building developments.

10.9 Roads within approximately 1km of a proposed solar PV development that may have a view of the PV panels should be assessed. Terrain heights and an additional height to account for the solar panel and eye level of a road user should also be considered. Roads are not typically assessed for building developments.

10.10 Where railway infrastructure is located within approximately 100m of a proposed solar PV or building development that may have a view of the PV panels, an assessment should be undertaken. Train drivers out to 500m should be assessed. Any signals, crossings or vital railway infrastructure within 500m that could be affected by glare should be assessed especially where railway signal utilises incandescent bulb⁵² technology and/or where no hood is attached. Terrain heights and an additional height to account for the solar panel/façade and eye level of a train driver or the height of a railway signal should also be considered.

⁵⁰ The azimuth range is the angle between the Sun and North, measured clockwise around the receptor's horizon. The Sun azimuth range shows the location of the Sun when a geometric solar reflection is possible. Therefore, it is possible to determine whether the Sun and the solar reflection are both likely to be visible to a receptor.

⁵¹ In W/cm² at the retina, for example.

⁵² Non-LED.

10.11 Aviation receptors out to 30km⁵³ from a proposed PV development should be considered to determine the requirement for assessment, if any. The typical receptors include the Air Traffic Control (ATC) tower and a 2-mile approach path for the relevant runway approaches. Additional receptors may be included where a solar reflection may be deemed a hazard to safety e.g. helipad approaches and the visual manoeuvring area (VMA). Aviation infrastructure is similarly assessed for building developments.

Assessment Significance

10.12 Determining the significance of a solar reflection varies for each receptor type. In general, the significance criteria for glint and glare effects are as follows:

- No Impact – A solar reflection is not geometrically possible or will not be visible from the assessed receptor. No mitigation required;
- Low – A solar reflection is geometrically possible however any impact is considered to be small such that mitigation is not recommended e.g. intervening screening will limit the view of the reflecting solar panels significantly or the glare time per year is considered negligible. No mitigation recommended;
- Moderate – A solar reflection is geometrically possible and visible however it occurs under conditions that do not represent a worst-case scenario e.g. a solar reflection originates from a less sensitive location. Mitigation recommended;
- High – A solar reflection is geometrically possible and visible under conditions that will produce a significant impact. Mitigation will be required if the proposed development is to proceed.

10.13 There may be instances where the solar reflection scenario does not fall accurately within the significance categories. Where this occurs, detailed consideration of the receptors and the modelling results should be undertaken.

10.14 See the following sections where the process for determining the significance of a solar reflection is described for each receptor type:

- Section 6 – Dwellings;
- Section 7 – Road infrastructure;
- Section 8 – Railway infrastructure;
- Section 9 – Aviation infrastructure.

10.15 In each section, the process for determining the significance of a solar reflection is described comprehensively.

⁵³ Aviation stakeholders can and have requested a glint and glare assessment beyond 30km.

Guidance Conclusions

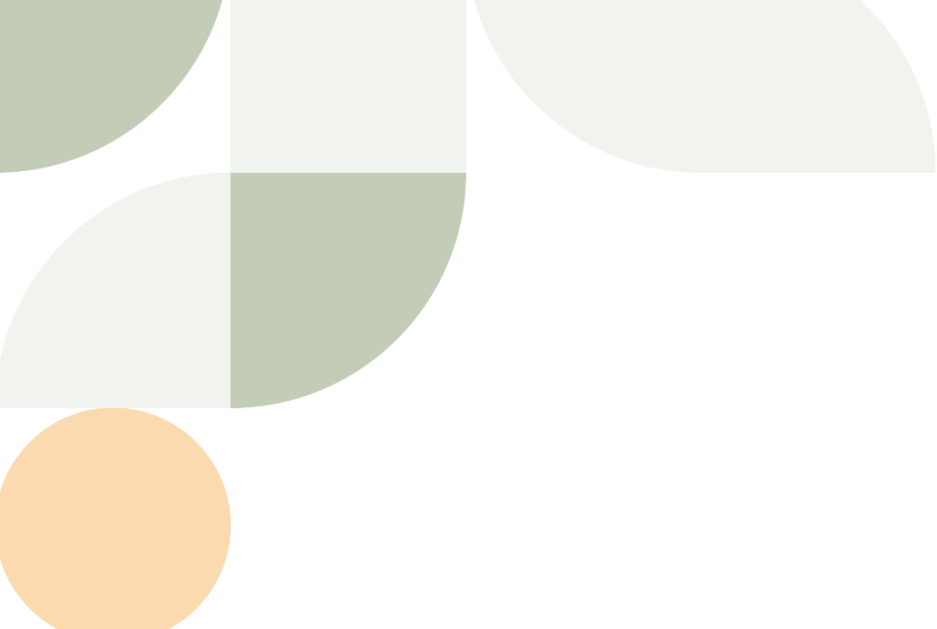
10.16 This guidance should be followed to ensure comprehensive assessment of solar PV and building developments with respect to glint and glare. This guidance is applicable for solar PV and building development anywhere in the world.



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Appendix D Glint and Glare Comparison of the Pager Power and Forge Solar Modelling Results



Lime Down

Solar Park

Appendix D: Glint and Glare Comparison of the Pager Power and Forge Solar Modelling Results

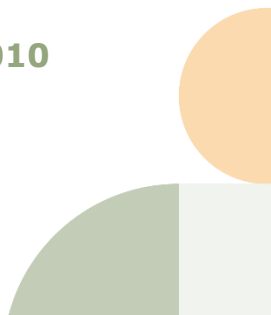
October 2026

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Document Reference: EXAM/9.80

The Infrastructure Planning (Examination Procedure) Rules 2010



Glint and Glare Comparison of the Pager Power and Forge Solar Modelling Results

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Lime Down Solar

September 2026

ADMINISTRATION PAGE

Job Reference:	12388C	
Author:		
Telephone:		
Email:		

Reviewed By:		
Email:		

Issue	Date	Detail of Changes
1	September 2026	Initial issue

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1 INTRODUCTION

1.1 Overview

This Glint and Glare Modelling Comparison document contains geometric modelling charts for a sample of glint and glare receptors, to allow a comparison between the Pager Power and Forge Solar models.

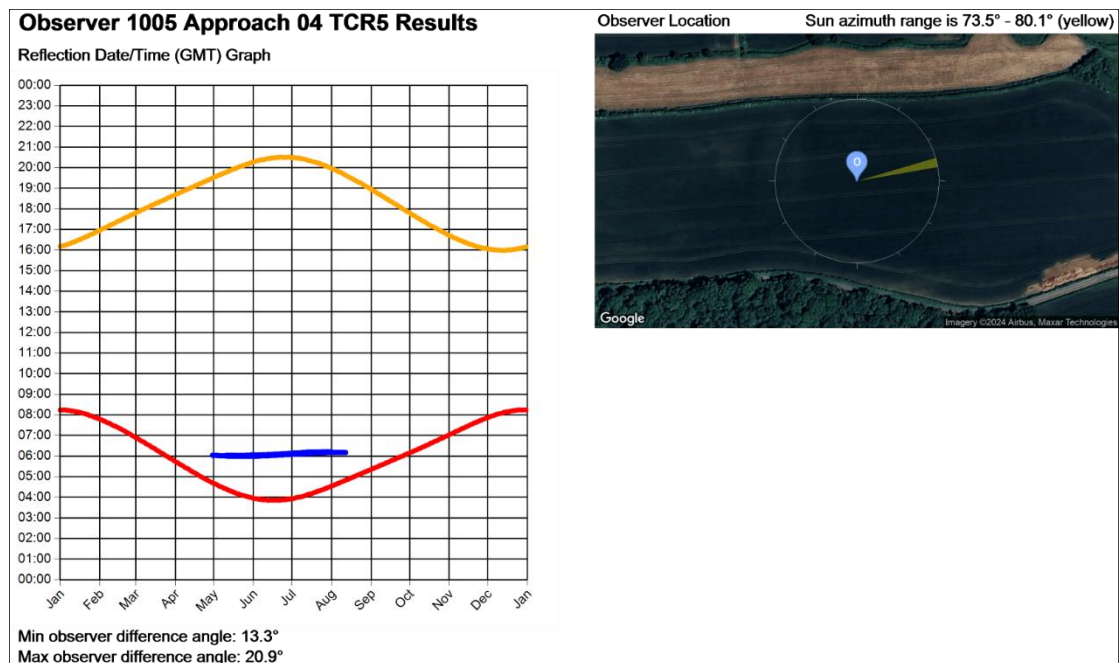
There are minor differences in methodologies between the two models, notably that Forge Solar includes consideration of slope error (based on assumed panel characteristics) whilst Pager Power's model does not, which can lead to slightly different times and durations of glare. A full explanation of the modelling methodology for each model is presented in Annex E of the Glint and Glare Assessment.

There is also a presentation difference between the models, whereby in Pager Power's model one chart is produced per receptor but in Forge Solar's model one chart is produced per reflecting panel area (and there may therefore be multiple charts per receptor); as such, for some receptors included in this comparison, it may be necessary to consider combined results across several Forge Solar charts.

2 MODELLING CHART COMPARISON

2.1 Examples

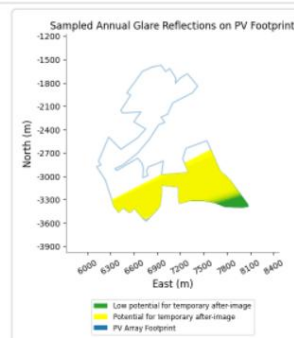
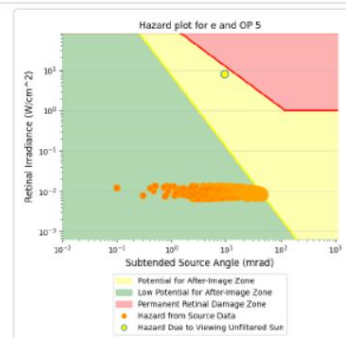
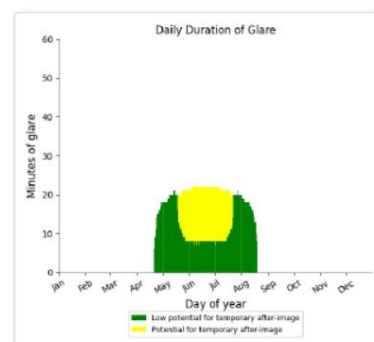
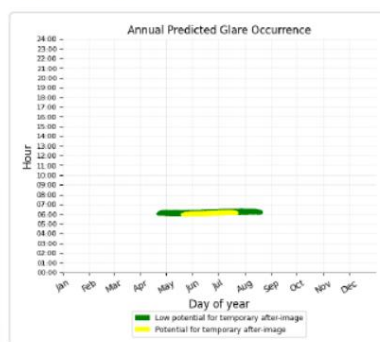
2.1.1 Hullavington Airfield – Runway 04, Receptor 1005



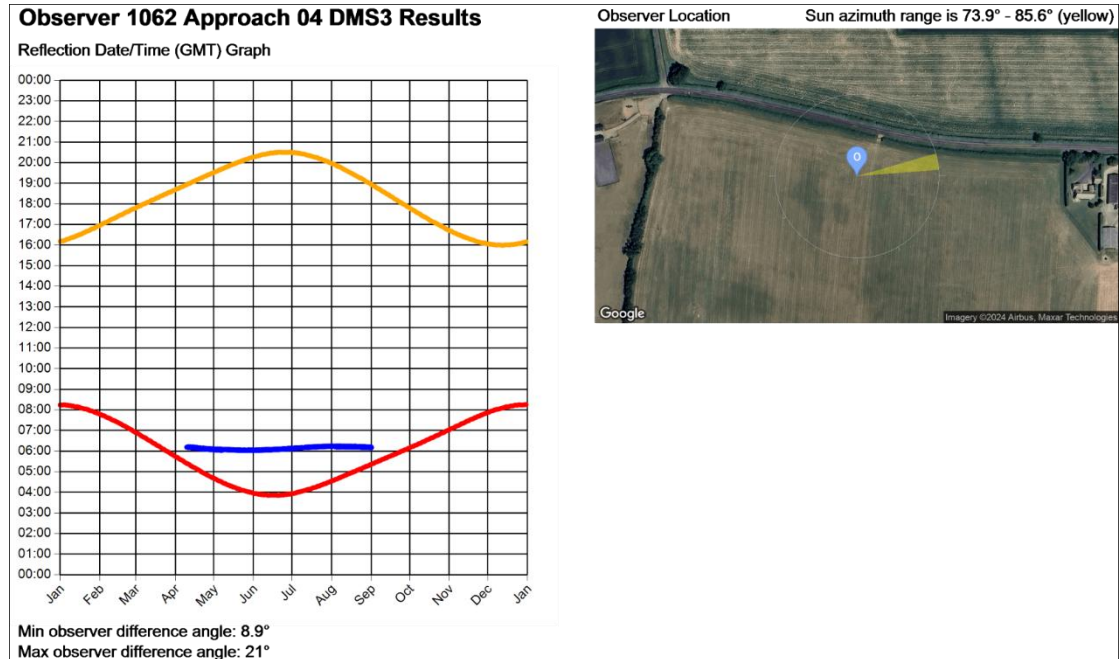
E and OP 5

Yellow glare: 825 min.

Green glare: 1,542 min.

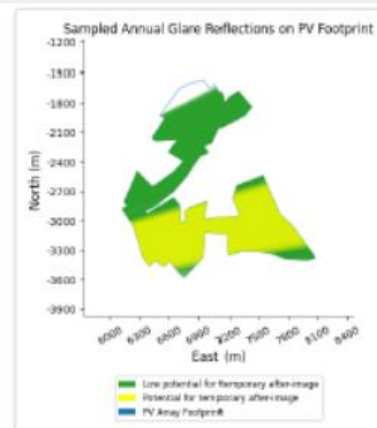
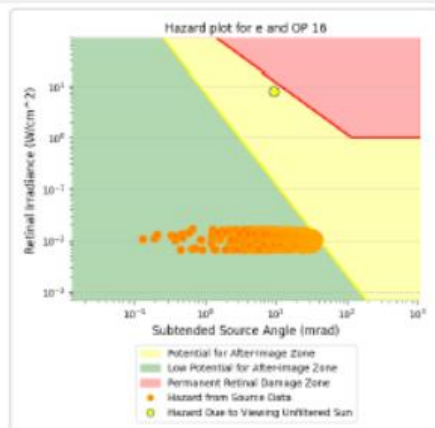
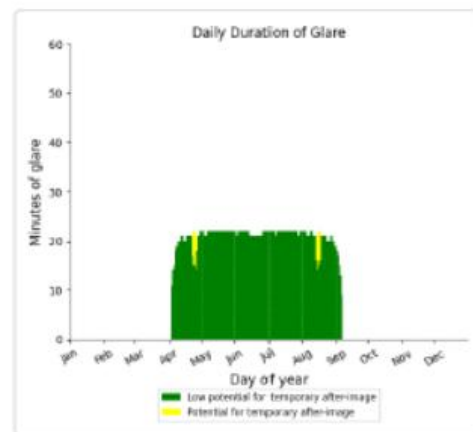
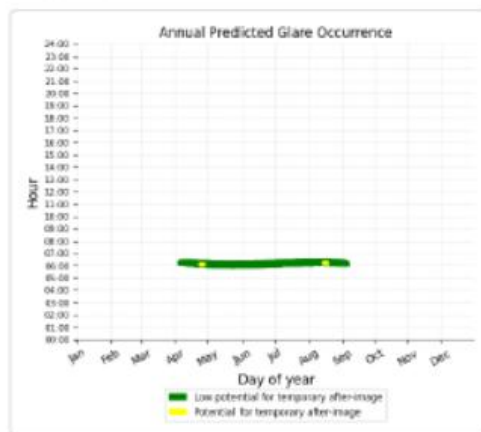


2.1.2 Hullavington Airfield – Runway 04, Receptor 1062



E and OP 16

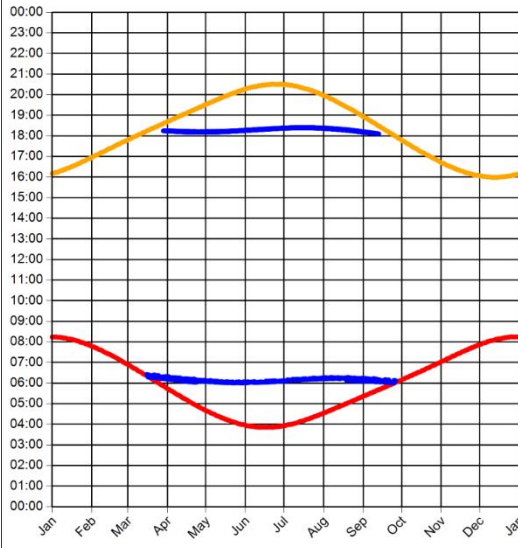
Yellow glare: 53 min.
Green glare: 3,230 min.



