Solar Glare Assessment for the Glass Façades of The SHARD

Report ZE18035-TS
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CONTENT

Executive Summary

The reflective glare of The Shard building was investigated for its potential to dazzle train drivers, road traffic or the office workers in an adjacent building.

At certain times of the day, there will be approx. 20 minutes of glare towards the railroad tracks. These glares, when directly looked into could pose a danger to railroad traffic.

During short periods glare will be emitted to road-traffic.

The neighbours of the adjacent high-rise building will see the reflections of the sun during long periods. The intensity of these glare could leave a temporary after-image on the eyes of the observer at peak periods.

1 Situation

1.1 Description

Glare from uncommon directions can pose risks and obstacles for humans while working, as well as reduce the recreational value outdoors, on balconies and even inside residential buildings in a way that it becomes an unreasonable nuisance.

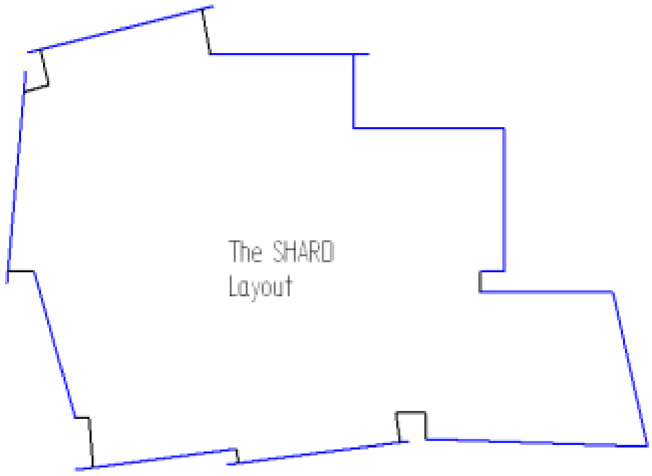
Vehicle drivers rely on good visibility. Glaring can impede the “running on sight” and the recognition of signs and signals, thus causing an obstruction to traffic and an increased risk of accidents.

The aim of this study is the examination if train drivers on the southeastern main line on the tracks from Greenwich to London Bridge are exposed to dazzling glare reflections from the 306 m high glass facades of “The Shard” building. Additionally the impact on road traffic and on the offices in a neighbouring building are investigated.

1.2 Location and situation of the reflectors

„The Shard“ building is located at 32 London Bridge Street, London SE1 9SG. It has 7 trapezoidal main glass facades arranged in different azimuth angles around the building core, partially reaching up to a height of 306 m above ground (GPS-coordinates: 51°30'16"N, 0°5'11"E).

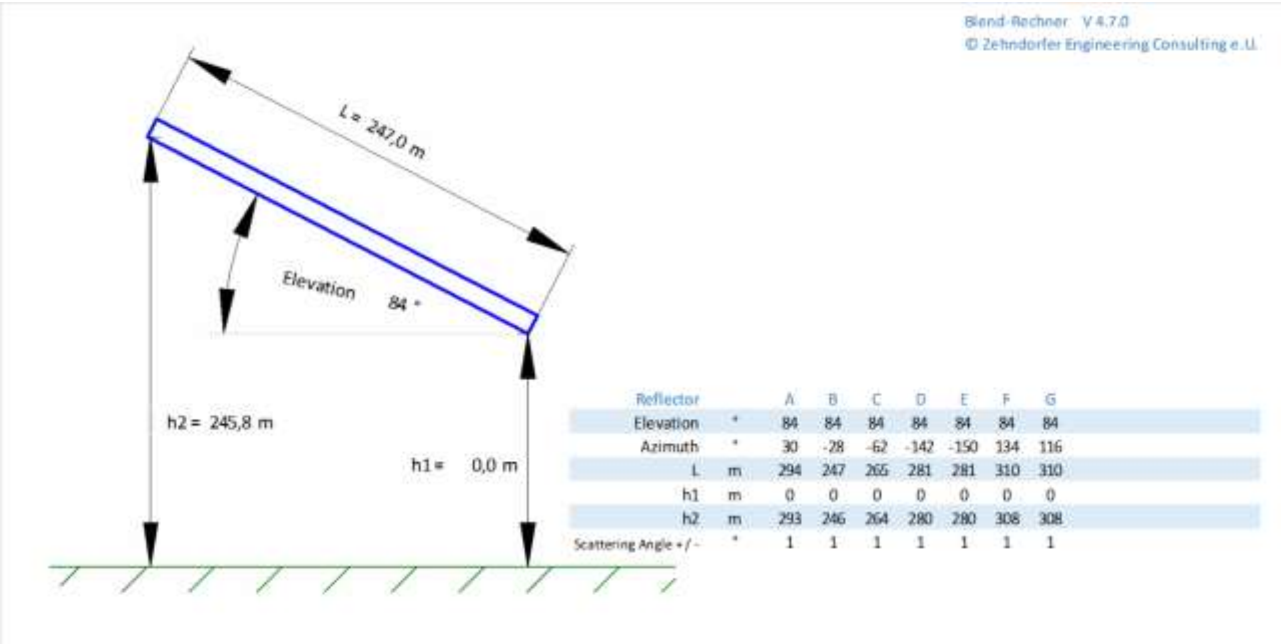
Figure 1 Floor Plan



The facades are oriented in different directions and partially overlapping. For the purpose of the glare calculation they have been modelled in trapezoidal quadrangles each.

Figure 2 Reflecting Surfaces Modell

Figure 3 Orientation of Reflectors (not to scale)



Reflector		A	B	C	D	E	F	G
Elevation	°	84	84	84	84	84	84	84
Azimuth	°	30	-28	-62	-142	-150	134	116
L	m	294	247	265	281	281	310	310
h1	m	0	0	0	0	0	0	0
h2	m	293	246	264	280	280	308	308
Scattering Angle +/-	°	1	1	1	1	1	1	1

Figure 2 and Figure 3 show the orientation of the reflecting surfaces in space. The façades are inclined with approximately 6° thus they have an elevation angle of 84° to vertical. Glass windows are modelled with a scattering angle of 1° due to manufacturing deviations and not being completely parallel.

1.3 Space under investigation

The Immission Points (IP) are those points of interest that are used for the glare calculation. They are located along the railway line as well as along major streets that could see glaring from the building. One point in a neighbouring high-rise building was also chosen to verify the impact on office workers there.

Figure 4 Imission Points (near)

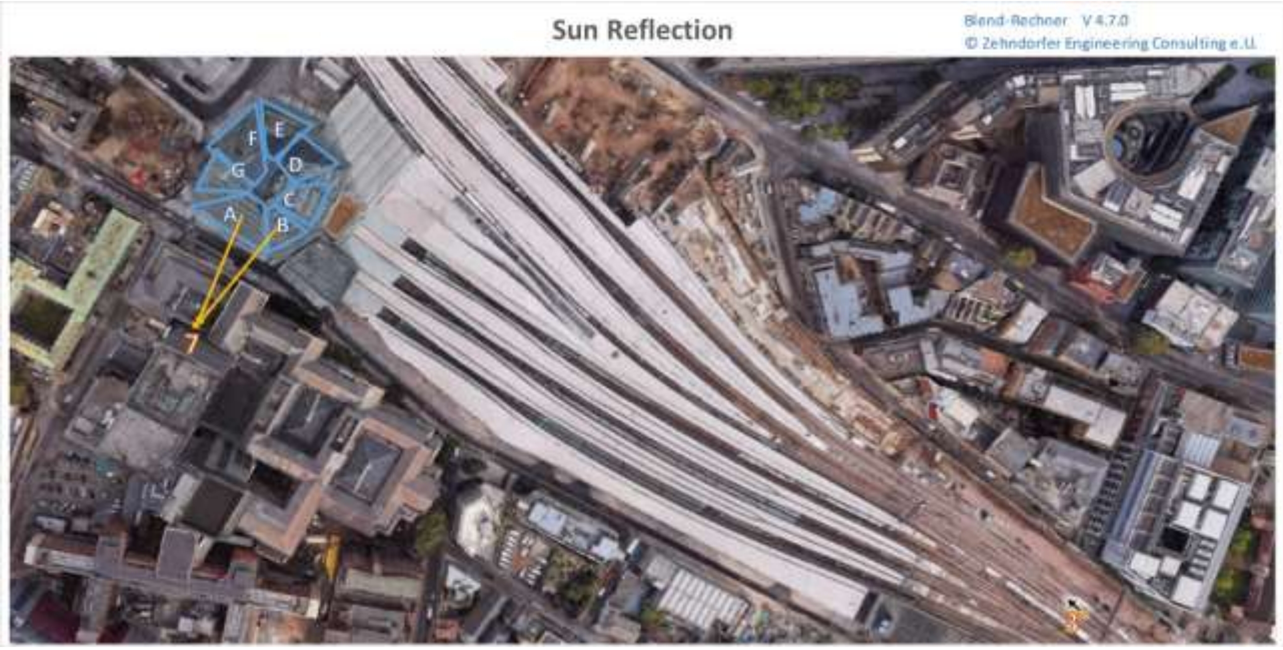


Figure 5 Imission Points (far)

Figure 4 and Figure 5 show the position of the points of immission (IP) and the reflectors. Immission Points were selected if they had an uninterrupted line of view towards one of the façades that is likely to cause reflections. IPs on traffic routes are equipped with a small black arrow to indicate the line of sight while driving. IPs on the road and the train tracks were chosen 2.5 m above the road/rail tracks on account of the height of the driver's head.

The IP of the approximately 120m high adjacent high-rise building was chosen at a height of 50 m above the ground. The detailed survey can be found in Annex 4.

