Appendix C: PDP Glint and Glare Assessment

PATTLE DELAMORE PARTNERS LTD
Level 2, 134 Oxford Terrace
Christchurch Central, Christchurch 8011
PO Box 389, Christchurch 8140, New Zealand

Office +64 3 345 7100
Web www.pdp.co.nz

solutions for your environment

memorandum

TO	Rā Tuatahi No. 1 Limited	FROM	Isobel Stout
		DATE	22 July 2024
RE	Reflected light (glare and glint) effects (updated proposal)		

Rā Tuatahi No. 1 Limited propose a solar farm of approximately 10 ha on flat farmland at 80 Struie Road, Hororata. This is a smaller area than originally proposed, however the approach to assessment and the conclusions remain the same.

This memo sets out the findings of an investigation into the actual and potential reflected sunlight effects from the photovoltaic panels of the proposal.

Background to assist in understanding the adverse effects of reflected light

Reflected sunlight can significantly affect nearby receptors under particular conditions. The key receptors with respect to reflected sunlight from a solar farm are residents in surrounding dwellings, road users, and aviation infrastructure (including pilots and air traffic controllers). The words glare and glint are used to describe two different effects of reflected sunlight:

- Glint is a momentary flash of bright light caused by either the observer or the source moving at some speed. In this context glint may be experienced from a photovoltaic (PV) panel by a passing motorist.
- Glare is a steady source of bright light experienced by a static receptor. In this context sunlight reflected from the panels may illuminate a dwelling for some part of the day.

The reflective properties of solar photovoltaic (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 reflected sunlight.

Solar farm proposal at 80 Struie Road.

PDP have used ‘Forge Solar’ a programme specifically designed for the assessment of glare from PV arrays and used globally by many jurisdictions to satisfy regulatory requirements including those of the FAA and EU.

The modelling software allows for the ‘mapping’ of relevant observation points such as dwellings, public roads and obstructions such as plantations/shelter belts. It takes geographic information such as ground level and terrain from Google Earth although coordinates can be entered manually.

Details include the panel’s tracking ability and height above the ground. Two reports from the model are attached and full details on the input data can be obtained on request.

1. The glare potential on seven receptor dwellings
2. Two indicative hot air balloon paths crossing directly over the site

Principal variables used in the model.

1 The solar panels are mounted on a rail that allows them to pivot. This is approximately 1.5m high. The panels only track the sun in one plane, east to west which is called single tracking. They can tilt up to 60 degrees on either side.

2 Seven dwellings have been identified on the basis that they may have line of sight to the panels. This has not been assessed on the ground for the purposes of the modelling. It is likely that in many cases there are windbreak hedges and other objects that may obscure some or all of the view of the panels. Further information on the visual effects of the proposal and the views from receptors towards the panels is contained in the landscape assessment conducted by others.

The seven nearest dwellings are marked on the plan used for the modelling. They are:

1. 2152 Bealey Road (Ballooning Canterbury is at 2126 Bealey Road, immediately to the east)
2. 44 Struie Road
3. 66 Struie Road
4. 90 Struie Road
5. 106 Struie Road
6. 132 Struie Road
7. 134 Struie Road

3 Two indicative flight paths have been modelled over the solar panels, one north-south and one east-west to test if a balloon flight at a nominal 200m above ground level would experience glare. This was chosen in case the ballooning company at 2126 Bealey Road may ever fly over or in proximity to the panels.

4 No other features such as plantations or hedge rows were mapped in order to give a 'worst case scenario' with no shielding. This additional work and assessment can be done should initial results indicate a glare issue, and the model needs further refinement.

Results

The result of two runs of the original model are attached. Neither the fly over model nor the dwellings model showed any glare at any time to any observer. This would remain the same from the smaller area of arrays now planned.

This is largely due to the single axis tracking used by this solar farm. PDP did run both models with dual axis tracking as a comparison and this did show that one residential location may have experienced some low-level glare late in the day in winter for a few minutes each day. A flight over the panels at 200m above ground level may also have experienced some glare but this would be from around 10.30 am to 2:30 pm in winter. The balloon flights are all early morning starts from around 6 am and tend to have finished at around 10:30 am. Balloon take offs, flight paths and landing sites take place at various locations chosen dependant upon weather conditions.