2.1.3 Hullavington Airfield – Runway 22, Receptor 2002

Observer 2002 Approach 22 TCR2 Results

Reflection Date/Time (GMT) Graph



Min observer difference angle: 0.7°
Max observer difference angle: 21.1°

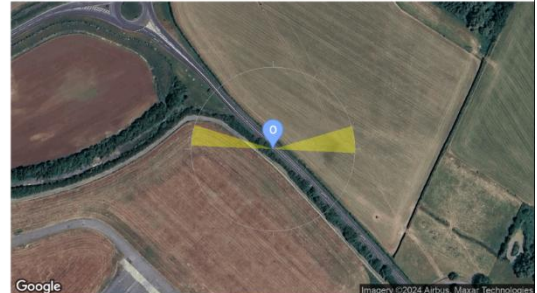
B C and OP 29

Yellow glare: 630 min.

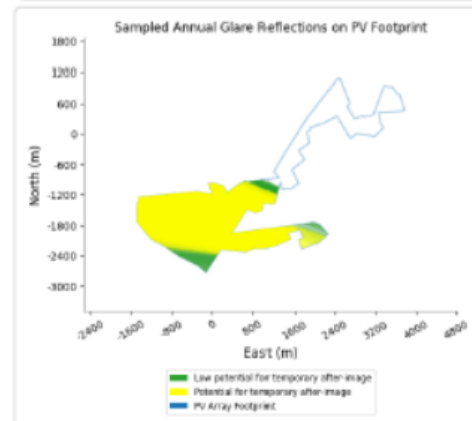
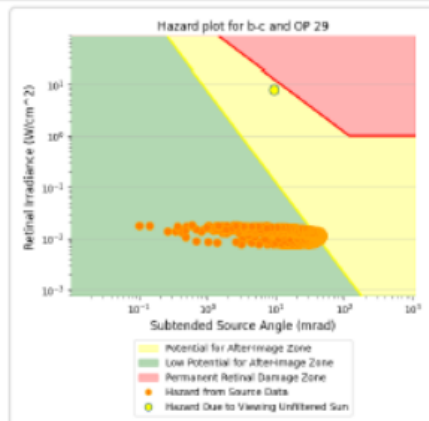
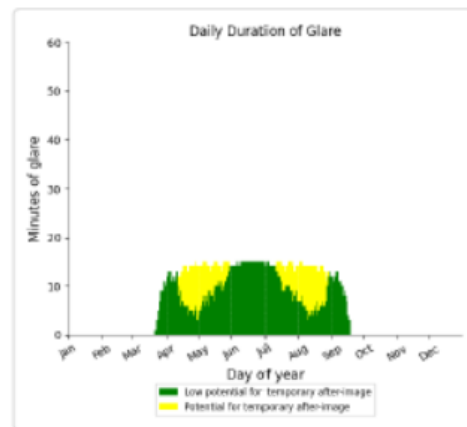
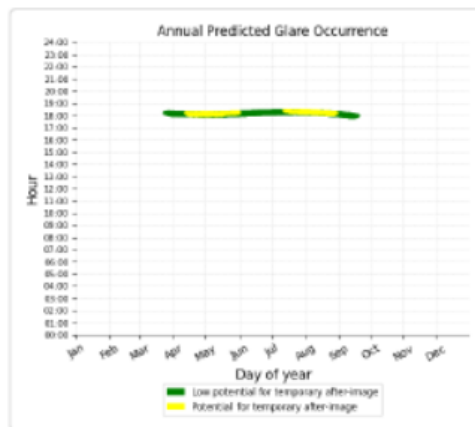
Green glare: 1,752 min.

Observer Location

Sun azimuth ranges (yellow)



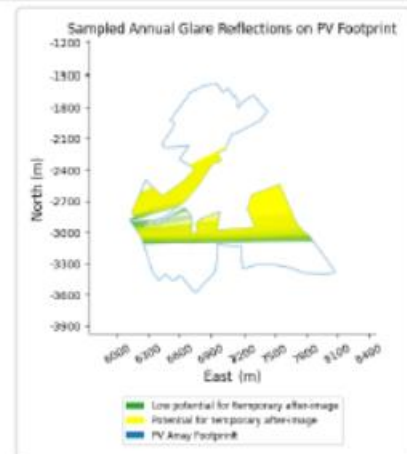
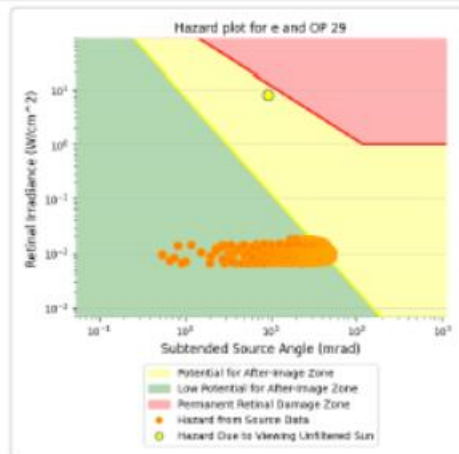
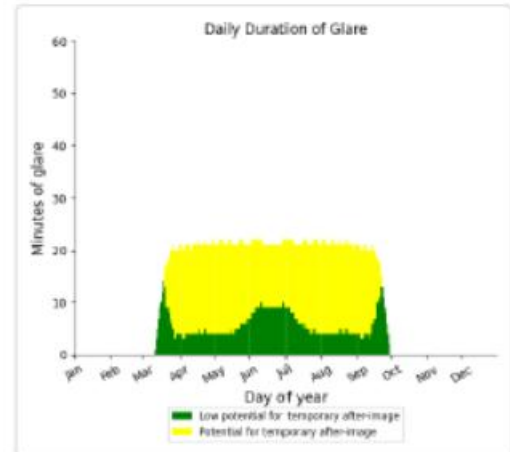
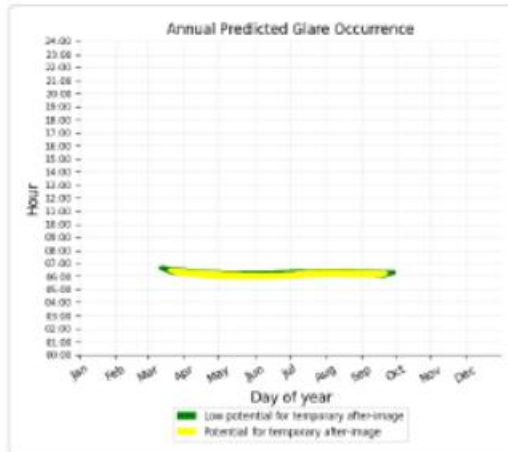
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)



E and OP 29

Yellow glare: 2,873 min.

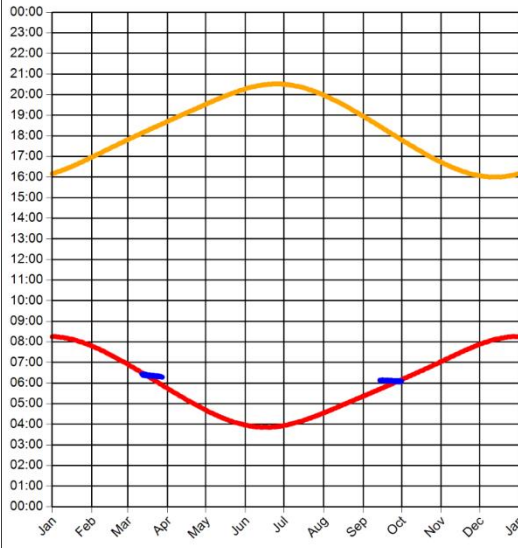
Green glare: 1,176 min.



2.1.4 Badminton Airfield – Runway 25, Receptor 4048

Observer 4048 Approach 25 CDN7 Results

Reflection Date/Time (GMT) Graph



Min observer difference angle: 0.7°
Max observer difference angle: 5.5°

A and OP 6

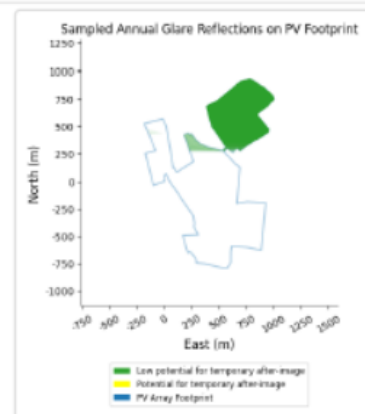
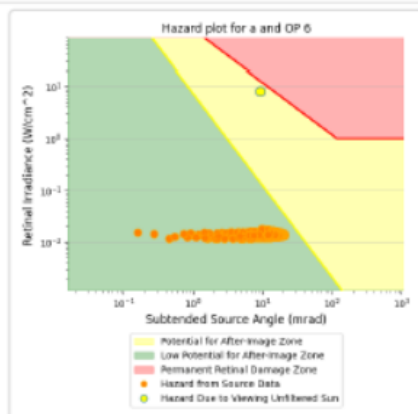
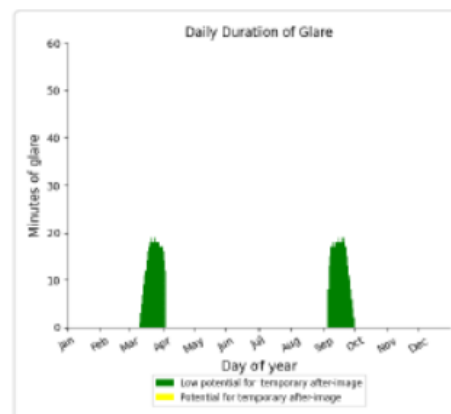
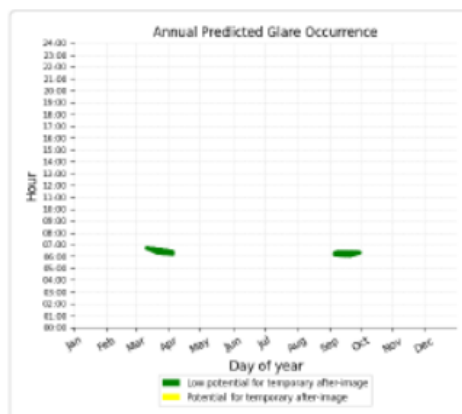
Yellow glare: none

Green glare: 743 min.

Observer Location Sun azimuth range is 88.6° – 93.5° (yellow)



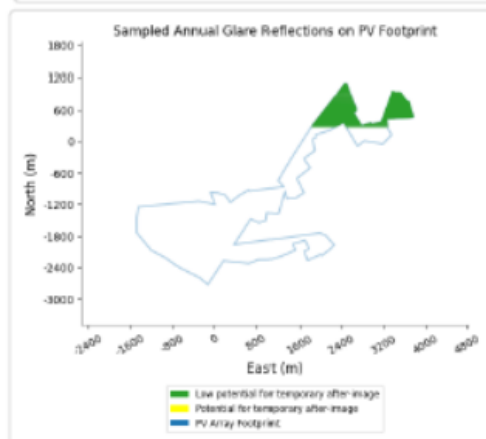
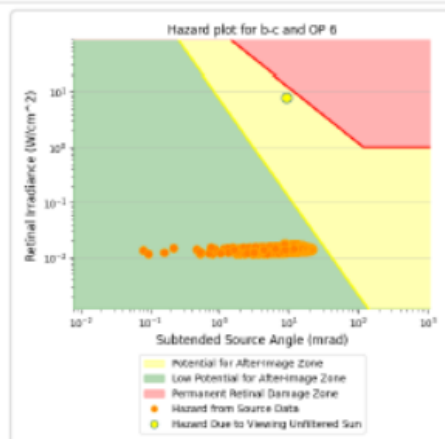
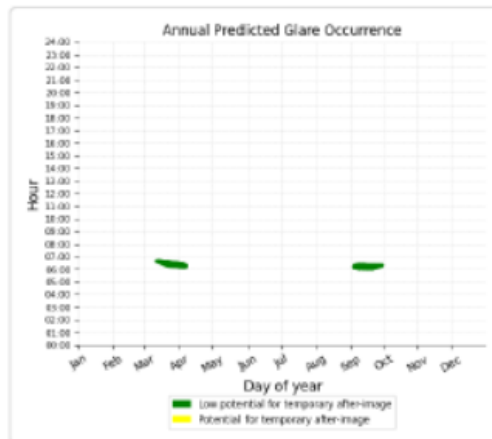
Panels: Reflecting (yellow), that would reflect but Sun is behind terrain (orange)



B C and OP 6

Yellow glare: none

Green glare: 744 min.



3 CONCLUSIONS

3.1 Overall Conclusion

The modelling comparison examples in Section 2 of this document show that both models produce substantially similar results, and using an alternative model would not affect the report conclusions or mitigation recommendations.

As the models were both developed independently of each other, there are minor differences in the modelling assumptions as discussed in Section 1. In some circumstances, this leads to slightly different times and durations of glare, but the overall results remain comparable. As can be seen in the example charts, the modelling outputs predict glare occurring at a similar time of day and year, demonstrating that using an alternative model would not result in changes to the report conclusions.

Overall, it is considered that this document demonstrates the substantial similarity in modelling outputs between the Pager Power and Forge Solar models and shows that these two models, developed independently, would both produce the same overall conclusions when utilised alongside the methodology of Pager Power's Glint and Glare Guidance.