1.4 Shading

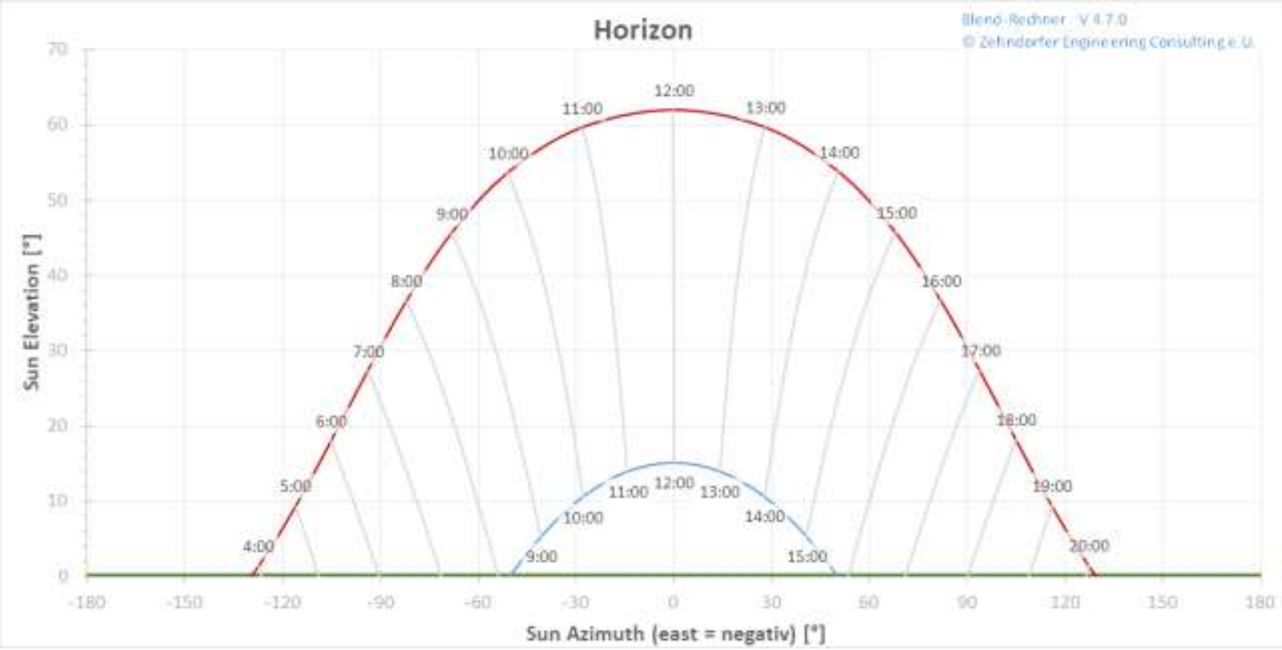
1.4.1 Local Topography

The surrounding topography is almost completely flat. There are no terrain edges, high enough to shade any IP from a reflecting surface.

1.4.2 Horizon

There are no mountains in the visible surroundings that could reduce sun hours.

Figure 6 Horizon



1.4.3 Plants

There are no bushes or trees between the IPs and the reflectors that could cause shading.

1.4.4 Artificial Shading

Between some of the IPs and the reflecting surfaces there are some buildings, that could interrupt the line of vison and thus reduce the glaring potential. These were not included in the glare calculation due to the fact that at least the upper part of the building under investigation is visible from all of the IPs.

2 Glare Calculation

2.1 Provisions for the Calculation

In the UK the Planning Practice Guidance states for solar farms: The proposal’s visual impact, the effect on landscape of glint and glare and on neighbouring uses and aircraft safety. This guidance will be applied for the building in this assessment on the basis that the visual impact is comparable to the reflection of solar farms. In the UK there are no specific guidelines for the assessment of solar reflections upon road traffic and buildings. Further notes on regulation can be found in Annex 2.

In its Technical Guidance for Evaluating Selected Solar Technologies on Airports and its related Interim Policy (78 FR 63276)., the US Federal Aviation Administration (FAA) states, that “1. No potential for glint or glare in the existing or planned Airport Traffic Control Tower (ATCT) cab, and 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 glidepath. Ocular impact must be analyzed over the entire calendar year in one (1) minute intervals from when the sun rises above the horizon until the sun sets below the horizon." Ocular impact must be evaluated in accordance with the Solar Glare Hazard Analysis Plot.

The technical guidance notes of the German Länderarbeitsgemeinschaft für Immissionsschutz is considered global best practice, when it comes to the quantitative assessment of reflective glare. It stipulates the following provisions:

- The sun is to be regarded as a point-source emitter
- The reflector is a perfect mirror (no scattering)
- The sun is emitting light from dawn to dusk (no exception for bad weather)
- The angle between sun and reflector shall have a minimum of 10°
- Considerable glaring is defined as 30 minutes per day or 30 hours per year

2.2 Calculation of Reflections

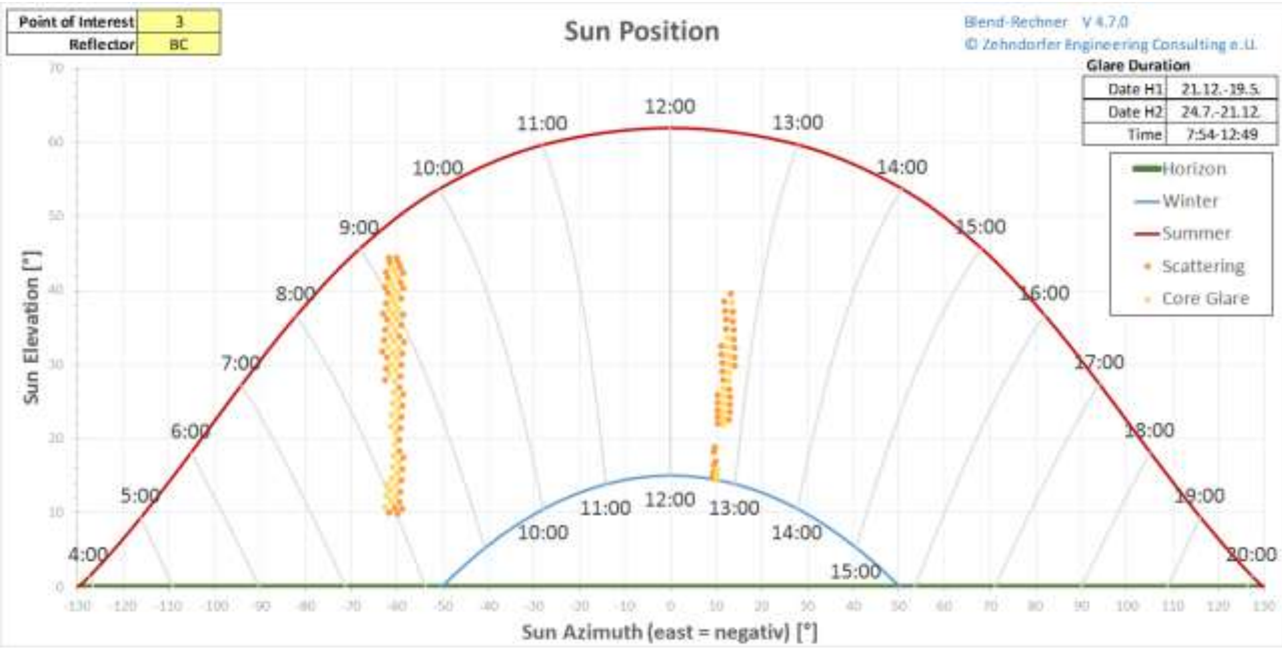
The calculation of reflections is based on the raytracing method (see Annex 3). Reflections are calculated for each point of immission separately.

Figure 7 Reflections towards IP 3

Figure 7 shows the Immission Points and the trace of any potential reflections.

Figure 8 shows at which time (day of the year and time of the day) reflections occur. The elevation and azimuth angles of the sun during times of glaring at IP3 is also indicated.

Figure 8 Sun Position while Glaring occurs at IP3



IP 3 will see glaring from the facade in the morning and around noon (depending on the day of the year). Results of the glare calculation are summarized in the following table. Results for all other IPs can be found in Annex 4.

Reflector		**BC**
Point of Interest		**3**
Distance	m	403
Elevation	°	18
Spatial Angle	msr	37
Date H1		21.12.-19.5.
Date H2		24.7.-21.12.
Time		7:54-12:49
Core Glare	min / day	20
Core Glare	h / year	27
Scattering	min / day	35
Scattering	h / year	57
Sun Elevation (avg)	°	27
Sun Azimuth (avg)	°	-25
Sun - Reflector angle (max)	°	171
Glare - Line-of-Vision angle (min)	°	11

2.3 Explanation of Results

Distance The distance between the reflector and the IP in meters.

Elevation The elevation angle of the reflector from the IP (0°representing the horizon)

Spatial Angle The Spatial Angle, expressed in milli-steradian. The Spatial Angle is a measure of the visible size of an object. It is calculated by dividing the visible area of an object by the square or its distance.