The solar farm may well be visible from some residential properties but there is very little chance of any reflected sunlight from the PV panels being noticeable to anyone in or around those dwellings. No effect of reflected sunlight, adverse or otherwise, is expected.

As the results of the model showed that there was no glare to be experienced at the dwelling, there would also be no glint experienced by users of Struie Road which is even further away from the proposal.

Prepared by

Isobel Stout

Service Leader – Environmental Science

Reviewed and approved by

Hamish Peacock

Group Director Planning

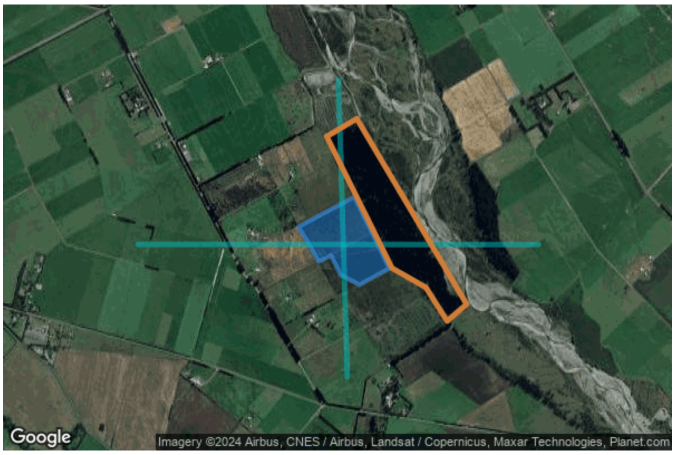
ForgeSolar

Hororata solar farm

Fly over 200m single axis shade

Created Dec 12, 2023
Updated Jan 19, 2024
Time-step 1 minute
Timezone offset UTC12
Minimum sun altitude 0.0 deg
Site ID 107700.18668

Project type Advanced
Project status: active
Category 5 MW to 10 MW



Misc. Analysis Settings

DNI: **varies (1,000.0 W/m^2 peak)**
Ocular transmission coefficient: **0.5**
Pupil diameter: **0.002 m**
Eye focal length: **0.017 m**
Sun subtended angle: **9.3 mrad**

PV Analysis Methodology: **Version 2**
Enhanced subtended angle calculation: **On**

Summary of Results

Glare with low potential for temporary after-image predicted

PV Name	Tilt	Orientation	"Green" Glare	"Yellow" Glare	Energy Produced
	deg	deg	min	min	kWh
PV array 1	SA tracking	SA tracking	299,965	0	-

Component Data

PV Array(s)

Total PV footprint area: 162,779 m^2

Name: PV array 1
Footprint area: 162,779 m^2
Axis tracking: Single-axis rotation
Backtracking: Shade
Tracking axis orientation: 180.0 deg
Maximum tracking angle: 60.0 deg
Resting angle: 60.0 deg
Ground Coverage Ratio: 0.5

Rated power: -
Panel material: Smooth glass without AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 6.55 mrad

Vertex	Latitude deg	Longitude deg	Ground elevation m	Height above ground m	Total elevation m
1	-43.539581	172.001404	180.00	1.50	181.50
2	-43.537916	172.005696	179.00	1.50	180.50
3	-43.541898	172.008399	176.00	1.50	177.50
4	-43.542816	172.006082	176.00	1.50	177.50
5	-43.542271	172.004644	177.00	1.50	178.50
6	-43.541183	172.003915	178.00	1.50	179.50
7	-43.541509	172.002970	178.00	1.50	179.50

Route Receptor(s)

Name: Route 1 N-S
Route type Two-way
View angle: 50.0 deg

Vertex	Latitude deg	Longitude deg	Ground elevation m	Height above ground m	Total elevation m
1	-43.531398	172.004472	184.00	200.00	384.00
2	-43.547964	172.005159	172.00	200.00	372.00

Name: Route 2 E-W
Route type Two-way
View angle: 50.0 deg

Vertex	Latitude deg	Longitude deg	Ground elevation m	Height above ground m	Total elevation m
1	-43.540561	171.989044	181.00	200.00	381.00
2	-43.540576	172.019879	172.00	200.00	372.00