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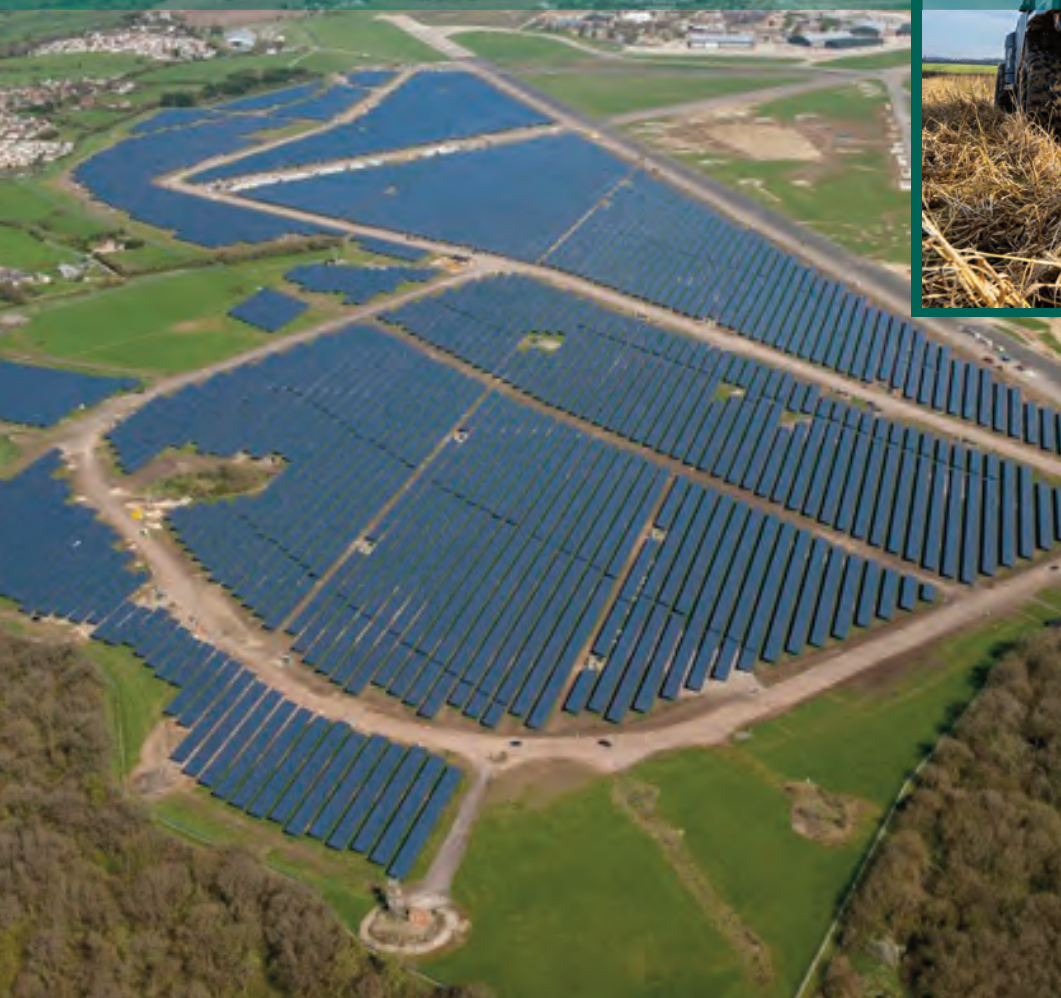
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Appendix E Archaeology and Solar Farms Good Practice Guide

ARCHAEOLOGY AND SOLAR FARMS

GOOD PRACTICE GUIDE

Advice for developers, archaeological advisors, consultants and contractors



THIS GUIDE HAS BEEN PREPARED BY

Association of Local Government Archaeological Officers



Chartered Institute for Archaeologists



FAME



Historic England



Solar Energy UK



SUPPORTED BY

Cadw



Historic Environment Division, DfC



Cover photos: Historic England, Wessex Archaeology

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PART 1 PRINCIPLES FOR GOOD PRACTICE



Credit: Low Carbon

1 INTRODUCTION

1.1 ABOUT THIS GUIDE

- 1.1.1** This guide on archaeology and solar farms sets out good practice to promote consistent approaches to the process and timing of archaeological work on large-scale solar farms only.¹
- 1.1.2** The guide considers the evaluation and significance of above- and below-ground archaeological remains and the potential for direct impacts² from the preparation for and construction, operation and decommissioning of solar farms. It does not cover the setting of heritage assets or impacts upon historic landscapes. These are covered by other guidance.³
- 1.1.3** The guide has relevance across England, Northern Ireland and Wales only. The differences in the planning and infrastructure regimes in each nation mean that the precise language used in this guide may vary from the language used in each nation. However, the concepts and principles are similar.
- 1.1.4** This guide is for developers, archaeological advisors, planning case officers, archaeological consultants, and contractors. Without prejudice to planning policy, the guide provides a framework for assessing and evaluating impact and design mitigation for the effects of solar farm development on the archaeological resource.
- 1.1.5** This guide will be reviewed within 3 years of publication to assess its effectiveness.
- 1.1.6** The guide is in two parts:
- **PART 1** outlines the shared principles that stakeholders across both sectors are encouraged to adopt. It explains the importance of collaborative working practices, which balance the need for efficient and timely project delivery with the requirement to uphold policies that protect the historic environment. It also highlights the close relationship between the applicants providing detailed information on design and the ability of archaeological advisors to provide informed advice.
 - **PART 2** offers practical tools and useful information on the context for solar farm development and archaeology on solar farms. It defines the main elements of solar farm development, explains key roles, outlines when specific actions should be taken and explores the range of techniques available for assessing archaeological potential and mitigating impacts on the cultural significance of heritage assets. Part 2 also includes a model checklist for the applicant to complete and provide to the archaeological advisor, identifying the location and possible impact of all aspects of the solar farm development.

¹ This guide is not intended to apply to small-scale installation of ground-mounted solar panels

² This guide defines impact as 'a scaled measure of the degree to which a change would impact the cultural significance of an asset' (see IEMA, IHBC, CifA 2021 *Principles of Cultural Heritage Impact Assessment in the UK*)

³ Historic England 2017 *The Setting of Heritage Assets. Historic Environment Good Practice Guide in Planning Note 3* (Second Edition); Department for Communities, Historic Environment Division 2018 *Guidance on Setting and the Historic Environment*; Cadw 2017 *Setting of Historic Assets in Wales*;

1.2 SUMMARY OF AGREED PRINCIPLES

- 1** Solar farm development plays an important role in delivering Government renewable energy targets
- 2** Archaeological remains are a valued cultural resource worthy of protection
- 3** Consultation should occur early and be integrated into solar farm planning processes
- 4** Design flexibility can be utilised to protect the significance of archaeological remains
- 5** Defining ground disturbance and sensitivity zones provides opportunities to streamline archaeological management
- 6** Archaeological methodologies should be aligned to specific site conditions and project impacts
- 7** High-quality non-intrusive evaluation is critical to developing an understanding of archaeological potential at a landscape scale
- 8** A pragmatic approach to trial trenching will enhance confidence while enabling development
- 9** Mitigation options: balancing archaeological sensitivity with relative impact
- 10** Public engagement and knowledge dissemination should be integrated into the delivery of solar farms

- 1.2.1** These principles describe a suggested approach for undertaking archaeological investigation where this required as part of solar farm developments. The approach seeks to satisfy policy requirements for the historic environment, while also ensuring delivery of solar farm development in line with Government goals for clean energy. This approach will ensure that there is sufficient information available to make decisions about the balance of impacts against benefits of a scheme.
- 1.2.2** Developers need to integrate archaeological considerations into their approaches to scheme preparation and programming. This will help ensure an appropriate level of information about archaeological remains and their significance is provided to enable informed advice to be given and decisions to be made. Pre-application discussions should identify where archaeological impacts are likely to arise.
- 1.2.3** Developers, in communication with archaeologists, may be able to use the flexibility of solar schemes to make the case for adjusting the timing of certain archaeological evaluation methods, such as trial trenching. Zoning of areas of ground disturbance and understanding the variable sensitivity of remains should enable pragmatic solutions if enough detail to inform decisions has been provided. If seeking to delay pre-determination archaeological evaluation trial trenching, developers should consider their approach to risk management, as early evaluation may benefit scheme delivery where it reduces the likelihood of more costly delays at later phases of the development.
- 1.2.4** This guide does not remove the need for careful negotiation of site-specific requirements for archaeology, reflecting the specific conditions of archaeological remains and local constraints. However, it should provide a framework for negotiation to ensure consistent application of the principles.

2 PRINCIPLES FOR GOOD PRACTICE

2.1 PRINCIPLE 1 SOLAR FARM DEVELOPMENT PLAYS AN IMPORTANT ROLE IN DELIVERING GOVERNMENT RENEWABLE ENERGY TARGETS

- 2.1.1 The UK and devolved governments have set ambitious targets for renewable energy generation. These targets will require a trebling of solar capacity by 2030 and ground-mounted solar will play a key role in reaching that target. Solar power is one of the cheapest forms of renewable energy; this guide supports efforts to reach Net Zero and acknowledges how archaeology should be appropriately managed while enabling that goal to be reached.

2.2 PRINCIPLE 2 ARCHAEOLOGICAL REMAINS ARE A VALUED CULTURAL RESOURCE WORTHY OF PROTECTION

- 2.2.1 The IEMA, ClfA, and IHBC Principles of Cultural Heritage Impact Assessment state that ‘Our valued cultural heritage is a resource worthy of protection. This is recognised in government policy and legislation that seeks to safeguard and maintain the most important cultural heritage assets. Safeguarding the cultural significance of places and objects need not prevent change.’⁴
- 2.2.2 Solar farm developers, as well as archaeologists, are committed to ensuring that the projects they design and deliver achieve this aim. Any solar farm application could have implications for below-ground or above-ground (earthwork) archaeological remains. Conservation (including preservation in situ/by design) and, where necessary, the appropriate assessment, investigation and recording of archaeological remains impacted by development should be proportionate to the importance of the remains in question and the proposed impact upon them. The purpose of archaeological investigation is to yield information about the past to advance our understanding of the human story – this core purpose of archaeological work is a public benefit.

2.3 PRINCIPLE 3 CONSULTATION SHOULD OCCUR EARLY AND BE INTEGRATED INTO SOLAR FARM PLANNING PROCESSES

- 2.3.1 Communication between solar farm developers, local authority planners and archaeological advisors (and other statutory heritage consultees) should take place early, at a pre-application stage. The precise timing of consultation is likely to depend on various non-archaeological factors/risks and should be decided on a case-by-case basis but should be as early as possible and informed by appropriate/sufficient information.
- 2.3.2 As an application progresses, the consultation should include the exchange of assessment reports and draft proposals. In due course it will include the exchange of project designs/written schemes of investigation (WSI) and, eventually, mitigation proposals.
- 2.3.3 Communication should continue throughout the application process, as the exchange of emerging data about design, proposed impact and the archaeological potential of the land will improve risk management and decision making. Further detail may also be required in response to planning conditions (see Section 8).

⁴ IEMA, ClfA, and IHBC 2021 *Principles of Cultural Heritage Impact Assessment in the UK*. Page 5, Section 1.3

- 2.3.4** It is important to exchange detailed construction information, including plans, elevations and proposed development impacts, as well as information on archaeological potential, as soon as it becomes available, to inform discussions.

2.4 PRINCIPLE 4 DESIGN FLEXIBILITY CAN BE UTILITISED TO PROTECT THE SIGNIFICANCE OF ARCHAEOLOGICAL REMAINS

- 2.4.1** Solar farms typically retain a relatively high level of flexibility in terms of the design and location of infrastructure.⁵ The precise location of infrastructure with higher-ground disturbance can often be moved away from zones of high archaeological sensitivity. This flexibility should inform the development of the archaeological data-gathering strategy for a specific site.
- 2.4.2** Sharing the details of proposals as early as possible allows archaeologists to identify those locations where layout adjustments (ie micro-siting) may avoid significant archaeological impacts.
- 2.4.3** Identifying areas of lower or higher ground disturbance can influence investigation methods, timing and subsequent mitigation options. For example, in parts of a proposed solar farm where there will be sufficient flexibility in the location of infrastructure with higher ground disturbance, consultees are likely to have increased confidence that trial trenching could take place post-determination, as part of the scope of an agreed mitigation strategy secured by pre-commencement condition.
- 2.4.4** Where a full mitigation scheme cannot be drawn up at the time of application submission, it will need to be secured by planning conditions/Development Consent Order⁶ (DCO) Requirements. Where assessment and design work is continuing post-determination, that work should inform the final scheme of mitigation via conditions/Requirements. It is recommended that at least an outline approach to mitigation is set out at application submission. This is needed both for the confidence of the decision maker and so that there is a reference point against which post-determination submissions for discharge of conditions/Requirements for mitigation can be judged.
- 2.4.5** In cases where archaeological data-gathering (evaluation) is to continue post-determination, planning conditions/DCO Requirements should secure a process whereby such work is carried out (see Section 8) as part of an agreed evaluation and mitigation strategy. The scope of such works would be defined within approved written scheme of investigation(s) (WSI). Results should iteratively inform an updated mitigation strategy.
- 2.4.6** Planning conditions/DCO Requirements should recognise the specific flexibility of design factors and differential impacts of solar farm schemes. Such conditions have an important role to play in ensuring the sustainable management of the finite archaeological resource, while accounting for the needs of solar farm development and the delivery of nationally set clean energy targets (see Section 8).

⁵ Solar farm 'infrastructure' in this document is understood to include any construction element which has a potential to impact upon below-ground archaeological assets. See the checklist in Section 7 for a non-exhaustive list.

⁶ DCO process applies to certain nationally significant infrastructure projects in England and Wales only

2.5 PRINCIPLE 5 DEFINING GROUND DISTURBANCE ZONES AND SENSITIVITY AREAS PROVIDES OPPORTUNITIES TO STREAMLINE ARCHAEOLOGICAL MANAGEMENT

- 2.5.1** The difference in levels of anticipated ground disturbance across a solar farm lends itself to the zoning of distinct areas. A solar farm will often contain large areas of land subject to a low level of ground-disturbance (ie panel supports), with smaller areas which will have consistently higher levels of ground disturbance. Higher-disturbance areas can include slabs for substations, transformers and other electrical infrastructure, cable routes, drainage swales, balancing ponds, areas of planting for landscape reasons and changes agreed for ecological mitigation. These different areas can be spatially defined as low- and high-ground disturbance zones, which can aid archaeological decision making.
- 2.5.2** Archaeological sensitivity will also vary across a site for a variety of reasons, including the type of archaeological remains and the relative depth at which they occur. When the presence and type of archaeological remains is understood, it is possible to map areas of higher and lower sensitivity, based upon the potential relative significance and character of archaeological assets and their sensitivity to change.
- 2.5.3** As archaeological data is collected during the course of the development, understanding of sensitivity across the site may change, so an iterative approach is needed. Developers and archaeologists should anticipate the potential for change in the boundaries and number of archaeological areas as more detailed information is gathered.

2.6 PRINCIPLE 6 ARCHAEOLOGICAL METHODOLOGIES SHOULD BE ALIGNED TO SPECIFIC SITE CONDITIONS AND PROJECT IMPACTS

- 2.6.1** Identifying buried archaeological remains and their survival, significance, extent, depth and distribution across the landscape may require different forms of archaeological assessment. The precise methodologies applied to gather the data needed will depend on the types of archaeological remains, the land in question and the types of impacts proposed. This means a variety of archaeological techniques will be used to obtain a sufficient level of information, proportionate to the impact, with which to make well-informed decisions.
- 2.6.2** Archaeological remains range from dispersed, early prehistoric artefact scatters to dense and complex features such as well-preserved Roman or medieval settlements. Remains may comprise artefacts, features such as pits, ditches and walls, human remains and standing structures. The context in which the archaeological remains are present is also important, as some environments preserve ancient remains better than others, so buried remains may be reliant on a wider environment for their preservation.
- 2.6.3** As archaeological remains differ in character and sensitivity, they will be impacted in different ways by ground disturbance. For example, inserting panel supports along sections of large ditches may cause only minimal disturbance. However, a buried mosaic floor would experience a greater impact as a result of the same panel support being put through part of it. Therefore, it is important to consider the sensitivity of archaeological remains in relation to the proposed ground disturbance.
- 2.6.4** Developers should expect a consistent approach to the application of successive phases of archaeological work between projects. This will involve gathering non-intrusive data, followed by targeting of additional phases of survey to answer remaining questions at specific locations of impact. The types of survey may vary based on the likely type of archaeology, the type of geology present and the potential for impacts from preparation,

construction and decommissioning, with different methodologies being best suited dependent on these factors. Consultants and archaeological officers can provide more detailed advice on individual projects and the reasons behind the methodology being applied in each case.