Date (H1/H2) The date in each half-year at which glaring starts and ends

Time The maximum time span during which glaring can occur

Core Glare The duration of specular glare in minutes per day and hours per year

Scattering The duration of light scattered on the uneven surface of the reflector in minutes per day and hours per year. In case that scattering is disregarded (according to regulation) this value will be the same as the Core Glare

Sun Elevation The average elevation of the sun at the time of glaring

Sun Azimuth The average azimuth of the sun at the time of glaring

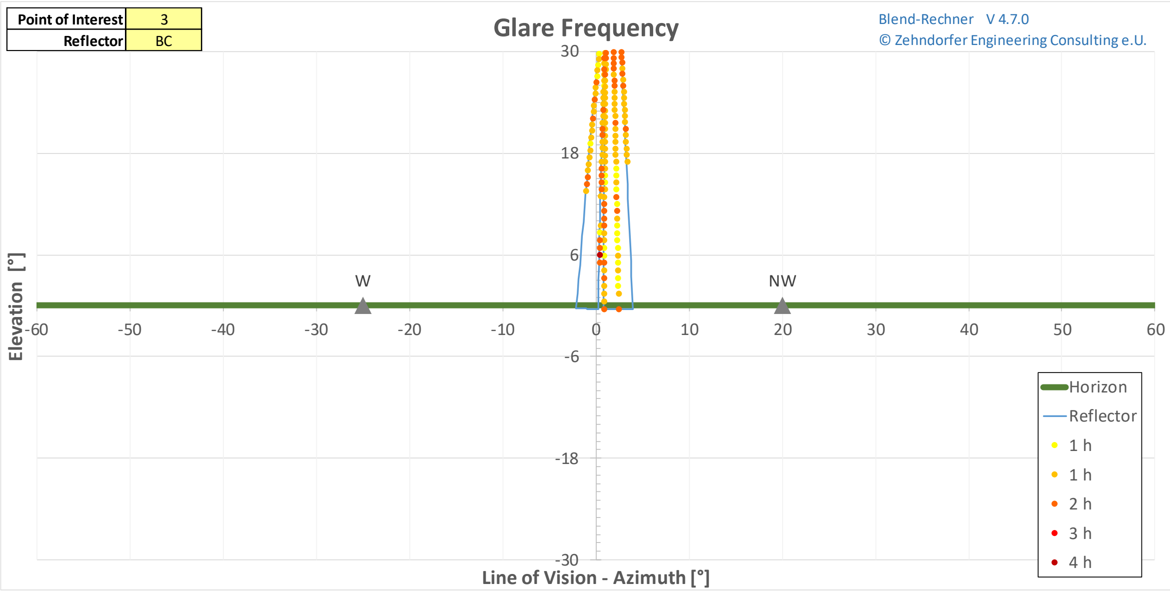
Sun-Reflector Angle The visual angle between reflector and the sun at the time of glaring. In case of a small angle (e.g. <10°) the glaring might be minor and negligible compared to the light of the much stronger sun from the similar direction

Glare - Line-Of-Vision Angle The minimum angle between line of sight (e.g. heading while driving) and the part of the reflector from which reflections can occur. If the angle is large (e.g. with a deviation to the line of sight larger than 15°) the glaring will not pose a danger to the driver who keeps his eyes on the road

2.4 Visual Field

In order to show the visual relation to the reflector as well as potential reflections and sun position, the 3D view is chosen in the direction of the reflector or the driving direction. The angles displayed are realistic, i.e. an average observer will see the image shown in this picture. Figure 9 also shows the frequency of glare from the different parts of the building in hours per year.

Figure 9 Reflectors with Glare Frequency



2.5 Glare Impact

The impact of a glaring hazard on humans depends on several parameters. The following parameters are influencing the dazzling impact on humans

- Size and projected area of the reflector
- Reflectance of the materials used
- Distance between IP and reflector
- Angle between sun and reflecting area
- Frequency and duration of the reflection
- Season and time of the reflection
- Task a person is performing when glare is noticed
- Possibility to protect oneself from the glare

2.5.1 Dimensions

The measurements represented in the following table shall provide a comparative guide to grasp the significance of size in the glare calculation. Since the eye cannot detect real size, but only optical angles (i.e. the relation of the size to the distance), all measurements are represented in angular measurements (milli-steradian).

Point of View	Spatial Angle
Field of vision	2,200 msr
sun disk on the sky	0.068 msr
Thumb of the extended hand[1]	1.55 msr

[1] Thus the sun or the moon can be completely covered with the extended thumb.

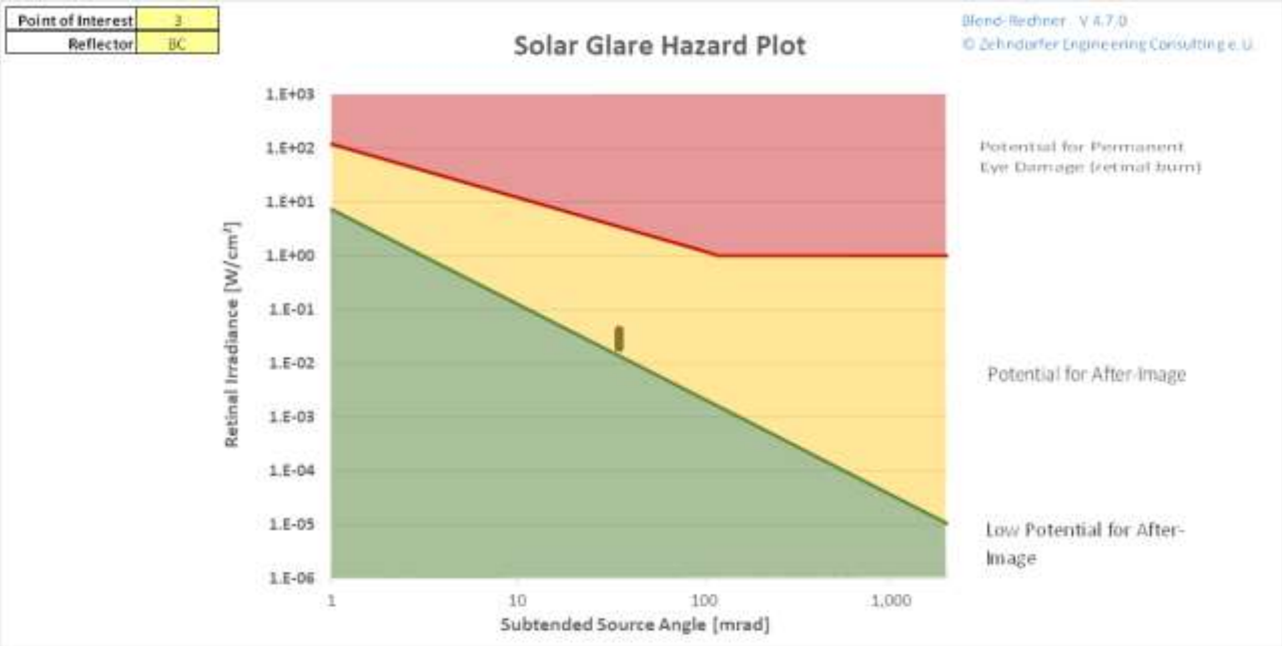
The maximum visible size of the reflector of IP7 (1,188 msr) is rated extremely large (due to the proximity of the building).

2.5.2 Glare intensity

Even though glass transmits a major portion of light, it also reflects a small but still significant portion of sunlight. The larger the angle between the surface-normal and the sunrays, the higher the reflectance.

In this study, Glare Intensity has been calculated for each glare occurrence in W/cm² at the retinal level, as required by FAA regulations. The results are shown in the Solar Glare Hazard Plot in Figure 10. The plots for remaining IPs can be found in Annex 5.

Figure 10 Ocular Glare Hazard for IP3



2.5.3 Direction of the Glare

The direction of the glare can play a decisive role for its dazzling impact. While glaring from above (e.g. the sun) is a natural phenomenon and consequently humans are not very sensitive towards it, horizontal light rays can disturb humans considerably. Glare from farther left or right of the line of view are perceived less disturbing than glare at the centre of vision.

International guideline " Lighting of work places“ BS EN 12464, for example, reduces the calculated impact of lateral glaring with the Guth-Positions-Index[2].

This is why for this assessment glare is only considered to be relevant for traffic if it occurs within an angle of +/-15° towards to line of vision (e.g. heading).

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[2] In this regard we want to refer to a study of Natasja van der Leden, Johan Alferdinck, Alexander Toet with the title “Glare from sound barriers”, which concludes that the driving performance is reduces especially at small angles (5°) towards the line of vision.

2.5.4 Glare Duration

Figure 11 Glare duration at IP3

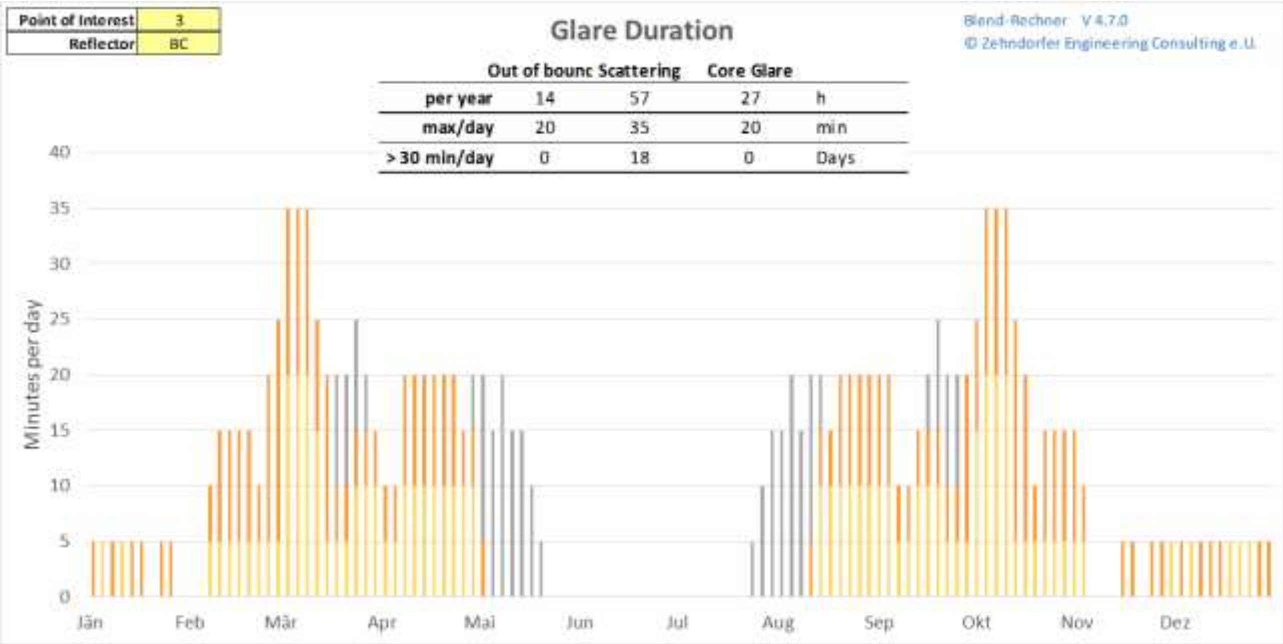

Figure 11 shows the yearly distribution of glare duration per day.