Obstruction Components

Name: shelter belt
Upper edge height: 25.0 m

Vertex	Latitude	Longitude	Ground elevation
	deg	deg	m
1	-43.534543	172.003570	182.85
2	-43.533547	172.005887	182.00
3	-43.543907	172.014342	172.00
4	-43.544840	172.012839	172.00
5	-43.542974	172.011209	174.00
6	-43.541885	172.008591	176.00
7	-43.534543	172.003570	182.85

Summary of PV Glare Analysis

PV configuration and total predicted glare

PV Name	Tilt deg	Orientation deg	"Green" Glare min	"Yellow" Glare min	Energy Produced kWh	Data File
PV array 1	SA tracking	SA tracking	299,965	0	-	-

Distinct glare per month

Excludes overlapping glare from PV array for multiple receptors at matching time(s)

PV	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
pv-array-1 (green)	27551	23572	22295	18455	16203	14677	15738	18022	20739	24404	26174	28252
pv-array-1 (yellow)	0	0	0	0	0	0	0	0	0	0	0	0

PV & Receptor Analysis Results

Results for each PV array and receptor

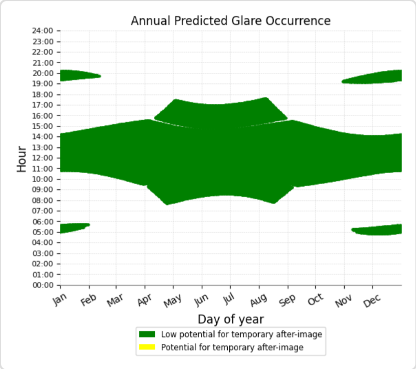
PV array 1 low potential for temporary after-image

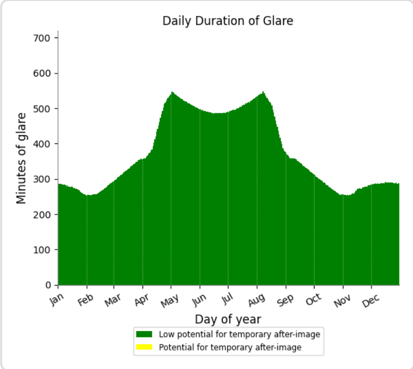
Component	Green glare (min)	Yellow glare (min)
Route: Route 1 N-S	137148	0
Route: Route 2 E-W	162817	0

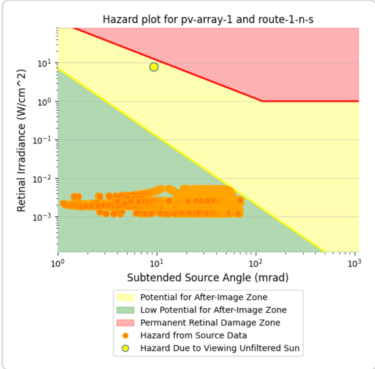
PV array 1: Route 1 N-S

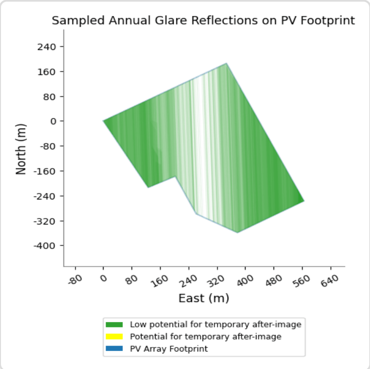
PV array is expected to produce the following glare for this receptor:

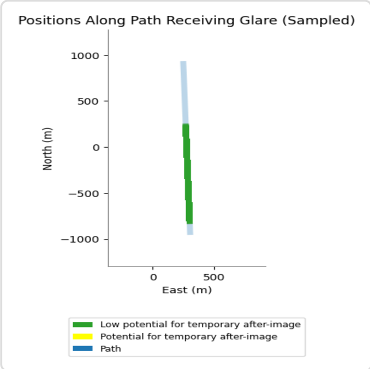
- 137,148 minutes of "green" glare with low potential to cause temporary after-image.
- 0 minutes of "yellow" glare with potential to cause temporary after-image.