2.7 PRINCIPLE 7 HIGH QUALITY NON-INTRUSIVE EVALUATION IS CRITICAL TO DEVELOPING UNDERSTANDING OF ARCHAEOLOGICAL POTENTIAL

- 2.7.1** The approach to understanding archaeological remains present in solar farm areas should begin with a broad historic environment appraisal at site selection stage to identify key constraints presented by known heritage assets.
- 2.7.2** Subsequently, an understanding of the site should be formulated at a landscape scale, bringing together information on the known resources into a desk-based assessment (DBA) report. The DBA will draw on information from the Historic Environment Record (HER) and other existing data on geology, topography, aerial photography, cartography, documentary material and find spot data (eg, Portable Antiquities Scheme, Scottish Treasure Trove). There is sector guidance on how such assessment should take place.⁷
- 2.7.3** In some areas a high level of archaeological investigation has already taken place, meaning a relatively high level of knowledge already exists. The reverse is true elsewhere. The pre-existing level of knowledge influences what types of additional data-gathering are needed to effectively assess the archaeological potential within an area of land. Areas of the site where no ground disturbance will occur can, in all but exceptional circumstances, be scoped out of further evaluation at this stage.
- 2.7.4** Following the completion and discussion of the desk-based assessment (DBA) with the determining authority and their archaeological advisors, the applicant should commission a range of evaluation techniques, such as geoarchaeology and deposit modelling, geophysical survey and airborne remote sensing (see Section 5 for more details). The results of these surveys should be synthesised and professional judgement (and if possible, predictive modelling) used to create the best understanding of where archaeological remains are likely to be located on a site, including for those areas which are at that point lacking definitive evidence.
- 2.7.5** There may be cases where this non-intrusive or minimally intrusive work will provide sufficiently detailed information about the impacts of the scheme on the significance of archaeological remains for planning and for viability decisions to be made.
- 2.7.6** Where the results of this work are inconclusive, or if an insufficient range of non-intrusive techniques have been used to give confidence in the results, or further information is required to determine the effect and mitigation of localised impacts upon significance (for example, for fixed assets in areas of high archaeological potential), more intrusive assessment techniques may be necessary.
- 2.7.7** There may be solar sites where a full suite of non-intrusive survey techniques cannot provide sufficient clarity about the archaeological potential of the site (for example where much of the site is covered by green waste, rendering geophysical survey methods less effective, and other approaches like fieldwalking, test pitting,

⁷ ClfA 2020 [*Standard and guidance for historic environment desk-based assessment*](#). Note: there are other ClfA standards and guidance documents covering specific techniques such as geophysical survey.

geoarchaeological assessment or additional remote sensing have added little further information), where trial trenching may be required to inform determination.

2.8 PRINCIPLE 8 A PRAGMATIC APPROACH TO TRIAL TRENCHING WILL ENHANCE CONFIDENCE WHILE ENABLING DEVELOPMENT

2.8.1 Trial trenching is a valuable technique that helps to test for the presence or absence of archaeological evidence and clarify the results of non-intrusive surveys. The data it can provide gives a high level of confidence on archaeological impacts, enabling an understanding of the significance, depth, date, character, state of preservation and relative complexity of archaeological remains, enhancing evidence collected via non-intrusive methods.

2.8.2 The timing of trial trenching should be carefully considered. Solar farm developers often cite reasons why it is challenging to undertake extensive trial trenching pre-determination (see Section 3.8). Archaeologists should consider whether it is reasonable to move any or all trial trenching requirements to the post-determination stage.

2.8.3 For this to happen, four key pre-requisites should be met:

- the flexibility for design changes and relocation of specific solar farm assets to avoid archaeological sites and features identified after determination needs to be demonstrated
- the solar farm developer ideally would have undertaken an effective range of non-intrusive surveys at the pre-application stage, or at least as soon as possible prior to the determination stage and ensure that the results are properly synthesised
- in any area of inflexibility or high disturbance, the information provided should be sufficient to demonstrate the presence/absence of important archaeological remains. For areas of high flexibility or low disturbance, sufficient information should be provided to demonstrate that impacts can be managed through design flexibility and archaeological mitigation secured by condition.
- there needs to be an agreed written scheme of investigation (WSI) secured by planning condition/DCO Requirement that sets out a post-determination programme for design development and targeted trial trenching to devise an appropriate mitigation strategy.

2.8.4 Where these pre-requisites cannot be met, archaeological advisors may require that a greater proportion of the trial trenching needs to happen prior to determination. Where this is the case, planning archaeologists should be able to provide reasoning why pre-determination trial trenching of any low ground disturbance areas is required to come to a planning decision. Any pre-determination trenching requirements for zones of low disturbance should be made with specific reference to their likely archaeological sensitivity, and be the minimum required to establish an acceptable characterisation of the historic environment to proceed to determination.

2.8.5 Managing archaeology alongside multiple risks on development projects is complicated and solar farm developers will balance this in full understanding of these risks. However, there are also advantages to solar farm developers in undertaking a proportion of trial trenching prior to determination. In considering their approach to risk management, they will need to balance the potential benefits of maximising information collection as early as possible with the chance of delays if this is left until later phases of pre-construction.

- 2.8.6** It is often the case that infrastructure that requires higher ground disturbance such as cable trenches, connectors and transformers can be relocated, even post-determination. However, where their location is fixed or where developers have been unable to provide sufficient detail on the proposed development and location of ground disturbance, targeted pre-determination trenching of these fixed aspects of the scheme may be required.
- 2.8.7** Whenever trial trenching is taking place, the quantity of trial trenches should be based on answering specific questions, either resulting from previous non-intrusive work or which can only be addressed via intrusive survey. Untargeted trenching across large areas should be avoided, provided that a wide range of other non-intrusive techniques have been used, the techniques used are considered reliable in that context and the results have not indicated the potential for important archaeological remains. The use and precise layout of trenching is best defined at the point when the applicant can provide archaeological advisors with an acceptable level of information about the specifics and layout of the solar scheme and clarity around the degree of flexibility of specific parts of the site.
- 2.8.8** Given the potential for low levels of ground disturbance associated with large parts of a solar farm scheme, it is also appropriate to consider the environmental sustainability of trial trenches and other ground disturbance impacts associated with trial trenching (for example to soil health, biodiversity, soil carbon and on farming operations – see section 3.9). These include carbon emissions from the use of plant and the release of soil carbon during trenching (in particular on permanent pasture and areas of peatland). To support Net Zero and carbon reduction targets, those planning archaeological work should be confident that every trench has a clear and proportionate purpose.

2.9 PRINCIPLE 9 MITIGATION OPTIONS SHOULD BALANCE ARCHAEOLOGICAL SENSITIVITY WITH RELATIVE IMPACT

- 2.9.1** Where evaluation results indicate the presence of archaeological remains within the area of development, archaeological mitigation will need to be considered and an appropriate strategy agreed. There is a mitigation hierarchy which places avoidance of harm and preservation by design above the more destructive solution (for archaeology) of investigation and recording. Given the flexibility of solar farms, preservation of these remains within the solar scheme should be the first consideration. The lowest impact option and one that is commonly used on solar farm developments is avoidance, through exclusion from the development area or inclusion as an area of open grassland. Where these options are chosen, such areas need to be protected during the construction programme, require methodologies for any habitat creation (to avoid potential impacts from activities such as soil inversion) and will benefit from management plans to ensure their long-term preservation. Where these options are chosen, Management Plans should be submitted to the Local Authority for agreement detailing how these aims will be achieved during the life of the project from construction through to decommissioning.
- 2.9.2** Depending upon the relative significance of the archaeological remains, it may be acceptable to install panel arrays directly over an archaeological site where the impact from panel supports will not affect the ability to understand the site in the future, thus substantially preserving it beneath the panel arrays. If remains are considered to be of such sensitivity that this level of disturbance is not appropriate, and avoidance is not possible, then alternative methods of construction could be considered (eg, non-penetrative panel supports and

cable trays). Where such solutions are implemented, consideration should be given to the formation depth for pads and/or need for ground levelling in order to implement such non-penetrative solutions. All of the above considerations rely upon a sufficiently detailed dataset existing for a proposed development area. This should contain information on the spatial extent, character, depth and importance of the archaeological remains in question to determine whether the form of mitigation is appropriate.

- 2.9.3** The use of above-ground panel support solutions (concrete feet or ballast) to preserve remains should be carefully considered. These solutions have sometimes been considered as a standard precautionary measure, however their use should be balanced with the sustainability considerations of bringing additional materials to site. These materials may also affect the potential of land to be smoothly returned to agricultural use upon decommissioning. For example, where gravel is used below concrete feet and/or in the form of ballast, this introduces new materials which were not formerly part of the topsoil. These above-ground panel support solutions remain viable in high sensitivity areas but should be used only when expressly necessary. Careful consideration of these solutions is required to ensure that they would successfully achieve the desired effect of preservation in situ. Further innovation is needed to find more sustainable non-penetrative solutions.
- 2.9.4** In areas of higher ground disturbance (substations, construction compounds, cable routes) where archaeological remains are present and avoidance is impossible, archaeological investigation during or in advance of groundworks would usually be required.
- 2.9.5** Arriving at the correct mitigation option (and different options are likely to be required across any large solar farm development site) will require discussion and consultation between the applicant, their consultants and the local authority/determining authority.

2.10 PRINCIPLE 10 PUBLIC BENEFIT AND KNOWLEDGE DISSEMINATION SHOULD BE INTEGRATED INTO THE DELIVERY OF SOLAR FARMS

- 2.10.1** Developers and their consultants and local planning authority archaeologists should consider how to maximise public benefits from archaeology undertaken as part of solar farm development from the beginning of the scheme, and where appropriate secure these through planning conditions.
- 2.10.2** Dissemination of knowledge gained through investigation should be woven into proposals. Information produced by any archaeological evaluation or investigation should be fully analysed and reported on, the results placed in the public domain and the material curated in an appropriate archive.
- 2.10.3** Opportunities to engage local communities and improve public understanding of the landscape should also be considered. For example, public rights of way located within or on the edges of solar farms may present options to disseminate archaeological information to the public.

PART 2 PRACTICAL ADVICE



Credit: Wessex Archaeology

3 UNDERSTANDING HOW SOLAR FARMS ARE DESIGNED AND CONSTRUCTED

- 3.1.1** Solar farms differ in some ways from many traditional forms of built development, and this distinction has direct implications for how archaeological risk should be understood and managed. Unlike housing estates, transport infrastructure, commercial buildings and other forms of energy-generating stations which typically involve intensive ground disturbance across much of the scheme area, solar farms are typically characterised by often larger areas of dispersed, relatively low-intensity ground disturbance (eg, vertical panel supports), flexibility in layout, and a fixed lifespan. The scale of solar farms, in spatial area, is often larger than many other types of development (eg, an industrial estate). These characteristics can sometimes enable adaption that accounts for archaeological sensitivity, including areas of lower ground disturbance or complete avoidance of remains, where required.
- 3.1.2** Solar farm developments include areas of more conventional (higher) ground disturbance (eg, substations and cable runs) and while solar farms have a fixed lifespan, the physical impacts of these types of construction activities on archaeological remains are permanent.
- 3.1.3** Allowing time for an iterative approach to collecting and sharing archaeological and design information is critical. Some archaeological areas can be more sensitive to disturbance than others and will demand an archaeological and design approach specifically adapted to these circumstances; this should be understood and prepared as early as possible.

3.2 GRID CONNECTION AND HOW IT AFFECTS THE PROGRAMME

- 3.2.1** Solar farm sites are selected partly on the basis of the grid connection that they offer. The grid connection is of critical importance to a solar farm development, so developers cannot select land only to avoid certain qualities (eg, archaeological potential). Other factors then influence whether that land is appropriate for an application; this can include heritage setting, archaeological potential, landscape and visual matters, ecological concerns, hydrology, topography and various other technical matters.
- 3.2.2** While securing a grid connection is a fundamental part of the project lifecycle, the process of delivering that connection is currently subject to widely publicised delays. These delays are often due to the need for broader grid reinforcement works that are outside the control of the developer of any particular solar project.
- 3.2.3** These delays can significantly influence the implementation timeline of solar projects. In particular, long lead times between planning consent and construction start are becoming increasingly common. As a result, it is often necessary for land to remain in agricultural use for several years after consent is granted, simply because the connection infrastructure is not yet in place. In contrast, sites subject to an accelerated build programme also exist, where requirements will be different.
- 3.2.4** The extended timeline associated with arranging grid connection has practical and financial implications for how and when certain preparatory activities, such as intrusive archaeological investigations, are carried out. The timing of their implementation, if required, should align with the anticipated grid delivery schedule to minimise disruption to land earlier than necessary.

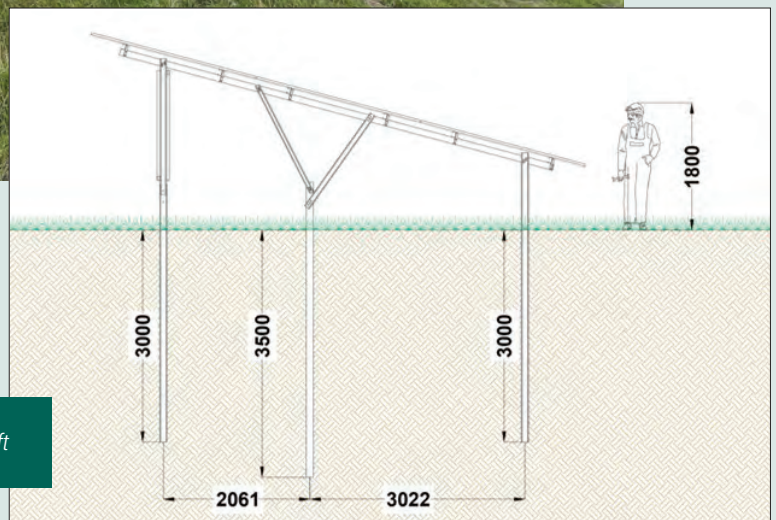
3.3 LIMITED GROUND DISTURBANCE WITHIN SOLAR PANEL ARRAYS

- 3.3.1** The potential impacts of large parts of solar farms on either below-ground or above-ground (earthwork) archaeological remains can often be minimised (see Section 4). This is because much of a solar farm consists of solar panel arrays mounted on narrow steel supports that are driven vertically into the ground, rather than requiring extensive groundworks. These supports affect only small cross-sectional areas, and the spatial arrangement of the arrays, usually with several metres between each row, results in limited disturbance to below-ground deposits.
- 3.3.2** The panel supports needed within these arrays are often the focus of attention as they are driven into the ground, with a fairly obvious potential impact upon buried archaeological remains. Some classes of features (such as burials and buildings) may still be highly sensitive to these impacts.
- 3.3.3** When seeking to understand these impacts, it is important to note that the overall impact in these areas (which form the largest portion of a solar farm) relies upon other aspects of the proposals being implemented in ways which preserve archaeological remains. Therefore, activities such as stripping topsoil and managing the movement of heavy plant during construction, or running cables above ground instead of below ground, are also important considerations.