Potential grey areas are those times where glaring does occur, but due to the 10°-rule according LAI-2012 (angle between sun and reflector at a minimum of 10°) or the inner field of vision (+/-15° from the line of vision) it is not considered to be relevant.

For the calculation of times of core glare (reflection without scattering) neither the prolonging effect of light scattering, nor the reducing effect of bad weather (rain, snow, fog, clouds) are considered.

2.5.5 Potential subjective effects

There are tasks for which the unhindered view in the direction of the reflector is necessary. In this particular case that might be true for train drivers, trying to observe light signals before entering the London Bridge railway station.

3 Evaluation

IP1 to 3 (railway)

At certain times of the day there will be glaring upon the rail road track southeast of the building of investigation, under small angles towards the heading of the train. The glare has the potential to leave a temporary after-image on the retina of the train driver if he looks into the glare. This in turn, might be dangerous for his recognition of light signals along the railroad track.

IP4 to 6 (roads)

At certain times of the day there will be glaring upon the road traffic on these IPs. The glare has the potential to leave a temporary after-image on the retina of the driver if he looks into the glare.

IP 7 (neighbour)

The neighbours will be exposed to glare for rather long times during the day and on every day of the year. Due to the slope of the building façade the direction of the glare will, at times, also come from below the horizon.

At peak times the glare might have the potential to leave a temporary after-image.

Date: 9.7.2018

Surveyor:

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Jakob Zehndorfer
Zehndorfer Engineering Consulting

ANNEX 1 DEFINITIONEN

Glaring (in general)	a disturbance of visual perception, caused by a strong source of light in the field of vision.
Psychological Glaring	a form of glaring which is perceived as nuisance or a distraction, often only subconsciously disturbing the perception of visual information, without technically hindering the perception of details.
Physiological Glaring	a form of glaring, which reduces the perception of visual information technically measurable. It is caused by scattering within the eye, thus reducing the perceivable contrasts by causing veiling.
Glaring impact	The impact of glaring on an individual.
Tolerable Glaring	In the available regulations and laws the term „tolerable glaring“ is not defined.
Reflection (Physics)	The casting back of light on a surface or interface.
Directed reflection	The Law of Reflection is valid for (almost) flat surfaces.
Luminance	is a photometric measure of the luminous intensity per unit area of light travelling in a given direction. It describes the amount of light that passes through, is emitted or reflected from a particular area, and falls within a given solid angle [cd/m²] or the luminous flux per visual area of the reflector and solid angle (of the distant eye) [lm/m²sr].
Luminosity	The luminous flux per solid angle [lm/str].
Luminous Flux	a measure of how many photons are emitted by a light source per unit of time – measured in lumen [lm]
IP	The Immission Point - points under consideration for the glaring calculation.
PV	Photovoltaic power plant
Azimuth	Angle (on the ground) between object and South
Elevation	angle measured between horizontal line and object
coordinate system	The coordinate system used is oriented parallel to the surface of the earth in its x/y plane, the z-vector points directly up. In the calculation several other coordinate systems are used for practical reasons, without further relevance for the results of the calculation
Surface roughness	Next to is special chemical composition and a potential anti-reflective coating in many cases glass also comes with the feature of a “rough” surface. – small prisms, with the purpose of reducing the reflection and increasing the transmission of light through the glass. On these small surfaces stronger scattering of light can be observed.

ANNEX 2 GUIDELINES, PRESCRIPTIONS AND RULES

Planning Practice Guidance, 2016 UK National Planning Policy Framework

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.

The proposal's visual impact, the effect on landscape of glint and glare and on neighbouring uses and aircraft safety

USA, 2017 FAA Procedures for Handling Airspace Matters

Glare is the obscuration of an object in a person's field of vision due to a bright light source located near the same line−of sight (e.g., as experienced with oncoming headlights). The Critical Flight Zone (CFZ) is the airspace within a 10 NM radius of the airport reference point, up to and including 10,000 feet AGL. The effective irradiance of a visible laser beam is restricted to a level that should not cause transient visual effects (e.g., glare, flashblindness, or afterimage).

USA, 2013 FAA Interim Policy

The solar energy system shall meet the following standards: No potential for glint or glare in the existing or planned Airport Traffic Control Tower (ATCT) cab, and 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 glidepath. Ocular impact must be analyzed over the entire calendar year in one (1) minute intervals from when the sun rises above the horizon until the sun sets below the horizon. Ocular impact must be evaluated in accordance with the Solar Glare Hazard Analysis Plot.

German „Hinweise zur Messung, Beurteilung und Minderung von Lichtimmissionen" of the Bund/Länder-Arbeitsgemeinschaft für Immissionsschutz (LAI-2012), 13.09.2012

3. Relevant Points of Immission and situations

Relevant Points of Immission are a) spaces worth protecting, which are used as living quarters, sleeping quarters, including sleeping rooms at lodging, hospitals and sanatoriums, class-rooms in schools, universities and similar institutions, office spaces, doctors' offices, workshops, seminar rooms and similar workrooms. surfaces adjacent to buildings (e.g. terraces and balconies) are treated as rooms worth protecting during daytime from 6:00 to 22:00. b) Empty spaces at a height of 2 m above ground at the most affected edge of the areas, on which according to building legislation, buildings with spaces worth protecting are allowed.

For the appraisal of Immissions (Times of Glare) idealized assumptions are used

- The sun is to be regarded as a point-source emitter
- The reflector is a perfect mirror (no scattering)
- The sun is emitting light from dawn to dusk (no exception for bad weather)

For the times of immission, only those times shall be considered, during which the line of vision towards the sun and towards the PV panel differs with a minimum of 10°.

A considerable disturbance in the sense of the Bundes-immissionsschutz-gesetz (Federal immissions-protection regulation) caused by the maximum possible astronomical glare duration, considering all surrounding PV installations, can be present, when it lasts at least 30 minutes per day or 30 hours per year.

ANNEX 3 CALCULATION METHODS

The simulation is done via raytracing. In this process the sun position during a full year is calculated with a resolution of 1 to 5 minutes. It is further transformed into the incidence angle on the reflecting area and mirrored mathematically. Scattered rays are modelled as beam expansions at the reflector's surface. All times of reflections towards the Immission Points are noted and displayed in the graphical Sun Position diagram. The Glare Duration is calculated as daily and yearly accumulation of glare times. All calculations are done utilizing advantageous coordinate systems and rotation matrices.

For the Solar Glare Hazard Analysis Tool (SGHAT) the realistic Direct Normal Irradiation (DNI) is calculated using the Bird and Hulstrom's solar radiation model. Reflectance is modelled according Sandia National Laboratories reflectance formula for "smooth glass without ARC". Retinal Irradiance is calculated according D.H.Sliney derivation from the corneal energy incident. Subtended beam angle is the minimum of scattered beam width and the average reflector diameter.