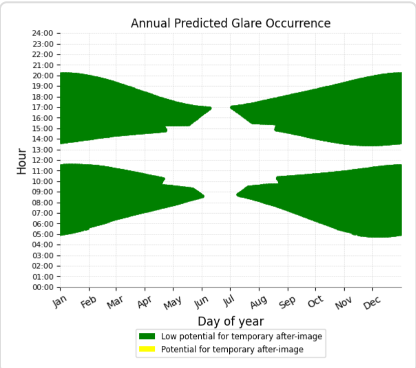


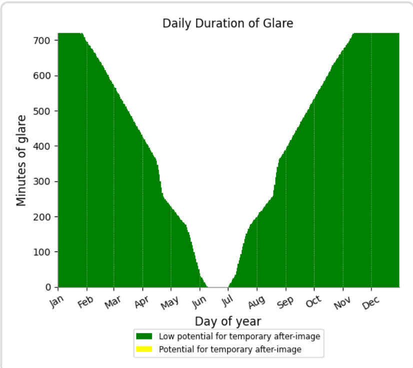


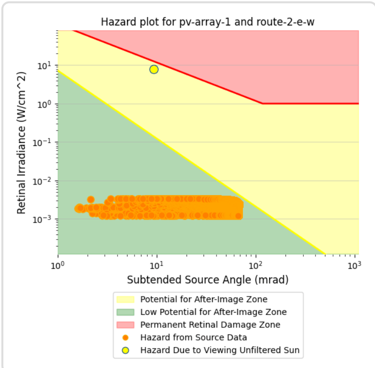
PV array 1: Route 2 E-W

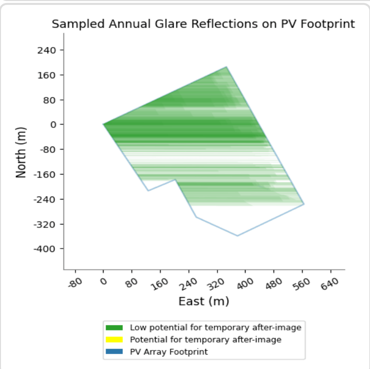
PV array is expected to produce the following glare for this receptor:

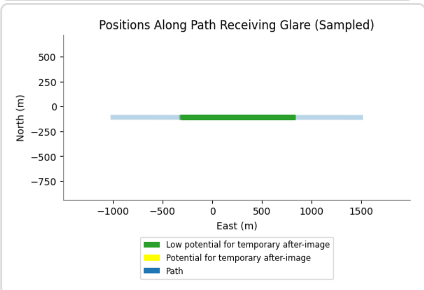
- 162,817 minutes of "green" glare with low potential to cause temporary after-image.
- 0 minutes of "yellow" glare with potential to cause temporary after-image.











Assumptions

- Times associated with glare are denoted in Standard time. For Daylight Savings, add one hour.
- Glare analyses do not automatically account for physical obstructions between reflectors and receptors. This includes buildings, tree cover and geographic obstructions.
- Detailed system geometry is not rigorously simulated.
- The glare hazard determination relies on several approximations including observer eye characteristics, angle of view, and typical blink response time. Actual values and results may vary.
- The system output calculation is a DNI-based approximation that assumes clear, sunny skies year-round. It should not be used in place of more rigorous modeling methods.
- Several V1 calculations utilize the PV array centroid, rather than the actual glare spot location, due to algorithm limitations. This may affect results fo large PV footprints. Additional analyses of array sub-sections can provide additional information on expected glare.
- The subtended source angle (glare spot size) is constrained by the PV array footprint size. Partitioning large arrays into smaller sections will reduce the maximum potential subtended angle, potentially impacting results if actual glare spots are larger than the sub-array size. Additional analyses of the combined area of adjacent sub-arrays can provide more information on potential glare hazards. (See previous point on related limitations.)
- Hazard zone boundaries shown in the Glare Hazard plot are an approximation and visual aid. Actual ocular impact outcomes encompass a continuous, not discrete, spectrum.
- Glare locations displayed on receptor plots are approximate. Actual glare-spot locations may differ.
- Refer to the **Help page** for detailed assumptions and limitations not listed here.

ForgeSolar

Hororata solar farm

single tracking all dwellings

Created Jan 19, 2024
Updated Jan 19, 2024
Time-step 1 minute
Timezone offset UTC12
Minimum sun altitude 0.0 deg
Site ID 110006.18668

Project type Advanced
Project status: active
Category 5 MW to 10 MW

Misc. Analysis Settings

DNI: **varies (1,000.0 W/m^2 peak)**
Ocular transmission coefficient: **0.5**
Pupil diameter: **0.002 m**
Eye focal length: **0.017 m**
Sun subtended angle: **9.3 mrad**

PV Analysis Methodology: **Version 2**
Enhanced subtended angle calculation: **On**

Summary of Results No glare predicted!