*What we see above the ground – a row of solar panels.
Credit: Statkraft*



The below part of a solar panel array. Credit: Statkraft



3.4 HIGHER GROUND DISTURBANCE ASSOCIATED WITH INFRASTRUCTURE

- 3.4.1** There are a variety of other types of ground disturbance associated with solar farm developments. These include, but are not limited to, the main cable routes to the point of connection, cable routes which run adjacent to solar panel arrays on some solar farms (in other cases they are held above ground and run between panels), temporary and permanent access tracks, construction compounds and substations (see more detail in Section 4). These parts of a solar farm may have a higher potential to impact on below ground archaeological assets, although in spatial terms these higher ground disturbance areas take up a small part of the solar farm (see Section 7 for a checklist of the range of development elements associated with solar farms).
- 3.4.2** Other impacts to consider include the way land is treated prior to remains being preserved by either design solutions (eg, non-penetrating panel supports) or by avoidance. Such land must not experience other ground disturbances prior to preservation, or that preservation may be nullified. The way solar farms are decommissioned also needs consideration and careful management to ensure that minimal impacts during construction are not followed by large impacts when the solar farm is taken out of use.



Cable route adjacent to solar panel arrays. Credit: Statkraft

- 3.4.3** Upgrading works or large-scale repair/replacement of parts during the lifetime of a solar farm could also involve ground disturbance. Planning conditions should consider the construction, use and decommissioning periods of a solar farm in relation to archaeological matters (see Section 8).

3.5 WHY ASPECTS OF SOLAR FARM DESIGN MAY NOT BE FIXED AT THE PLANNING APPLICATION STAGE

- 3.5.1** The more information available on design, the better able an archaeologist is to design targeted assessment and thereby help remove risk earlier in the project lifecycle. A best-case scenario would be to have detailed information about proposed design/s and detailed information on the spatial extent, depth and character of archaeological remains. That would allow officers to give the optimum level of advice to decision makers.
- 3.5.2** The reason that precise information is often unavailable early in the application process lies in the staged and responsive nature of solar farm project design. Prior to an application being made, the layout is necessarily indicative or conceptual. It shows general equipment zones, access and infrastructure, sufficient for assessment purposes, but it may not reflect detailed engineering design. This is because detailed design depends on post-determination work, including:
- topographic and geotechnical surveys
 - contractor input on construction methods
 - refined drainage, landscape and cable routing strategies
- 3.5.3** All of these are informed by site-specific conditions and evolve in tandem. For instance, final drainage design depends on detailed levels and contractor methodology, and landscape mitigation depends on where final equipment is sited. Information resulting from further archaeological assessment, which may take the form of trial trenching, should also be considered when finalising the design.
- 3.5.4** Substations needed for a solar farm may come under a separate application. These are not always built by the solar farm developer but may fall under the remit of a Distribution Network Operator (DNO). On occasion, cable routes, which run offsite to link to the grid, also fall under a separate application.

3.6 DESIGN FLEXIBILITY

- 3.6.1** Most large-scale solar farms benefit from a high degree of design flexibility. Infrastructure such as inverters, substations, cable runs within the solar farm, and access roads can usually be repositioned within the site boundary to avoid areas of known archaeological sensitivity.
- 3.6.2** Certain design elements will be less flexible. For example, the main cable corridor (route) to connect the solar farm to the external grid may be substantially inflexible at certain points. Furthermore, the location of some items may also be constrained by other factors, such as the setting of a heritage asset or ecological considerations. Main cable routes are often shown as a corridor at the proposal stage. The exact cable route, including any associated easement, within the corridor can often be moved to follow an optimal route that, for example, avoiding known archaeological remains.

- 3.6.3** The deployment of this elasticity in design, especially on larger schemes, should be informed by archaeological assessment and the evolving relationship, both pre- and post-determination, between archaeological understanding and scheme design. Landscapes with complex depositional processes may be more likely to conceal large or highly sensitive features and may require a broader range of assessment techniques to be used to better understand them.
- 3.6.4** While presence of archaeological remains may influence the layout or impose additional mitigation costs, it is unlikely to render a project unviable, provided sufficient archaeological investigation has been undertaken. This is particularly the case for larger projects, where layouts are more flexible. The relatively large scale of many solar farms means that there is an opportunity to conserve archaeological remains if flexibility is upheld within the design process.

3.7 CONSTRAINTS AT THE PRE-DETERMINATION STAGE

- 3.7.1** There are challenges that constrain solar farm developers at the pre-determination phase of solar farm developments. The amount of land which many solar farms occupy is larger than many other forms of development. Often, much of that land is in active (eg arable) agricultural use prior to becoming part of a proposed solar farm. This means crop compensation and disruption to the agricultural cycle are amplified on solar farm applications. In comparison, it may also be the case that other forms of development, for example quarry sites, are phased over many years, meaning the effect of trial trenching is experienced over a longer timeframe along with the disruption and costs associated with it.
- 3.7.2** Projects can take several years to progress from site identification to planning application submission, during which access to land is often limited because of ongoing agricultural use. Intrusive evaluation (trial trenching) can disrupt cropping schedules and/or livestock management.
- 3.7.3** The challenges associated with early-stage and large-scale intrusive archaeological investigation should be considered carefully by decision makers. Conversely, the need to allow for sufficient characterisation of a site's archaeological remains should be considered at an early stage. Where complicated archaeological issues are likely, this process should start as soon as possible, in suitable agricultural windows for access, and not left to the final months before an application.

3.8 LIFESPAN OF A SOLAR FARM

- 3.8.1** Most solar farms are consented for a lifespan of 40 or 60 years, after which the consent will expire and the land will revert to its former use, unless further planning/development consent order (DCO) applications are made. The relatively fixed-term lifespan of such development contrasts with permanent developments like industrial or housing estates. Repowering/upgrading of a solar farm during or at the end of its proposed lifespan may also occur, but this would need to be subject to a separate consent so does not need to be considered in detail. This could, potentially, introduce new impacts upon archaeology. The implications of repowering should be considered when conditions are attached to a planning permission/DCO. (see Section 8).
- 3.8.2** A fixed-term use does not equate to a temporary harm of archaeological remains. Impacts on below-ground archaeological remains will be permanent where they take place.

- 3.8.3** In cases where solar farm construction leads to archaeological remains being wholly or partially preserved because they have been taken out of regular mechanical ploughing, that preservation may also come to an end when the solar farm is decommissioned. To ensure that these benefits are not lost at the end of the scheme, the decommissioning/reinstatement strategy will need to consider how land restoration/recultivation can take place without damage to these preserved remains. For example, sub-soiling in response to concerns about compaction and pan formation could directly negate the scheme's preservation of remains by design up to that point.
- 3.8.4** Specific methods for decommissioning works cannot be determined at the application stage. While an application could outline potential mitigation methods for decommissioning, these should remain flexible and would ultimately be secured through a decommissioning Environmental Management Plan, to be approved by the Local Planning Authority prior to works taking place.

3.9 TIMING AND COSTS OF EVALUATION WORKS

- 3.9.1** Desk-based assessment, which includes walkover survey and analysis of a range of data sources (eg, Local Authority HER, aerial photographic and lidar survey), can take place at various points in the project cycle including at the land acquisition stage, or later when the design of proposals is being considered along with other disciplines such as landscape and ecology. It is recommended that this is undertaken as early as is reasonable.
- 3.9.2** Site-based archaeological surveys do not usually take place until grid connection and land acquisition are well advanced, which can be several years after site selection. Geophysical survey is a core part of the evaluation process. This requires access rights from landowners; having surveyors on land which may have crops and/or livestock on it is disruptive to the farming cycle so this should be well planned. These surveys should not be left until late on, as that reduces the ability to fit around the farming cycle and reduces the opportunity to plan further targeted work around cropping and cultivation. It also means that data which may be useful for design/redesign purposes may not be available in a timely way. That also has potential impacts on timescales and costs, albeit at the delivery point of a project rather than at the application stage.
- 3.9.3** Intrusive trial trenching involves disturbance of the soil and potential damage to crops/pastureland. This is more disruptive to a working farm than non-intrusive surveys. The physical effects on soil, which can affect future crop yields, and the potential strain on landowner relationships is notable. In addition to the archaeological costs of trial trenching, additional payments in relation to crop loss/compensation and damage to/repair of agricultural land drains will increase the financial cost of these surveys. Because of the specific characteristics of solar farm development sites, extensive trial trenching can be experienced by applicants as disproportionately costly and disruptive pre-determination (relative to the costs of other pre-application surveys). For this reason, solar farm developers usually prefer intrusive evaluation to be conducted post-determination, secured by condition, once project risk is reduced and design details are sufficiently advanced to allow the trenching to be as targeted as possible. The costs are still present once permission/consent is granted (subject to conditions), but a degree of uncertainty over the project has then been removed, and this is a significant turning point in the management of project risk. However, it should be recognised that this approach may carry associated risks for delivery which will need to be managed in accordance with planning policy.

4 DEFINING THE ARCHAEOLOGICAL IMPACT OF SOLAR FARMS

4.1 ELEMENTS OF A SOLAR FARM

4.1.1 A solar farm scheme often consists of the following elements (not an exhaustive list):

- solar arrays
- cabling trenches
- roads and site vehicles
- substations, inverters, transformers and battery storage
- fencing
- landscaping and drainage
- temporary construction infrastructure
- habitat creation

4.1.2 The following paragraphs describe the potential impacts on archaeological remains from each design element (based on common solar farm construction practices) and consider possible future impacts during operation and decommissioning.



Access road, cable route and panels. Credit: Statkraft

4.1.3 An example checklist identifying all potential construction activities and their possible archaeological impacts, which should be completed by the solar farm developer and their consultants, is provided in Section 7. Use of this checklist would allow any impacts resulting from activities not identified below, or relating to slightly different construction methods, to be captured and assessed more fully.

4.2 ARRAYS

4.2.1 Large parts of a solar farm development consist of the panels, mounted on frames which usually have one to three (galvanised) steel supports that are driven into the ground. The depths will vary with ground conditions but typically range from 1m to 3m below ground level. These supports have a range of profile designs (depending on the manufacturer but a flanged C or U shape is common) and usually measure about 200mm by 100mm. The metal sheeting is usually 3–5mm thick. They are pushed/driven into the ground on a standard grid layout by small track-mounted rigs which cause minimal disturbance to the topsoil.

4.2.2 The physical impact of these supports on archaeological remains has not been directly investigated but based on available guidance on piling and archaeology,⁸ the impact of any individual support would be like a sheet pile, albeit with a different profile. In most ground conditions the support is pushed into the ground with limited vibration. The area that is disrupted by the installation would usually be limited to the cross-section of the support, and soil either side of the metal support would rarely be disturbed or disrupted.

⁸ Historic England 2019 *Piling and Archaeology: Guidance and Good Practice*. Swindon: Historic England. (accessed 17 June 2025)

Solar array under construction. Credit: Statkraft



- 4.2.3** A typical array layout has supports at 2–3m intervals along a set of panels, and a gap of 3–4m to the next set of panels. Usually, the area disturbed by the supports is far less than 1 per cent of the land parcel. Archaeologically, the impact of one metal support is limited and unlikely to harm the archaeological interest of most archaeological features either singularly or cumulatively (ie, make it hard for the future investigation of the site to take place once the solar array is removed).
- 4.2.4** There are some types of archaeological remains, such as burials/graves, that it would not be acceptable to install supports into, and others – such as ancient masonry, earthen structures or large pieces of waterlogged wood – where the impact could be larger than just the cross-section of the support if they cause an obstruction and are dragged downwards, so installation of supports in these areas would not be recommended.
- 4.2.5** Other panel support systems may have slightly different impacts which should be considered on a case-by-case basis using the checklist in Section 8. Nonetheless, the cross-section of ground disturbance for most support systems is limited compared with other construction infrastructure elements.
- 4.2.6** Where solar schemes are constructed in areas of previous wetlands (such as fens, or in river valleys), installing panel supports into existing waterlogged deposits (like burial peats) will be very unlikely to lead to any changes to either the water levels or the buried environment more generally.⁹

4.3 FENCING

- 4.3.1** Most sites will have an exterior fence around their perimeter. The impacts of fencing will depend on the installation method. This can range from driven posts through to more substantial foundations requiring excavation of holes or trenches into which concrete is poured. It is thus important that the fencing methodology is clearly specified alongside other design documentation, as some areas may need appropriate archaeological mitigation.

⁹ Based on general hydrogeological and geochemical principles, as set out in Historic England 2016 *Preserving Archaeological Remains* – main guidance and Appendix 3. The risk of dewatering is marginally higher in areas with perched water tables, which rarely occur in these environments.



Perimeter fencing with CCTV cable trench running alongside it. Credit: Pre-Construct Archaeology

4.4 CABLE TRENCHES

- 4.4.1 Cables that connect the solar panels to each other are usually attached to the back of the panels. These are connected to cables from the other rows of panels at one end of the array (usually at the edge of the field) and run in cable trenches to transformers and other electrical infrastructure.
- 4.4.2 Cable trenches are usually about 1m deep and about 1m wide, and their excavation would physically impact any archaeological remains within the trench through their removal or truncation, requiring appropriate levels of archaeological mitigation. Cable trenches cause ground disturbance similar to other development types (such as footings and utilities needed for housing). Further impacts could arise from topsoil stripping and storage for any cable trench working easement; identifying early on the lowest impact location and method for cable trench excavation will help manage impacts and focus evaluation efforts on areas of highest risk.
- 4.4.3 The amount and depth of cable trenching are important considerations that should be clarified at the earliest stage to inform assessment and mitigation options. Where cable configuration differs from that described above, this should be assessed for any additional impacts (using the checklist in Section 7).

4.5 ROADS AND SITE VEHICLES

- 4.5.1 Permanent roads are constructed into and around the site to facilitate construction and maintenance of the solar arrays. These can be designed to sit on the topsoil or may require the removal of topsoil and subsoil to build a more solid base prior to surface treatment. The archaeological impact of soil removal for roads could include compaction and the loss or truncation of archaeological features, requiring appropriate levels of archaeological mitigation.
- 4.5.2 Unintentional impacts can occur from vehicle rutting and uncontrolled site stripping/preparation works. Working in appropriate weather/soil conditions and using track mats can reduce these impacts.



Cable trench. Credit: Statkraft

4.6 SUBSTATIONS, INVERTERS, TRANSFORMERS AND BATTERY STORAGE

- 4.6.1** Given the substantial weight of these facilities, they usually require foundations, which involve the removal of soil from the area under the structure. This may impact any archaeological remains in that location, requiring appropriate levels of archaeological mitigation.

4.7 LANDSCAPING AND DRAINAGE

- 4.7.1** Schemes may include landscaping and levelling or require areas to be excavated for drainage (such as swales and attenuation ponds). Landscaping that requires groundworks, ie, pond creation, or that removes archaeological earthworks could have impacts, requiring appropriate levels of archaeological mitigation.

4.8 TEMPORARY CONSTRUCTION INFRASTRUCTURE

- 4.8.1** Topsoil will normally be stripped prior to building construction compounds and temporary roads and or may cause soil compaction. Where compounds are initially located in an area of archaeological sensitivity, the most effective mitigation option is to move the compound to a less sensitive location (as there is usually more flexibility at this stage of the project). Temporary roads can be constructed by building up from the topsoil (laying protective matting or appropriate geotextile separator materials and imported fill) if these need to cross areas of archaeological sensitivity (or to protect tree roots, for example). Consideration should be given to temporary construction methods to ensure they do not result in settlement of the topsoil/subsoil, which would then require subsequent loosening/ripping to improve soil texture, as this could damage any archaeological remains that the mitigation measures were designed to protect (eg artifacts within topsoil and buried remains).
- 4.8.2** Where topsoil or subsoil is removed prior to the construction of temporary infrastructure, the archaeological impact could include the loss or truncation of archaeological features, requiring appropriate levels of archaeological mitigation.