ANNEX 4 SURVEY OF THE ENVIRONMENT

The following coordinate system was chosen: UTM Zone 30, with false northing -5,000,000

The reflectors are situated at the following locations

Reflector	A				B				C			
Corner Point	C1	C2	C3	C4	C1	C2	C3	C4	C1	C2	C3	C4
x	702,161	702,197	702,195	702,188	702,198	702,215	702,200	702,196	702,216	702,225	702,207	702,199
y	709,935	709,914	709,937	709,942	709,914	709,924	709,937	709,934	709,928	709,948	709,947	709,938
z	11	11	11	11	11	11	11	11	11	11	11	11
h	0.0	0.0	292.9	292.9	0.0	0.0	245.8	245.8	0.0	0.0	263.7	263.7

Reflector	F				G			
Corner Point	C1	C2	C3	C4	C1	C2	C3	C4
x	702,189	702,168	702,190	702,195	702,172	702,164	702,187	702,189
y	709,985	709,964	709,946	709,953	709,962	709,943	709,943	709,947
z	11	11	11	11	11	11	11	11
h	0.0	0.0	308.4	308.4	0.0	0.0	308.4	308.4

The following points of immission were regarded in this simulation

Point of Interest	1	2	3	4	5	6	7
Description	IP1	IP2	IP3	IP4	IP5	IP6	IP7
x	703,591	702,854	702,571	701,306	701,677	701,620	702,167
y	708,982	709,556	709,756	709,873	709,917	709,454	709,878
z	11	11	11	11	11	11	11
h	2.5	2.5	2.5	2.5	2.5	2.5	50.0
Line of Vision	114	131	130	-94	-108	-130	

ANNEX 5 Detailed Simulation Results

Reflector		BC	BC	BC	AFG	AFG	ABG	AB
Point of Interest		**1**	**2**	**3**	**4**	**5**	**6**	**7**
Distance	m	1,679	748	403	876	502	746	61
Elevation	°	4	10	18	10	17	12	50
Spatial Angle	msr	3	11	37	16	41	15	1188
Date H1		21.12.-1.4.	21.12.-16.4.	21.12.-19.5.	21.12.-25.2.	21.12.-26.3.	21.12.-21.6.	21.12.-21.6.
Date H2		10.9.-21.12.	26.8.-21.12.	24.7.-21.12.	16.10.-21.12.	16.9.-21.12.	21.6.-21.12.	21.6.-21.12.
Time		7:30-12:07	7:49-12:29	7:54-12:49	9:55-10:15	9:41-10:16	5:06-12:48	12:51-16:29
Core Glare	min / day	5	10	20	10	10	15	135
Core Glare	h / year	3	12	29	9	20	21	653
Scattering	min / day	15	15	35	15	20	20	140
Scattering	h / year	21	35	64	26	46	64	684
Sun Elevation (avg)	°	16	21	27	17	22	17	30
Sun Azimuth (avg)	°	-34	-30	-25	-28	-32	-49	43
Sun - Reflector angle (max)	°	163	170	171	68	64	139	167
Glare - Line-of-Vision angle (min)	°	11	11	1	4	16	1	11

Sun Reflection

Blend-Rechner V 4.7.0
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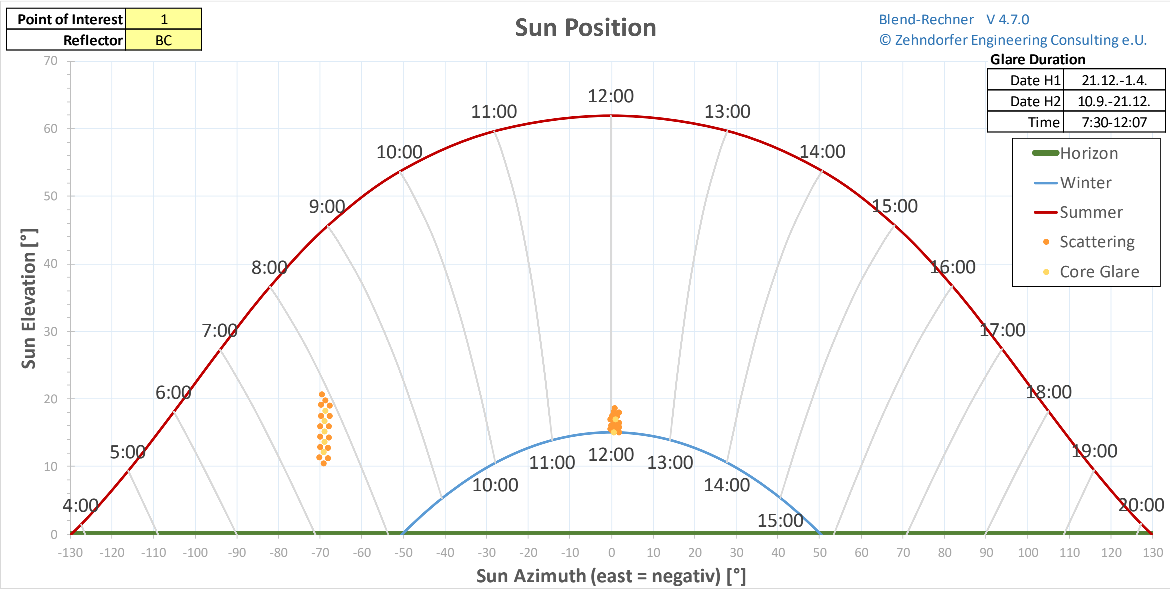
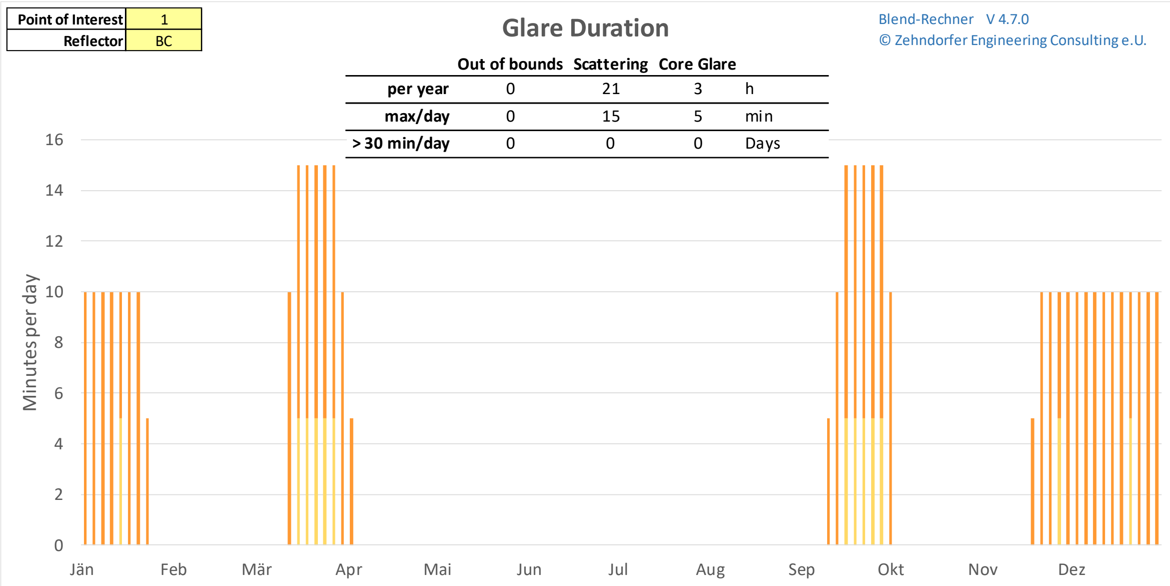
Point of Interest	1
Reflector	BC



Glare Duration

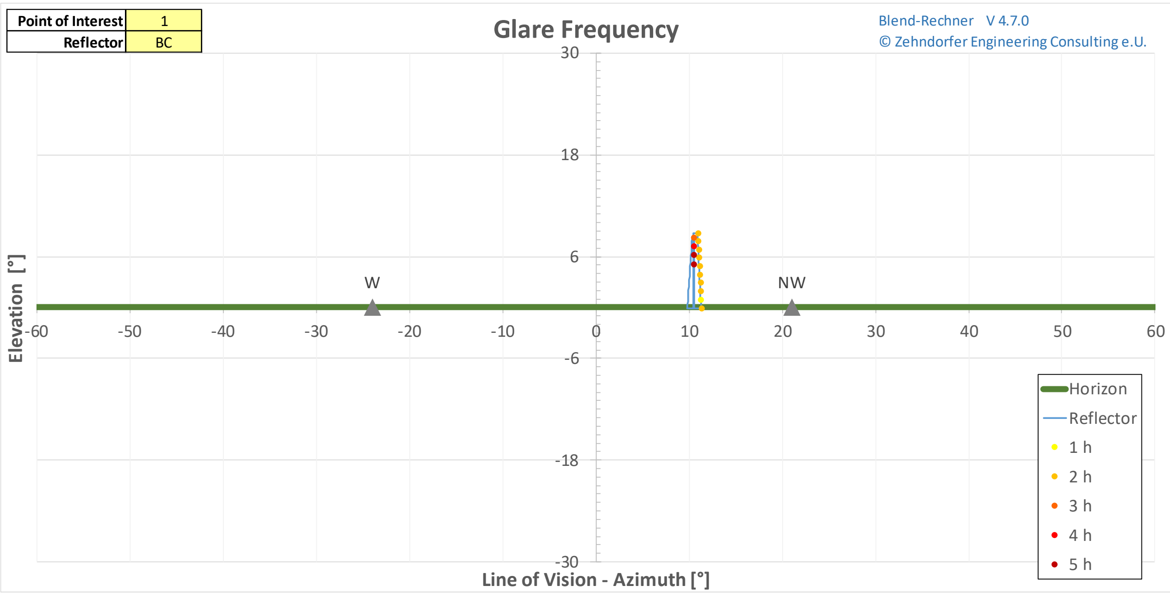
Date H1	21.12.-1.4.
Date H2	10.9.-21.12.
Time	7:30-12:07