PV Name	Tilt deg	Orientation deg	"Green" Glare min	"Yellow" Glare min	Energy Produced kWh
PV array 1	SA tracking	SA tracking	0	0	-

Component Data

PV Array(s)

Total PV footprint area: 164,760 m^2

Name: PV array 1
Footprint area: 164,760 m^2
Axis tracking: Single-axis rotation
Backtracking: Shade
Tracking axis orientation: 180.0 deg
Maximum tracking angle: 60.0 deg
Resting angle: 60.0 deg
Ground Coverage Ratio: 0.5

Rated power: -
Panel material: Smooth glass without AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 6.55 mrad

Vertex	Latitude deg	Longitude deg	Ground elevation m	Height above ground m	Total elevation m
1	-43.541488	172.002802	178.00	1.50	179.50
2	-43.541092	172.003896	178.00	1.50	179.50
3	-43.542180	172.004636	177.00	1.50	178.50
4	-43.542826	172.006053	176.00	1.50	177.50
5	-43.541908	172.008424	176.00	1.50	177.50
6	-43.539886	172.007222	178.00	1.50	179.50
7	-43.537989	172.005591	179.00	1.50	180.50
8	-43.539591	172.001343	180.00	1.50	181.50
9	-43.541543	172.002759	178.00	1.50	179.50

Discrete Observation Receptors

Number	Latitude deg	Longitude deg	Ground elevation m	Height above ground m	Total Elevation m
OP 1	-43.548457	172.007755	172.00	1.00	173.00
OP 2	-43.544849	172.002476	175.00	1.50	176.50
OP 3	-43.543449	172.000717	177.00	1.50	178.50
OP 4	-43.542018	171.998228	178.00	1.00	179.00
OP 5	-43.539696	171.997880	180.00	1.00	181.00
OP 6	-43.538538	172.001184	180.00	0.00	180.00
OP 7	-43.536422	172.000894	183.00	1.50	184.50

Summary of PV Glare Analysis

PV configuration and total predicted glare

PV Name	Tilt deg	Orientation deg	"Green" Glare min	"Yellow" Glare min	Energy Produced kWh	Data File
PV array 1	SA tracking	SA tracking	0	0	-	-

PV & Receptor Analysis Results

Results for each PV array and receptor

PV array 1 no glare found

Component	Green glare (min)	Yellow glare (min)
OP: OP 1	0	0
OP: OP 2	0	0
OP: OP 3	0	0
OP: OP 4	0	0
OP: OP 5	0	0
OP: OP 6	0	0
OP: OP 7	0	0

No glare found

Assumptions

- Times associated with glare are denoted in Standard time. For Daylight Savings, add one hour.
- Glare analyses do not automatically account for physical obstructions between reflectors and receptors. This includes buildings, tree cover and geographic obstructions.
- Detailed system geometry is not rigorously simulated.
- The glare hazard determination relies on several approximations including observer eye characteristics, angle of view, and typical blink response time. Actual values and results may vary.
- The system output calculation is a DNI-based approximation that assumes clear, sunny skies year-round. It should not be used in place of more rigorous modeling methods.
- Several V1 calculations utilize the PV array centroid, rather than the actual glare spot location, due to algorithm limitations. This may affect results fo large PV footprints. Additional analyses of array sub-sections can provide additional information on expected glare.
- The subtended source angle (glare spot size) is constrained by the PV array footprint size. Partitioning large arrays into smaller sections will reduce the maximum potential subtended angle, potentially impacting results if actual glare spots are larger than the sub-array size. Additional analyses of the combined area of adjacent sub-arrays can provide more information on potential glare hazards. (See previous point on related limitations.)
- Hazard zone boundaries shown in the Glare Hazard plot are an approximation and visual aid. Actual ocular impact outcomes encompass a continuous, not discrete, spectrum.
- Glare locations displayed on receptor plots are approximate. Actual glare-spot locations may differ.
- Refer to the **Help page** for detailed assumptions and limitations not listed here.