4.9 HABITAT CREATION

- 4.9.1** The creation of new and improved habitat (including Biodiversity Net Gain) can provide great public benefits, particularly where natural and historic environment plans are designed collaboratively – for example, placing areas of appropriate habitat over areas of archaeological preservation. Careful specification is needed to ensure that construction methods do not impact negatively on archaeological remains. For example, new ponds should be located away from areas of archaeological remains; similarly, woodland creation or screening planting should avoid these too. The creation of wildflower meadows can involve the turning of soil, and depending upon the depth of this, there is the potential for impacts on below-ground remains, requiring appropriate levels of archaeological mitigation. Such activities should be considered on a case-by-case basis, through the use of the checklist in Section 7, to avoid the situation where ecological mitigation affects archaeological remains. Cross-reference between Ecological Management Plans and Archaeological Management Plans can be beneficial. Notably, habitat creation is sometimes required early in the scheme construction process (so that the new habitat is established prior to any species translocation), so in terms of timing this may require early assessment.

4.10 OPERATION AND DECOMMISSIONING

- 4.10.1** During the operation of the solar farm, possible impacts on any archaeological remains preserved within the site boundary should be controlled by fencing, signage and site briefings. Consideration should be given within the archaeological management plan/mitigation strategy to any risks from future maintenance (repair of cabling; emerging drainage issues; replacement of damaged arrays) or upgrades.
- 4.10.2** Solar farm developments are consented for a fixed duration, after which they will be decommissioned. As very few solar farms have yet been decommissioned it is not possible to list every potential impact here. However, uninstalling panel supports, removing cabling or re-landscaping drainage features (for example) could all have potential archaeological impacts in the future. Each should be carefully considered within decommissioning documentation that is submitted with applications or developed during the lifetime/at the end of life of these schemes. How these are secured through planning conditions/agreements will require discussion between the applicant and the determining authority, and is beyond the scope of this document.
- 4.10.3** Following decommissioning, it is likely that the construction, use and removal of a solar farm will have a negative impact on the effectiveness of any future geophysical survey (particularly magnetometry) as a result of ground disturbance and the unavoidable presence of metal fragments (wire, screws, etc) in the soil. While this will not influence the decision-making process, archaeological advisors would usually be expected to have requested appropriate geophysical survey be completed and appropriately archived as part of the suite of non-intrusive survey methods in the application for a solar scheme, as it would be reasonably anticipated that its efficiency post decommissioning will be reduced.

Solar farm in operation. Credit: Low Carbon



5 EVALUATING THE SIGNIFICANCE OF ARCHAEOLOGICAL REMAINS WITHIN SOLAR FARM SITES

5.1 THE PURPOSE OF ARCHAEOLOGICAL DATA-GATHERING (EVALUATION)

5.1.1 In a planning and development context, archaeological investigations are undertaken to determine the presence or absence of archaeological remains within a particular site, and if present to understand the nature, spatial extent, preservation and significance of those remains. These types of archaeological investigations are referred to as archaeological evaluations and their function is to determine the archaeological potential of a site.

Desk-based assessment

5.1.2 The purpose of a desk-based assessment (DBA), is to determine, as far as is reasonably possible from existing records, the nature, extent and significance of the historic environment within a specified area.¹⁰

Non-/minimally intrusive surveys (subsequently termed non-intrusive)

5.1.3 Non-intrusive surveys either use sensors to analyse the properties of the soil to help detect archaeological features (eg, geophysical survey, airborne remote sensing) or record extant features (eg, topographical/walkover survey). Minimally intrusive surveys involve the retrieval of a small sample of physical evidence to help clarify the archaeological potential of a site, such as boreholes to collect geoarchaeological information for deposit modelling, archaeological metal detecting, fieldwalking, or test-pitting.

Archaeological field evaluation (trial trenches)

5.1.4 Trial trenching will seek to determine, record and report on the nature, extent, preservation, depth and significance of archaeological remains within a defined area.¹¹ These will vary in size due to site and aims but commonly comprise trenches of 50m length and 1.8m/2m width, excavated across an area, targeted on features identified through non-intrusive surveys and/or to explore areas of unknown potential.

5.2 TIMING OF ARCHAEOLOGICAL EVALUATION WORK

5.2.1 It is standard practice to start with desk-based work, which summarises known information and draws conclusions about the presence of known remains and potential of the application area based on existing data and archaeological experience. Some of this information may have been collected at the feasibility stage during site selection (see project lifecycle, Section 6), but once a site has been identified, a detailed desk-based assessment (DBA) should be completed, informed by discussion and consultation with relevant LPA archaeologists. Where a project was scoped into an EIA process, assessment and subsequent data-gathering would be drawn into Environmental Statement preparation.

¹⁰ CIfA 2020 *Standard and guidance for historic environment desk-based assessment*

¹¹ CIfA 2023 *Standard for archaeological field evaluation*

- 5.2.2** A key consideration in the DBA should be understanding the geology/geoarchaeology of the area (including assessment of past geotechnical/ground investigation (GI) work or GI undertaken for the project). This helps to refine subsequent geoarchaeological investigation and provides information for those designing and undertaking geophysical surveys, for example by identifying the presence of deep deposits (such as alluvium/colluvium covering older archaeological remains) or indicating areas where previous development/mineral extraction has already removed archaeological remains.
- 5.2.3** Geophysical survey can provide large-area coverage, ideal given the scale of solar farms, and is likely to identify a wide range of archaeological remains present in an area. It works in most situations (see below for more details) and is well-suited to being one of the first non-intrusive survey methods used on a site.
- 5.2.4** The information assembled can be augmented and further refined by collecting more remote sensing and field survey data. This additional work may be useful to better define areas of significance or to test blank areas. This can provide greater confidence for decision makers and reduce the risk to the historic environment and for developers that large areas of significant archaeological remains will be identified after the scheme has been consented.
- 5.2.5** Trial trenching is the most effective method to verify the interpretation of the preceding desk-based and survey work, to characterise the form, function, date, depth and state of preservation, and to assess the significance of the remains. It can be a useful tool to investigate areas where previous work has not identified archaeological remains.
- 5.2.6** When presenting evaluation information from multiple techniques as part of the development submission, it is advantageous for the individual specialist reports on this material to be fully synthesised at a landscape scale to provide sufficient characterisation of the potential archaeological resource within an application area and make this clear to the reader (rather than separate and disparate reports being submitted without further integration).
- 5.2.7** There is a preference from solar farm developers to move most or all trial trenching to the post-determination stage. This is on the basis that an appropriate level of information to inform decisions has been provided – for example, on the presence and significance of any archaeological remains present within the application area and the flexibility within the scheme to move elements if subsequent evaluation identifies more features/sites. There may be cases where it is possible to move the majority of trial trenching to post-determination, equally, there might be some locations of likely high sensitivity and/or design inflexibility that need targeted pre-determination archaeological evaluation trenching.
- 5.2.8** In considering the timing of intrusive archaeological investigations, a key consideration is whether the likely archaeological sensitivity and complexity of the site would be compatible with undertaking trial trenching post-determination. Key factors include the flexibility of the scheme to address archaeological sensitivity and still deliver the proposed energy output across the scheme. Crucially, build-out and connection timescales should allow both for the necessary investigations to be done post-determination and for the results of that work to inform design of the scheme, such that the balance of impact to public benefit as envisaged by the decision maker is reflected in the actual outcome. If timescales are tight or archaeological risks are high across large areas, then greater front-loading of trial trenching pre-determination is likely to be necessary.

5.3 METHODS/TECHNIQUES

Desk-based assessment (DBA)

5.3.1 DBAs collate known evidence from a site and the surrounding area to provide an assessment of the potential for the application area to contain archaeological remains. Evidence reviewed includes records from the Historic Environment Record (HER)¹², Portable Antiquities Scheme/Portable Antiquities Scheme (Cymru)/Scottish Treasure Trove data, previous archaeological investigations, aerial photographs, Lidar data, historic mapping, documentary evidence and details of local topography and geology. A walkover of the proposed development site is carried out to assess the presence of earthworks and other elements of the historic landscape such as hedgerows and historic footpaths (where applicable). Walkovers can also help to spot land use which may have truncated remains (eg, terracing or mineral extraction) or verify previous observations of disturbance identified from the desk-based work.

Geoarchaeological prospection and deposit models

5.3.2 The purpose of geoarchaeological prospection is to characterise sediments, identify any major palaeoenvironmental deposits or ancient land surfaces, and to assess how landscape evolution may have impacted on archaeological visibility, eg, burial and/or erosion of remains. Data can be used to construct deposit models that can provide an understanding of geomorphological processes and soil variation across a site. This is particularly useful in areas with complex environmental histories, such as the Fens.

Geophysical survey

5.3.3 Geophysical survey measures small variations in the earth's natural properties. These measurements work most effectively at close range; increasing the distance between the sensor and the feature reduces the effective resolution and sensitivity. Effective survey requires relatively clear and stable ground conditions (so site preparation in advance of survey may be required).

- **Magnetometry** is the ideal technique to use on the majority of sites; it is fast and cheap, works across most geologies and detects a sufficiently wide range of archaeological and other features to provide a preliminary level of confidence as to the archaeological potential of the site. The clarity of the results can be adversely affected by green waste, modern construction materials or the level of detectable contrast between any features and the background. The detectability of features can be increased by reducing distance between sensor and feature, using a more sensitive instrument, increasing the stability of the survey platform and by collecting more data over the survey area. Magnetometer systems can be deployed in different configurations – hand carried (< about 10ha per day), pedestrian cart-mounted (< about 12ha per day), or towed behind an all-terrain vehicle (ATV) (< about 20ha per day).
- Beyond magnetometry, additional complementary geophysical surveys provide greater confidence and can be used to further define detected features and/or validate areas of apparently low potential:
- **Ground-penetrating radar** (GPR) is effective for defining edges and/or depths of features. Unlike most other non-invasive techniques, it can produce fully 3D representations of the subsurface and may enable phasing of superimposed features. Depth penetration can be adversely affected by certain geologies and soil moisture

¹² National Monuments Record for Wales (NMRW) in Wales

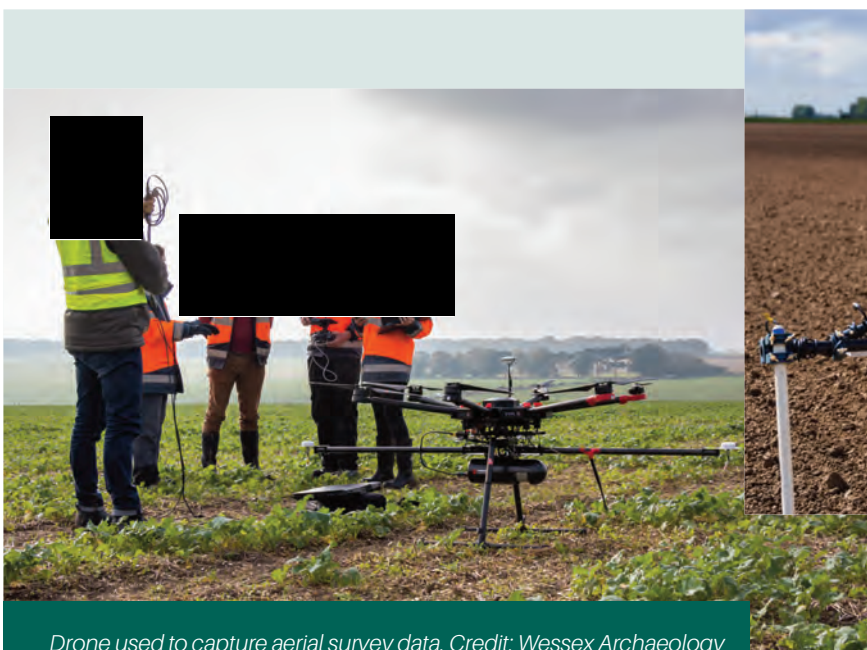
content. Speed and cost implications mean it is typically only used over targeted areas where additional information is desired.

- **Electromagnetic (EM) survey** measures complementary properties and can detect different features to magnetometry, and provide greater confidence where features are detected (or not detected) by both techniques. Most electromagnetic systems collect multiple depth measurements, allowing for the determination of coarse depth information. EM can be conducted over large areas, and when deployed simultaneously with magnetometry (ie, if mounted on the same platform), it can save time and money.

Other surveys

5.3.4 Developing a thorough understanding of the site through non-intrusive methods can help better target trial trenching at whatever stage it takes place. The techniques outlined below can provide additional information on the presence of archaeological remains.

- Topographical models can be created from **ground-based surveys, Lidar or aerial photography**. These can identify variations across the surface indicating the presence of extant archaeological remains, providing accurate measured data which can be used in GIS/topographic modelling. Observations from drone-acquired Lidar or photogrammetry can be combined with analytical earthwork survey to provide a more nuanced understanding of any archaeological earthworks present in the application area.
- **Multi-spectral and/or thermal imaging** can complement aerial photography and are used as tools to identify buried remains. They work by examining reflectance properties of vegetation and thermal properties of soils from an aerial or orbital platform. The effectiveness of these imaging techniques is dependent on the type of vegetation, soil moisture, seasonality and crop type/cover.
- The presence of archaeological materials in the topsoil may need to be assessed if topsoil is to be removed prior to construction. This can be undertaken through **fieldwalking**, which requires a site to be ploughed and harrowed to be effective. This method can identify evidence of ephemeral archaeological material such as



Drone used to capture aerial survey data. Credit: Wessex Archaeology



Geophysical survey being carried out. Credit: Magnitude Survey

lithic scatters or other early prehistoric activity. **Archaeological metal detecting** of topsoil can be used where appropriate, for instance if the presence of early medieval cemeteries, military camps/engagements, etc, is suspected. Both methods can be augmented by hand- or machine-dug test pits to better understand the volume and concentration of this material.

Trial trenching

5.3.5 Although these other techniques can provide information to build up a picture of the significance and potential of any archaeological remains sufficient to inform the decision-making process, it is likely that some level of trial trenching will be required to fully verify these results and provide information where other non-intrusive techniques don't work. This will provide a deeper understanding of date, depth and survival of the remains and assist with the final design process, so that areas containing archaeological material can be avoided or appropriately mitigated according to their significance.

Of particular importance in the case of solar farm development is to differentiate between those remains which are likely to be sensitive to only the more disruptive components of the scheme and those whose significance would be harmed by more localised ground disturbance such as that caused by panel supports. While some sensitive features such as buildings and ditches tend to be relatively easy to identify through geophysical survey, others such as burials may need to be inferred from metal detecting finds, landscape context or potential association with burial mounds etc. In these instances, intrusive work to test target areas will be required.

Some features such as enclosure ditches may be clearly visible on geophysical survey but the importance and sensitivity of the feature (and of associated features) may be unclear without intrusive investigation. Where features sit on the margins of former wetland, lapped by peat or alluvium which may have been a focus of activity such as fishing, salt making, burial or ritual deposition, these areas can have high preservation potential and sensitivity and should be a particular focus for intrusive investigations. Such cases are illustrative of the importance of deposit modelling and preservation assessment.