Point of Interest	1
Reflector	BC

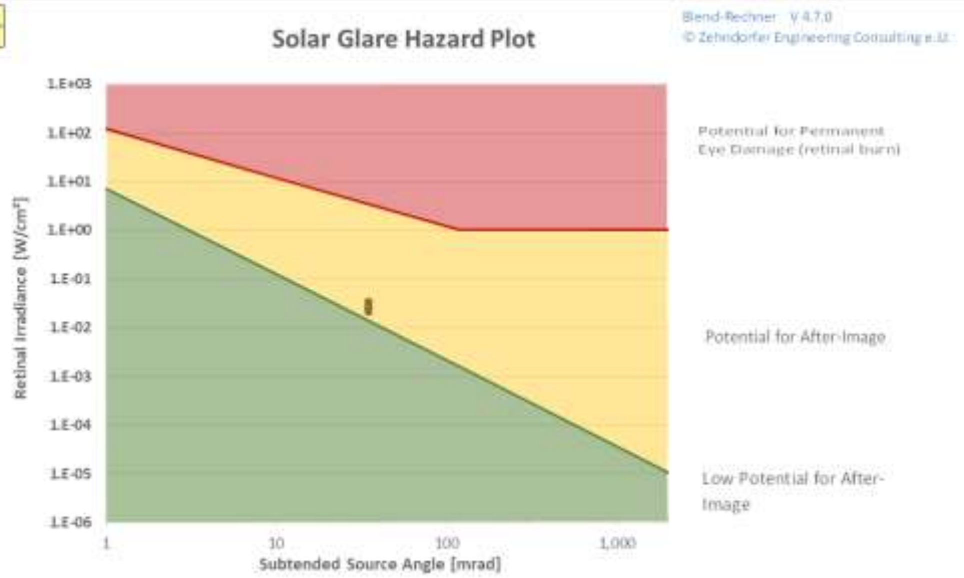


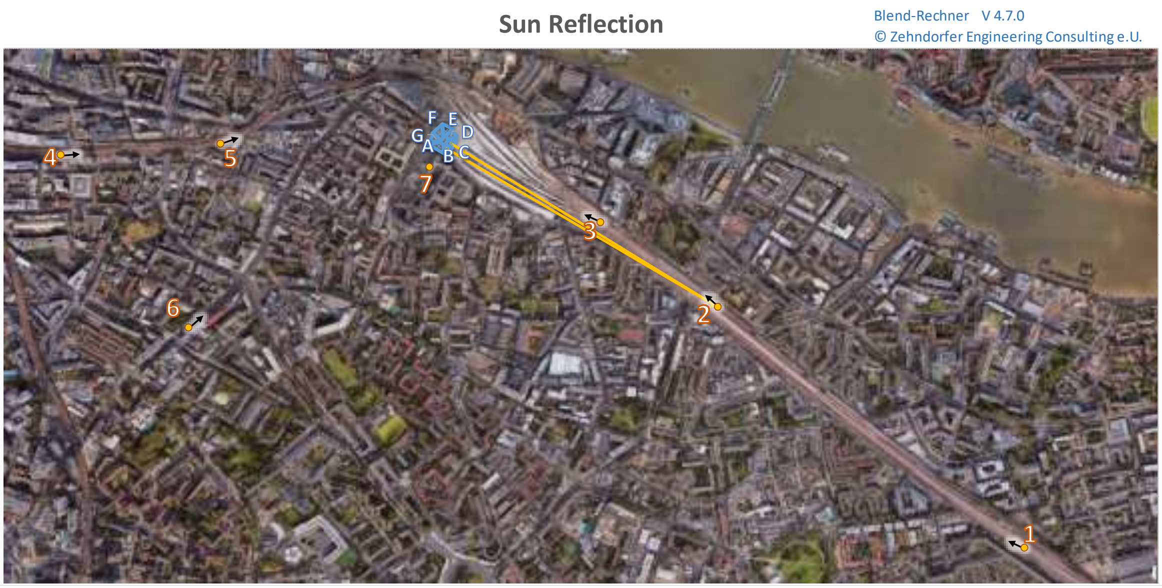
	Out of bounds	Scattering	Core Glare	
per year	0	21	3	h
max/day	0	15	5	min
> 30 min/day	0	0	0	Days

Point of Interest	1
Reflector	BC

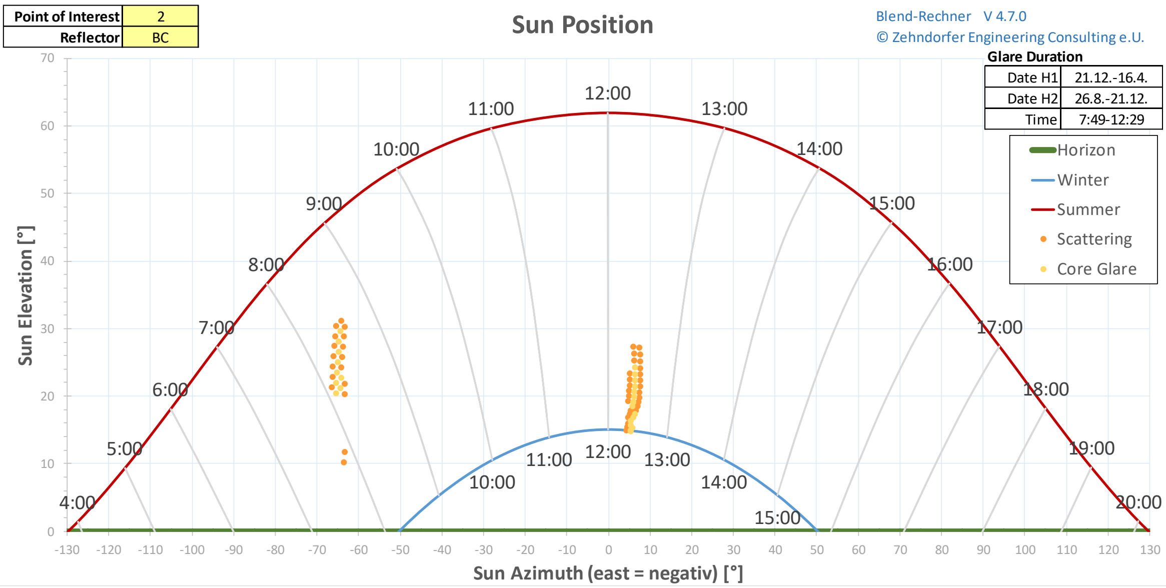


Point of Interest	1
Reflector	BC





Point of Interest	2
Reflector	BC



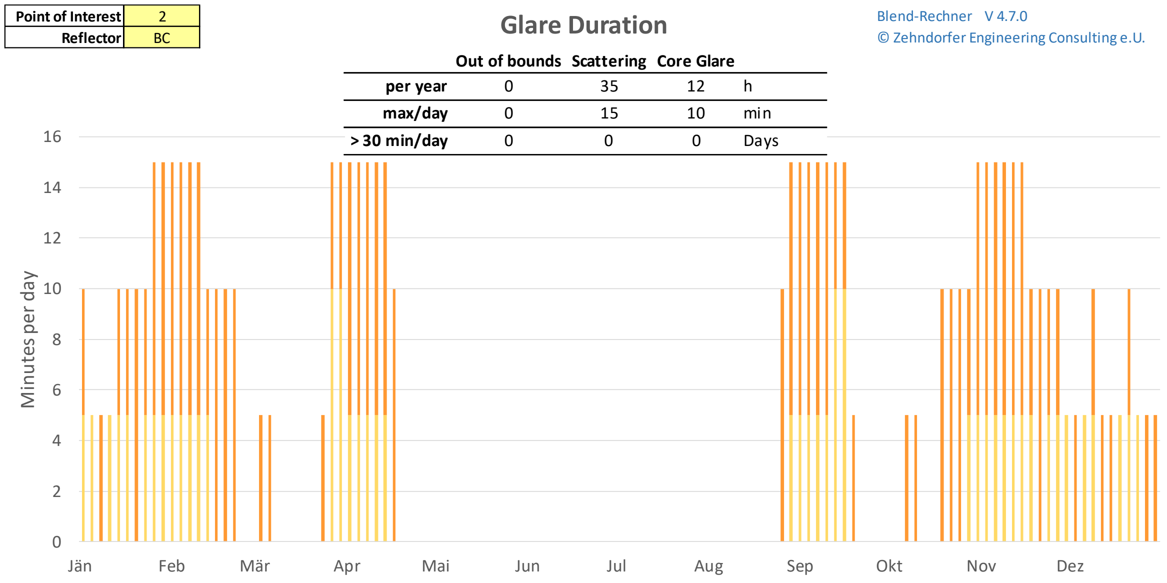
Glare Duration

Date H1	21.12.-16.4.
Date H2	26.8.-21.12.
Time	7:49-12:29

Point of Interest	2
Reflector	BC

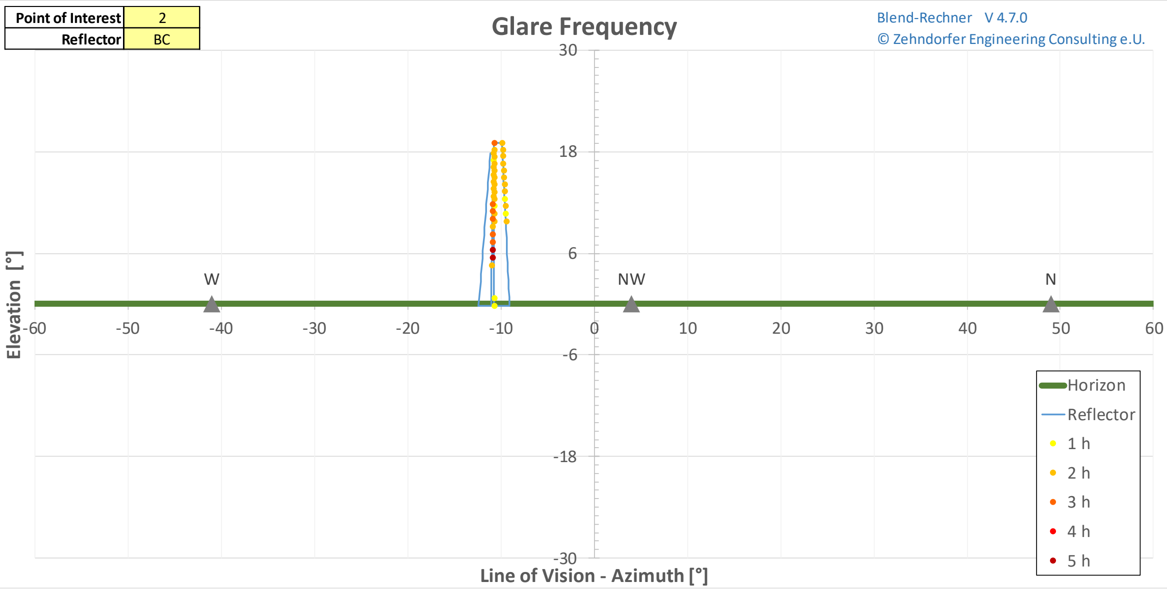
Glare Duration

	Out of bounds	Scattering	Core Glare	
per year	0	35	12	h
max/day	0	15	10	min
> 30 min/day	0	0	0	Days



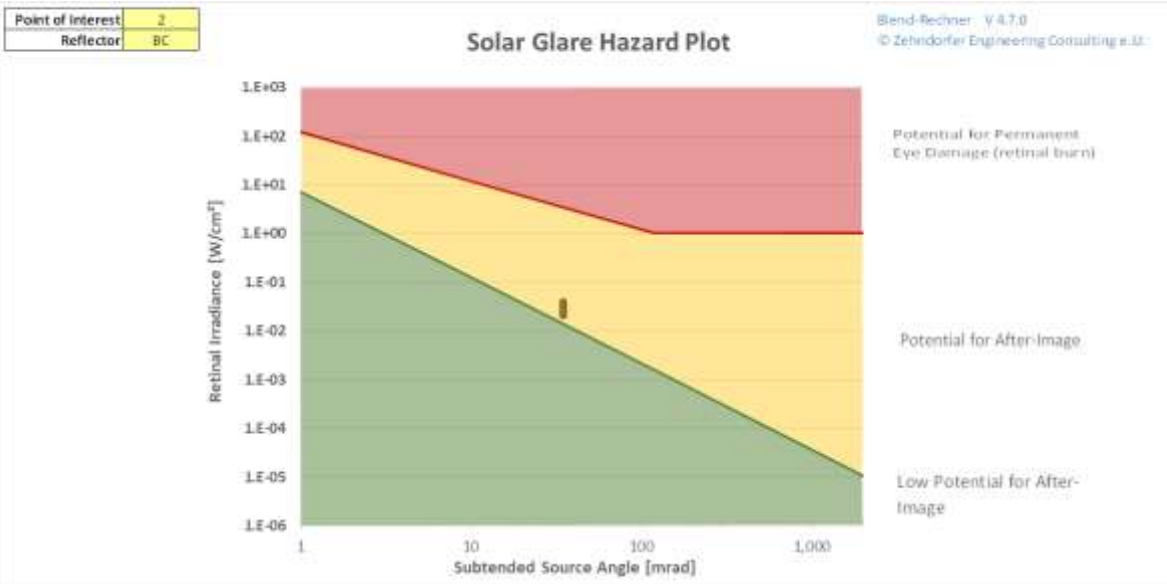
Point of Interest	2
Reflector	BC

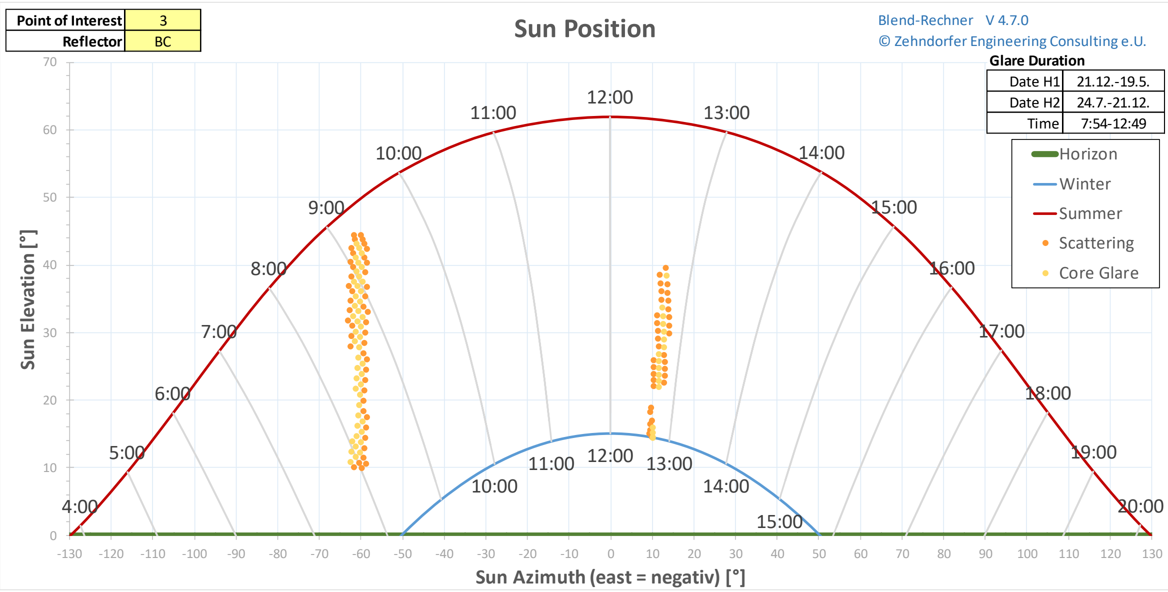
Glare Frequency

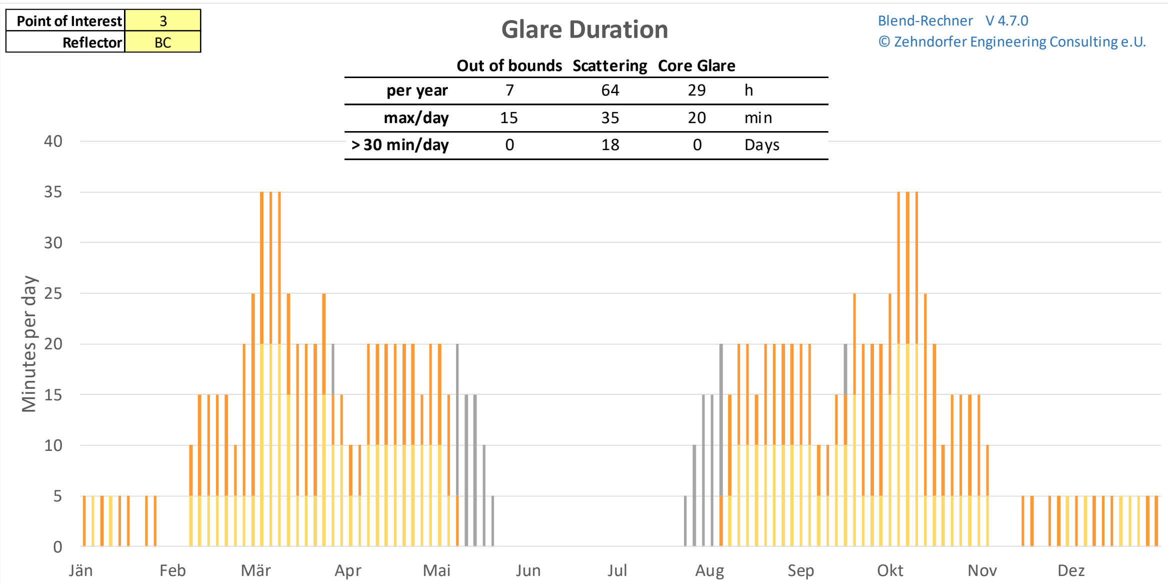


Point of Interest	2
Reflector	BC

Solar Glare Hazard Plot

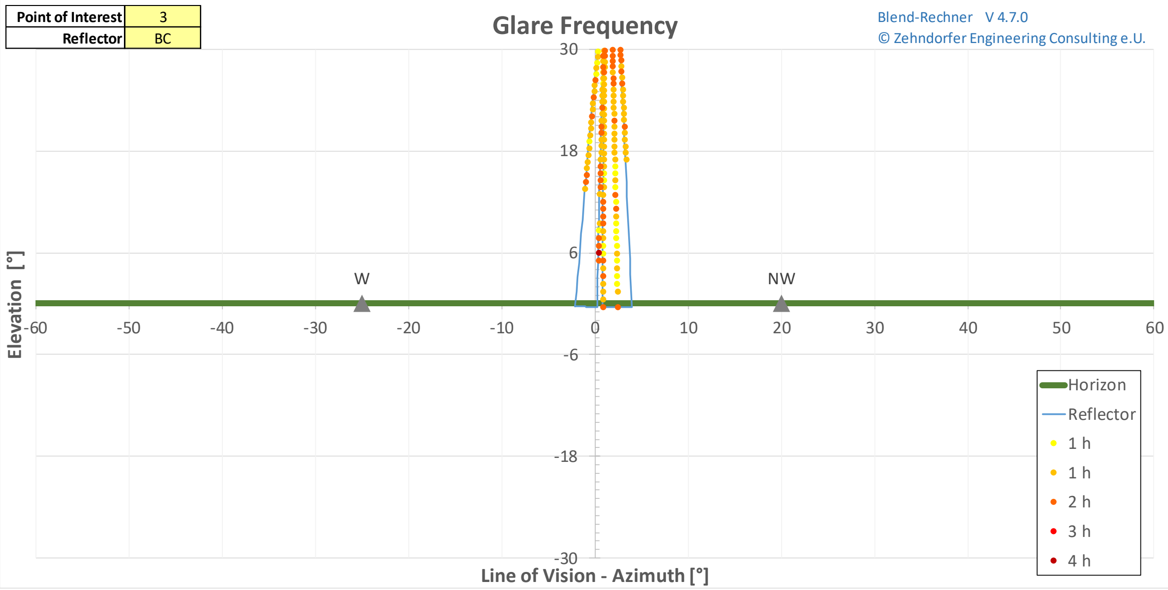




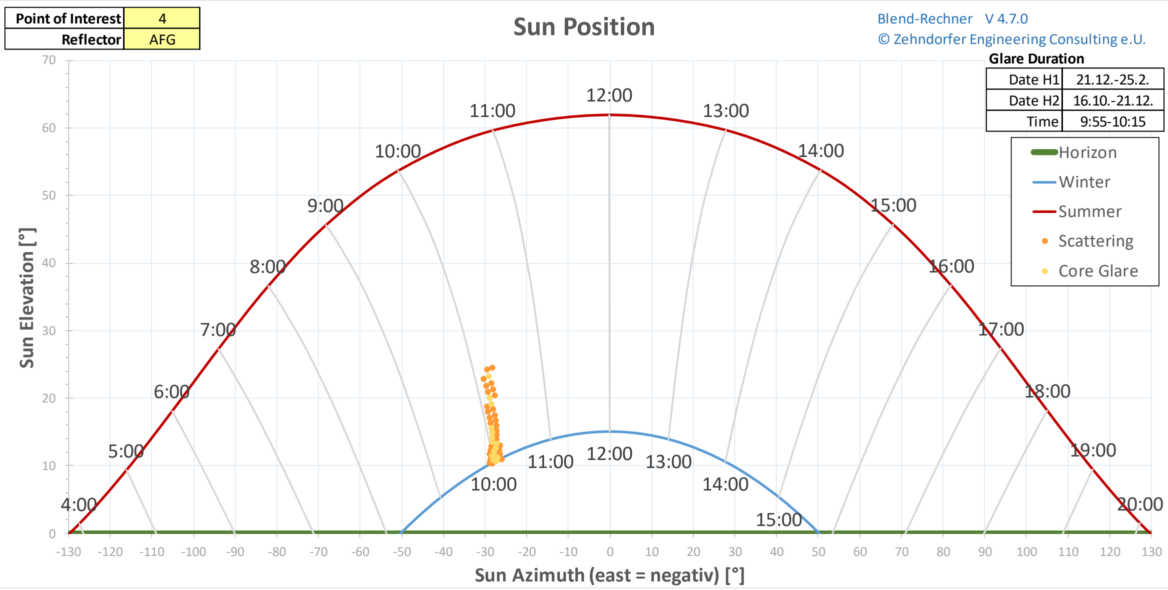