Trial trenching can also be used to test the presence of archaeology in areas where it has not been identified in previous non-intrusive surveys. It is not advisable to use this in all blank areas. There should be good reasons to have low confidence in the effectiveness of those previous methods and a high confidence that the frequency and distribution of trial trenches is sufficient to identify the types of features that an archaeological advisor believes may be present; trial trenching may be no more likely to identify small ephemeral sites or features than many of the non-intrusive methods outlined above.



Excavating an archaeological trial trench. Credit: Wessex Archaeology

6 MANAGING A SOLAR PROJECT LIFECYCLE

6.1 PREPARING FOR A DYNAMIC PROCESS

6.1.1 The following stages in the project lifecycle of a solar scheme have been identified and are explained as an aid to solar farm developers, archaeology advisors, planners, archaeological consultants and contractors. There will be variations to the lifecycle of different projects and there is no expectation that the following pathway will always be replicated. The series of steps is designed to indicate when a developer may seek advice from an archaeologist and when an archaeologist can expect certain data from a developer. The process is dynamic and the path from site selection through to an application being made has various points where a project could be dropped, paused or pursued.

6.2 SITE SELECTION

6.2.1 Developers identify sites based on grid capacity and availability, solar resource, landowner willingness, suitability of land and known planning or environmental constraints. Site identification may also be informed by policy. At this stage, various methods of ascertaining archaeological potential may be used (preliminary rapid appraisal). Grid connection applications are submitted and, if feasible, land rights are secured. These are key milestones: both are highly competitive and time-sensitive, often requiring significant early investment.



Site selection . Credit: Statkraft

6.3 PRE-APPLICATION

- 6.3.1 Step 1:** Land for a possible solar farm is identified as described in paragraph 6.2.1. Archaeological advice (from an archaeological consultant to the solar farm developer) at this stage may be provided in confidence and will be aimed at advising on feasibility. The intensity of research and advice will vary by project; the aim is to assess archaeological potential and identify risk, to enable an applicant to make informed decisions about whether to include/exclude particular pieces of land.
- 6.3.2 Step 2:** An indicative plan showing the possible layout of a proposal may be created and shared. Even at this early stage it is often possible to identify and label parts of the site which may be considered low or high disturbance:
- low disturbance: solar panel areas
 - high disturbance: substations and cable routes
- 6.3.3** At this stage, communication may be within the applicant's technical team however it is recommended that early contact is made with the local authority archaeology advisor and to discuss potential impacts and mitigation
- 6.3.4 Step 3:** It will usually be necessary to carry out a full desk-based archaeological assessment. Findings can inform a proposal and it may be that certain areas are now included/excluded on the basis of these findings. Communication with consultees should take place at this stage (prior to the start of the desk-based assessment (DBA)). This will ensure that appropriate methods of archaeological data-gathering are agreed and carried out. Often, the consultee will be the local planning authority archaeological advisor. This early collaboration helps improve the project and builds a good working relationship.
- 6.3.5 Step 4:** The results from the DBA and further design development enable initially identified areas of archaeological remains to be avoided and for non-intrusive surveys to be scoped, approved and carried out.
- 6.3.6 Step 5:** Combining the advice from the local planning authority archaeological advisor with archaeological data gathered via assessment and evaluation, and viewing both against the emerging proposals, ensures those proposals take account of all known archaeological data. This can be with a view to avoiding such remains and/or ensuring that they are located within lower-disturbance parts of the solar farm.

6.4 DETERMINATION

- 6.4.1** The applicant should provide the determining authority with information about the archaeological resource in the application area, the identified zones of sensitivity and the actions that will be taken to avoid or mitigate the archaeological impact of the development. This will be required to show that the archaeology, which is a material consideration in the determination of the application, has been fully considered and appropriate measures to avoid or mitigate the impact are included in the application.
- 6.4.2** The flexibility of solar farms creates opportunities for careful phrasing of planning conditions/DCO Requirements. This process could be best achieved through dialogue between the applicant and the relevant planning authority. Section 8 considers the types of information that it may be appropriate for the determining authority to include in conditions/Requirements – information that best captures the flexibility which solar farms have in terms of design, and the need for careful conservation of and/or mitigation of impact to archaeological remains.

6.5 PRE-COMMENCEMENT

- 6.5.1** Consent for the scheme is issued subject to conditions including ‘pre-commencement’, ie, those which must be met before development can begin, ensuring that the details of certain aspects of works are addressed and approved before being implemented. Such conditions can include further non-intrusive and intrusive archaeological evaluations. They will also generally stipulate an appropriate methodology for mitigation (often based on the outcome of evaluation works). Procurement and construction sequencing should allow sufficient time for pre-commencement trial trenching to take place, be reported on, and the results reviewed by the advisors; and for any results to then inform design changes and other forms of avoidance or mitigation.
- 6.5.2** The scope of archaeological works is often stipulated in a brief issued by the archaeology advisor to the relevant planning authority. A project design will be required to respond to the scope of archaeological works stipulated, setting out the methodology for undertaking them. The project design should be approved by the planning authority advisors prior to commencement. Briefs may set out further evaluation and/or mitigation options. Specific arrangements should be made with the relevant planning authority to ensure the condition of consent is correctly fulfilled and making reference to relevant national and regional research frameworks.

6.6 CONSTRUCTION

- 6.6.1** Construction may proceed with archaeological mitigation (if needed). Mitigation may be secured as part of a wider archaeological management plan and be overseen by an archaeological clerk of works, as appropriate. In other cases, archaeological fieldwork will have been completed by this stage.

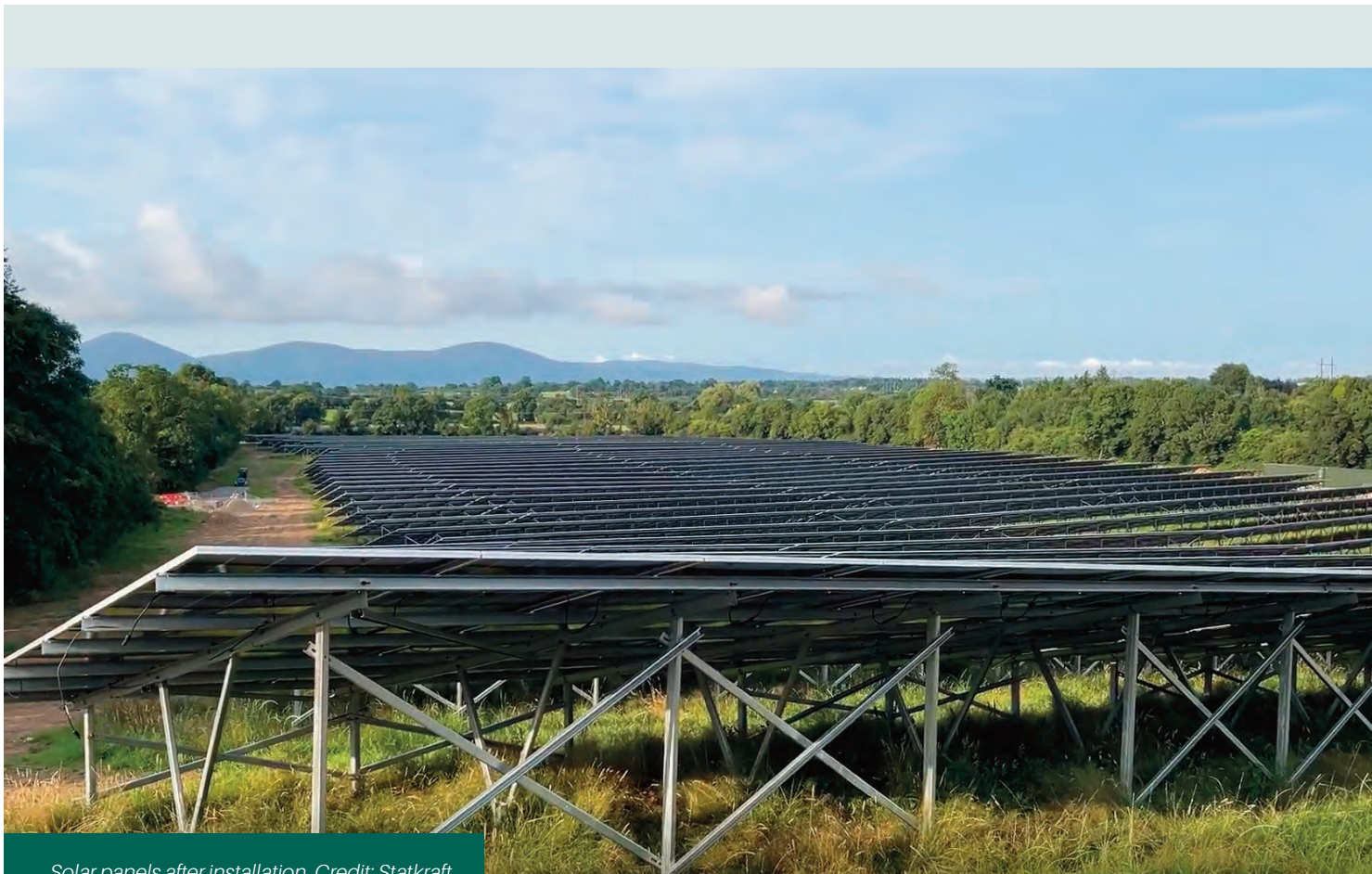


Panel supports and framing, during construction . Credit: Statkraft

6.7 OPERATION

- 6.7.1** Future innovation of generating infrastructure or repair and maintenance work may necessitate changes during the operational lifetime of a solar farm. On sites where conservation of archaeological remains has been secured through avoidance of their location beneath an area of solar panels, their presence should be recorded (for example within an archaeological management plan). Mechanisms for ensuring that any future maintenance/upgrading work does not impact these remains should be included in relevant approved management plans and project documentation.
- 6.7.2** The main public benefit of solar farm construction is the supply of clean, renewable energy. However, the dissemination of archaeological information (eg through the publication of archaeological fieldwork results and public engagement) is also a public benefit. There are various ways such information can reach the public. For example, where public access around sites is facilitated by footpaths, these footpaths could be utilised to provide informative signage describing archaeological findings, and using these to contextualise the history of energy transitions and the landscape.
- 6.7.3** There are many other opportunities for increasing the public benefit of solar farms and these are explored in more detail in relevant sector guidance.¹³

¹³ CIFA 2023 *Toolkit for Public Engagement* (accessed 28 October 2025)



Solar panels after installation. Credit: Statkraft

6.8 DECOMMISSIONING

- 6.8.1** There are currently no reliable, accessible studies on the impact of the decommissioning of a solar farm upon buried archaeology. As this document is prepared, studies are being supported related to projects which may provide the first reliable data in the UK on this topic. This will be invaluable, as decommissioning is clearly of vital importance to ensuring that remains subject to low impact at the construction stage do not experience greater impacts at the decommissioning stage. These studies should inform future iterations of this guidance.

6.9 BEYOND THE PROJECT LIFECYCLE - KNOWLEDGE SHARING

- 6.9.1** Knowledge sharing between parties in the process of solar farm development is important because solar farms remain an emerging and rapidly developing type of development. Sharing knowledge on a regular cycle, to help ensure good practice is continually shared and understandings evolve, may be best achieved through a website dedicated to collecting and sharing case studies which illustrate different aspects of good practice. Through the application of the good practice described in this guide and through the evolution of new solar farm designs and new archaeological techniques, we can look forward to the development of even better solutions in the future.
- 6.9.2** To further build rapport and deepen understanding, it may be beneficial for site developers or operators to offer site tours to archaeological advisors so they can, for example, observe the process of construction. Solar farm developers, equally, could be offered opportunities to visit archaeological sites during investigation, to observe the archaeological process.

6.10 BEYOND THE PROJECT LIFECYCLE - DESIGN AND INNOVATION

- 6.10.1** The solar energy sector is maturing in a dynamic environment, with new technology and new approaches likely to develop. Those new technologies will feed back into the cycle as new sites are searched for and scoped for development.
- 6.10.2** There are opportunities for both sectors to work together to design more effective investigation, mitigation, construction and decommissioning methods. Additionally, innovation and design changes may evolve during the construction of the current generation of consented and in-progress schemes. It is vital that developers and their consultants can adequately explain the possible impacts of any of these changes, with reference to the current understanding as set out in this guide and any scheme-specific documentation.

7 UNDERSTANDING THE KEY ELEMENTS OF SOLAR PROJECTS - PRE-DETERMINATION AND PRE-SUBMISSION CHECKLIST FOR APPLICATIONS

7.1 CHECKLIST (ILLUSTRATIVE EXAMPLE)

- 7.1.1** Information similar to the following should be provided to the archaeological advisor with a plan showing the location/s of the items listed. The earlier this is provided, the earlier the advisor can understand the level of impact a proposal may have upon archaeological significance, and advise accordingly. The number and type of rows and columns in this table will differ between projects.
- 7.1.2** If the location and dimensions of elements of the solar farm are not known/cannot be stated, as much detail as possible should be provided. Depth and spatial extent are particularly useful as these determine the size of proposed ground disturbance in physical terms, which is one of the key concerns with archaeological deposits. What matters most is clearly stating the depth and spatial extent of ground disturbance that could affect archaeological remains. Providing this key information early helps enable meaningful discussions with archaeological advisors. Additional details should be shared as they become available, as part of ongoing communication.



Indicative depth of a cable trench. Credit: Pre-Construct Archaeology



CCTV post installation. Credit: Pre-Construct Archaeology



*Perimeter fence and CCTV cable trench.
Credit: Pre-Construct Archaeology*

Table 1 Pre-determination and pre-submission checklist for applicants

Function of infrastructure	Construction activity of relevance to archaeology (text below is for reference only)	Depth of ground disturbance (mm) and description of work (text below is for reference only)	Location and description of flexibility (text below is for reference only)
Temporary construction compound	Enabling works	There will be two construction compounds. One will be xx m by xx m and the other will be xx m by xx m. Both will be stripped to a depth of xxx mm.	Zone X, medium flexibility.
Temporary equipment storage area		Equipment will be stored within the construction compounds.	Zone X, low options for re-siting. No-dig options possible.
Solar farm	Solar farm (an array of ground-mounted solar panels)	Supports for the solar arrays will be inserted xxxx-xxxx mm into the ground. However, in identified archaeologically highly sensitive zones, panels could be surface mounted – ie, only non-intrusive array supports used and all cabling in cable trays above ground.	Solar arrays in zones X-Y highly flexible micro-siting options.
Battery energy storage system (BESS)	Battery energy storage system (BESS)	Containers to be placed on concrete slab/s. Formation depth likely to be xxx-xxx mm. Spatial extent xx m – xx m.	
Ancillary infrastructure	Substation	Concrete slab/s. Formation depth likely to be xxx –xxx mm. Spatial extent xx m x xx m.	
	Inverters (mounted behind the solar panels)	No impact as the inverters are mounted to the back of the panels and do not touch the ground.	
	Transformer units	Transformer, x.x m x x.x m. Built off xxx mm plinth, surface mounted. Some levelling of the surface may occur. This is likely to be up to xxx mm deep.	
Cables	Cable runs between rows of panels	These will be surface mounted in trays for the most part. There may be some cables (running to the transformers) which need undergrounding (tbc).	
Cable route to grid	Cable trench	We anticipate that it would be in the region of 800mm wide and xxx-xxxx mm deep.	
	Width and depth of easement of cable	We anticipate that there will be no easement in this case.	
	POC mast CSE compound	Variable but parts up to xxxx mm.	
	Point of connection	Variable but parts up to xxxx mm.	

Function of infrastructure	Construction activity of relevance to archaeology <i>(text below is for reference only)</i>	Depth of ground disturbance (mm) and description of work <i>(text below is for reference only)</i>	Location and description of flexibility <i>(text below is for reference only)</i>
Roads and tracks	Main access road	For the main road in/out, an allowance for xxx mm depth should be made = xxx mm of stone, xxx mm of tarmac.	
Roads and tracks	Maintenance track (construction- and maintenance-related tracks)	Where new, the track will be xxx mm deep, where existing, no change.	
Landscaping	There are stretches of new hedgerow being proposed	Cultivation to xxx mm below existing ground level, potential root penetration below xxx mm in due course.	Site edges. Low flexibility, but subject to design decisions.
	There are several separate (small) areas of tree planting being proposed	Cultivation to xxx mm below existing ground level, potential root penetration below xxx mm in due course.	
	There is a proposed area of scrub planting	Cultivation to xxx mm below existing ground level, potential root penetration below xxx mm in due course.	
	There are areas of proposed wildflower meadow	Cultivation xxx mm below EGL.	
Ecology	Habitat compensation or enhancement areas	Cultivation to xxx mm depth and potential root penetration, soil inversion and topsoil strip.	Unknown at this stage. Subject to ecological evaluation.
Drainage	There is a proposed drainage basin proposed in the south-western part of the site	The basin would be x.x m deep.	
	Swales	There are swales for drainage; these would be xxx –xxx mm deep.	
Fencing	Fencing around the solar farm	Posts would be xxx mm by xxx mm and the posts would be driven xxx mm deep. They would be spaced x.x m apart.	Site edges. Low flexibility.
	Fencing around the BESS	Posts would be xxx mm x xxx mm and the posts would be driven xxxx mm deep. They would be spaced x.x m apart.	
CCTV	Post	TBC – likely to be narrow poles (approx. xxx mm by xxx mm); would be inserted xxx mm deep.	
Satellite dish post	Post	TBC – likely to be narrow poles (approx. xx mm by xx mm); would be inserted xxx mm deep.	
Lighting	Post	TBC – spaced at intervals around fenced areas in substation.	

8 DEVELOPING APPROPRIATE PLANNING CONDITIONS/DCO REQUIREMENTS

8.1 A NEED FOR APPROPRIATE CONDITIONS/DCO REQUIREMENTS

- 8.1.1** The decision maker needs to be confident that the planning balance struck at the point of decision can be secured through a process of archaeological understanding and appropriate mitigation and design. Because of the particular characteristics of solar schemes, decisions can often be made where investigations are on-going and design remains flexible. As such, the utilisation of planning conditions as part of a consent can be particularly important.
- 8.1.2** The following sections do not present ‘model’ conditions (or the equivalent). They instead include a diagram and associated text to help those drafting conditions to consider the process of framing conditions (or equivalent), their timing within the process, and some of the considerations that might need to be incorporated at each stage (eg, pre-commencement). For simplicity, the word ‘conditions’ has been used in this document to represent all such measures to secure the public interest in archaeological matters (eg, under the Planning Act 2008 these would be Requirements for a DCO).
- 8.1.3** Like many planning considerations, archaeology should be iterative, with each stage of work informing the next. Where a phase of post-determination investigation work discovers new archaeological information, this should inform any further work. This iterative process requires a mechanism in the condition to allow new information and understanding to supplement what was known at the time of consent, and conditions are a key tool to secure work post consent. The condition mechanism should enable staged investigation and mitigation linked to development phases.
- 8.1.4** These sections are not intended to be comprehensive (or prescriptive), rather they act as a guide to everyone involved in solar farm development. They should reinforce understanding of the type of archaeological works that are needed (and why) at each stage, and the effect that relevant information has on the type and number of conditions attached to any permission. Information provided pre-determination helps to increase confidence (and reduces risk) on all sides, reduces the number and complexity of conditions attached, and reduces the need for pre-commencement conditions. Conversely, some work may be more appropriately undertaken post-determination, to inform the final designs and scope of construction impacts.
- 8.1.5** This section does not cover the rationale for objection to consent, nor explicitly consider management during lifespan or decommissioning. Where these elements need to be addressed, we would expect this to be covered by relevant documents such as the Operational Environment Management Plan or a Decommissioning Environment Management Plan.
- 8.1.6** Where other types of work which might have an impact on archaeological remains are required post-determination (for instance for engineered or ecological solutions), the specifications or methodologies for these works should be informed by the results of the surveys carried out under the project designs (for example, ensuring that replacement badger setts are not located in areas of significant archaeological remains).

8.2 PROCESS FOR IDENTIFYING POSSIBLE CONDITIONS

- 8.2.1** This process figure (see below) contains decision points (diamonds) and actions (boxes) that contain the types of condition that may be required. Further explanation is given in the subsequent paragraphs. The process is designed to focus on what types of document and associated actions should be conditioned. It also groups the process into two parts, those actions/conditions that are likely to be ‘pre-commencement’, and those that are likely to be for ‘implementation prior to coming into use’ (which can also include other timescales, such as ‘within XX years of completion of fieldwork’). This is an important distinction as pre-commencement conditions have a major impact on project timescales and should be agreed with an applicant in advance of consent and clearly understood by all sides.
- 8.2.2** The type and number of conditions, and the timing of their implementation, is dependent on the amount of information available at the point of consent. Conditions can also be designed to be actioned at different phases of development. It is good practice to ensure that relevant paragraphs of specific planning policy/guidance are referenced for each condition.
- 8.2.3** The suggestions made in this section are not exhaustive and there may be other types of condition and timescales that are necessary or useful. Those drafting these conditions should also be mindful of existing best practice advice on writing sound conditions.^{14 15}

¹⁴ For example, *Planning Advisory Service: Effective Use of Conditions*

¹⁵ In Northern Ireland, please see guidance on standard conditions included in *Development and Archaeology: Guidance on Archaeological Works in the Planning Process* (DfC 2019).

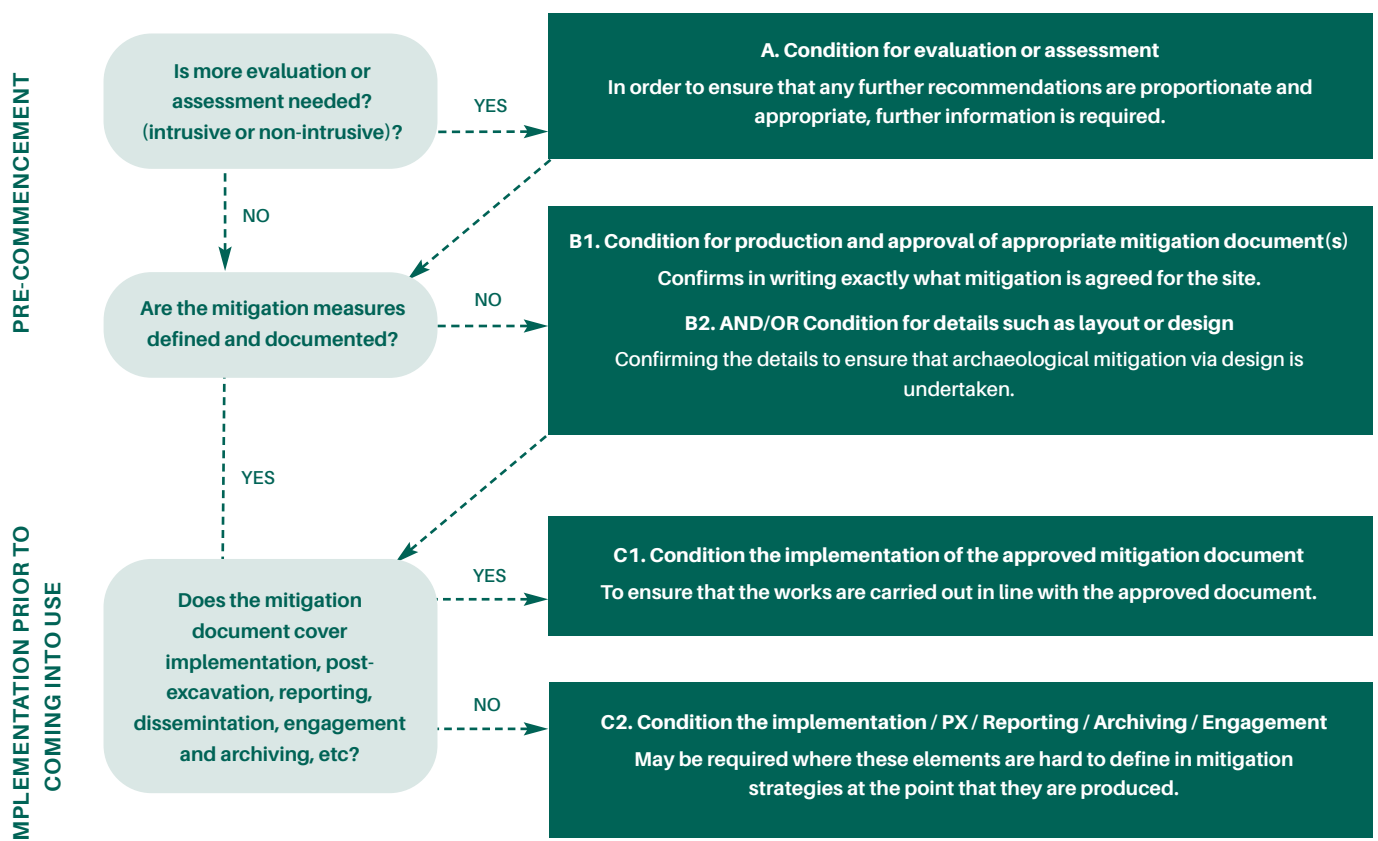


Figure 1 Process for decision making when applying conditions (detailed information on conditions in subsequent pages)

A. Condition for evaluation or assessment

The purpose of this pre-commencement condition is to ensure that requirements for further archaeological work to inform design refinement and detailed archaeological mitigation are secured. A condition might include the following points:

- the work should take place pre-commencement
- a draft written scheme of investigation (WSI) should be produced
- the WSI/Project Design will need to be approved (by archaeological advisor/statutory consultee and/or Planning Authority)
- all archaeological work should be undertaken in line with the approved WSI
- the work may need to be phased (eg, geophysical survey in previous no-access areas and then archaeological evaluation)
- post-excavation assessment and reporting should be undertaken after the fieldwork

Alongside this, separate condition(s) may be needed to cover further archaeological mitigation

B1. Condition for production of appropriate mitigation document(s)

The purpose of this condition is to confirm in writing exactly what mitigation is agreed for the site so that it can be approved. This needs to be pre-commencement to ensure that design of the development takes account of the results of the archaeology works, and that mitigation plans are properly designed prior to commencement of development. May include areas where impacts are managed through design, as well as those for archaeological investigation. A condition might include the following points:

- the work should take place pre-commencement
 - a document should be produced (eg, archaeological mitigation strategy, WSI/Project Design, overarching WSI, ongoing management plan) and approved
 - the document may require cross-referencing with other documents (eg, Construction Environmental Management Plan)
 - the document should include an agreed process for updating the document(s)
-

B2. AND/OR condition for details such as layout or design

The purpose of this condition is to confirm the details to ensure that archaeological mitigation via scheme layout/design is undertaken as agreed. This needs to be pre-commencement to ensure that design of the development takes account of the results of the archaeology works, and that mitigation plans are properly designed and approved prior to commencement of development. A condition might include the following points:

- the archaeological work should take place pre-commencement

- detailed layout or design should be provided
 - timescales may need to be phased as specific design elements are finalised
 - it may be cross-referenced to other documents or a specific plan
-

C1. Condition the approved mitigation document

The purpose of this condition is to ensure that the works are carried out in line with the approved document and prior to the commencement of the development. It may require:

- a document (eg, archaeological mitigation strategy, WSI, overarching Project Design) to be implemented
 - production of other WSIs (eg, for phases or areas)
 - timescales to be PHASED; conditions could be worded to allow documents and archaeological works to be approved and undertaken in phases, without needing to cover the entire scheme at once
 - sometimes to be combined with conditions in B (above)
 - a timescale, (eg, before the development is brought into its intended use)
 - cross-referencing with other documents
 - inclusion of details on implementation, including post-excavation, reporting and archiving, but this is often a separate condition, see C2.
-

C2. Condition the implementation/post-excavation/reporting/archiving/engagement

This condition may be required where these elements are hard to define in mitigation strategies at the point that they are produced, and/or where the scope and extent of those activities and the information they will produce are difficult to predict.

- it requires a timescale, (eg, before the development is brought into its intended use or within XX years of fieldwork being completed, or in line with the timescales described in the post-excavation assessment and project design)
- it may be used in addition to any of the conditions above

9 FURTHER READING

9.1 POLICY BACKGROUND

Department for Energy Security & Net Zero, 2025 *Overarching National Policy Statement for energy (EN-1)*. March 2025

Department for Energy Security & Net Zero, 2025 *National Policy Statement for Renewable Energy Infrastructure (EN-3)*. March 2025

Llywodreath Cymru: Welsh Government, 2024 *Planning Policy Wales*. Edition 12. February 2024

Ministry of Housing, Communities and Local Government, 2024 *National Planning Policy Framework*

The Northern Ireland Executive, 2025 *Strategic Planning Policy Statement*, Edition 2, December 2025

9.2 NATIONAL HERITAGE AGENCY GUIDANCE

Historic England, 2021 *Commercial Renewable Energy Development and the Historic Environment*. Historic England Advice Note 15

9.3 CHARTERED INSTITUTE FOR ARCHAEOLOGISTS STANDARDS AND GUIDANCE

Standard and guidance for archaeological advice by historic environment services

Standard and guidance for the creation, compilation, transfer and deposition of archaeological archives

Standard and guidance for commissioning work or providing consultancy advice on archaeology and the historic environment

Standard and guidance for the collection, documentation, conservation and research of archaeological materials

Standard and guidance for archaeological geophysical survey

Standard and guidance for the archaeological investigation and recording of standing buildings or structures

Standard and guidance for forensic archaeologists

Standard and guidance for historic environment desk-based assessment

Standard and guidance for nautical archaeological recording and reconstruction

Standard and guidance for stewardship for the historic environment

Standard and guidance: appendices

9.4 REPORTS FOCUSED ON ARCHAEOLOGICAL EVALUATION

Chartered Institute for Archaeologists, 2022 *Evaluation Strategies (Evals 1): understanding current practice and encouraging sector engagement*. Report and recommendations. August 2022. 70078423-ARC

9.5 PUBLIC BENEFIT OF ARCHAEOLOGY

CIfA, 2023 *Toolkit for Public Engagement*. Version 1.0 (September 2023).

9.6 CONSIDERING ARCHAEOLOGY IN A DEVELOPMENT CONTEXT

CIRIA. 2021 *Archaeology and Construction: good practice guidance* (C799D)

Department for Communities, 2019 *Development and Archaeology: Guidance on Archaeological Works in the Planning Process*.

Historic England, 2016 *Preserving Archaeological Remains. Decision-taking for sites under development*.

IEMA, CIfA and IHBC, 2021 *Principles of Cultural Heritage Impact Assessment*.

9.7 HERITAGE WITHIN THE PLANNING SYSTEM (RESEARCH)

DRP Archaeology, H Morel and D Phillips, 2021 *The Heritage Dimension of Commercial Renewable Energy Development in Planning*.

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