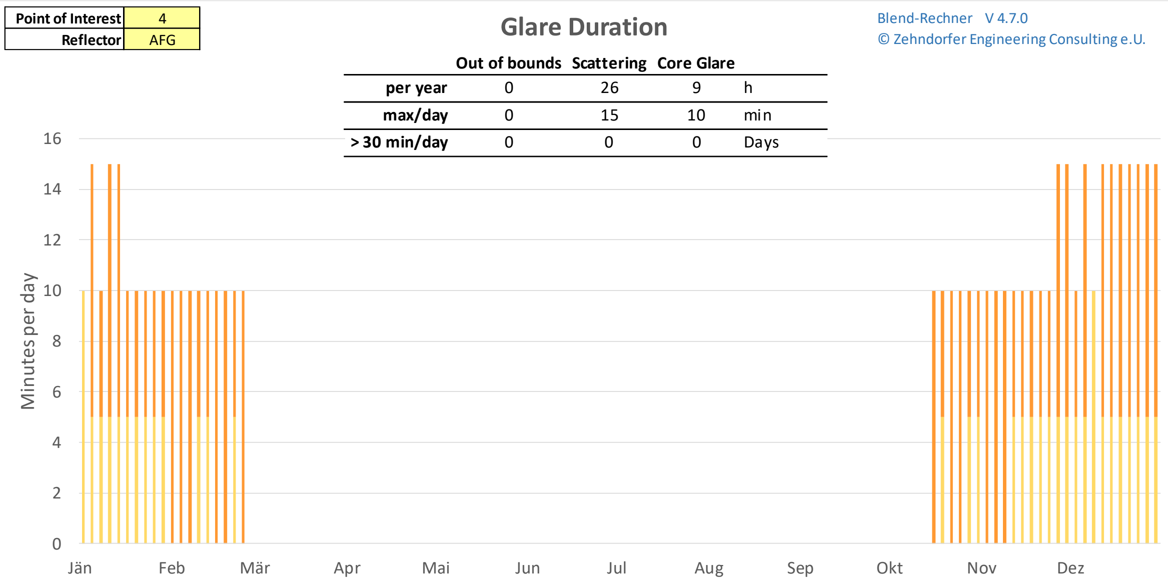
	Out of bounds	Scattering	Core Glare	
per year	7	64	29	h
max/day	15	35	20	min
> 30 min/day	0	18	0	Days

Point of Interest	3
Reflector	BC

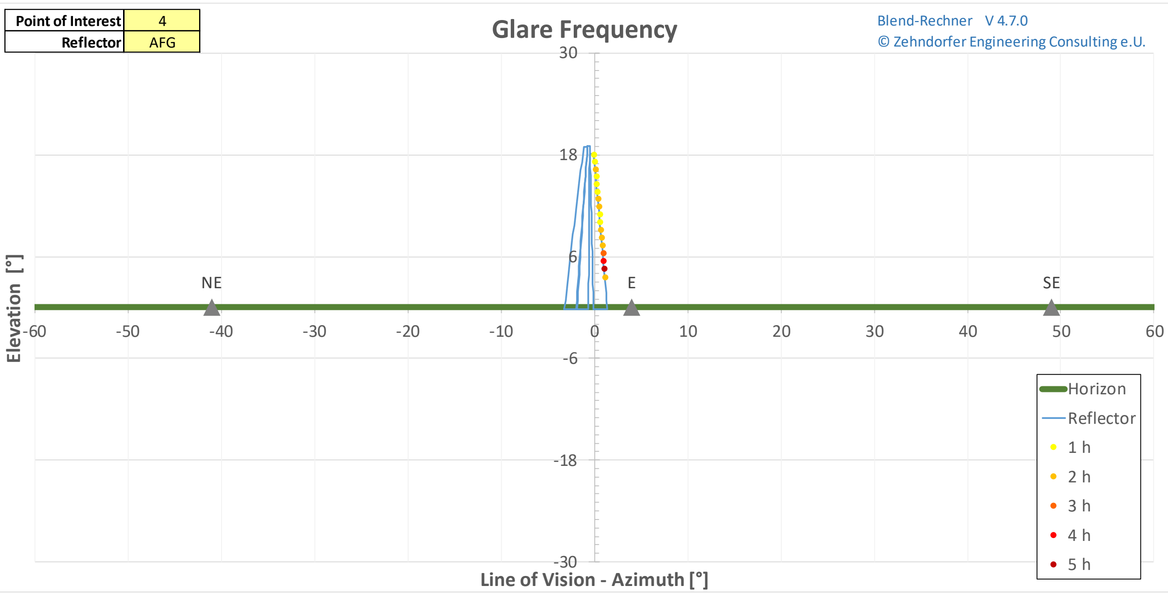


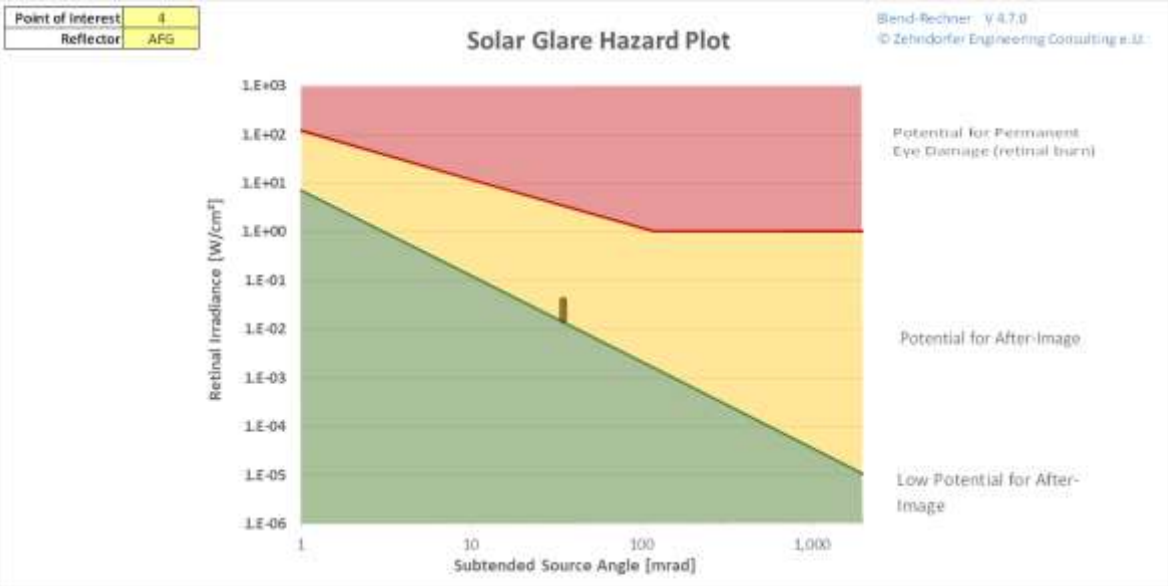
Point of Interest	3
Reflector	BC



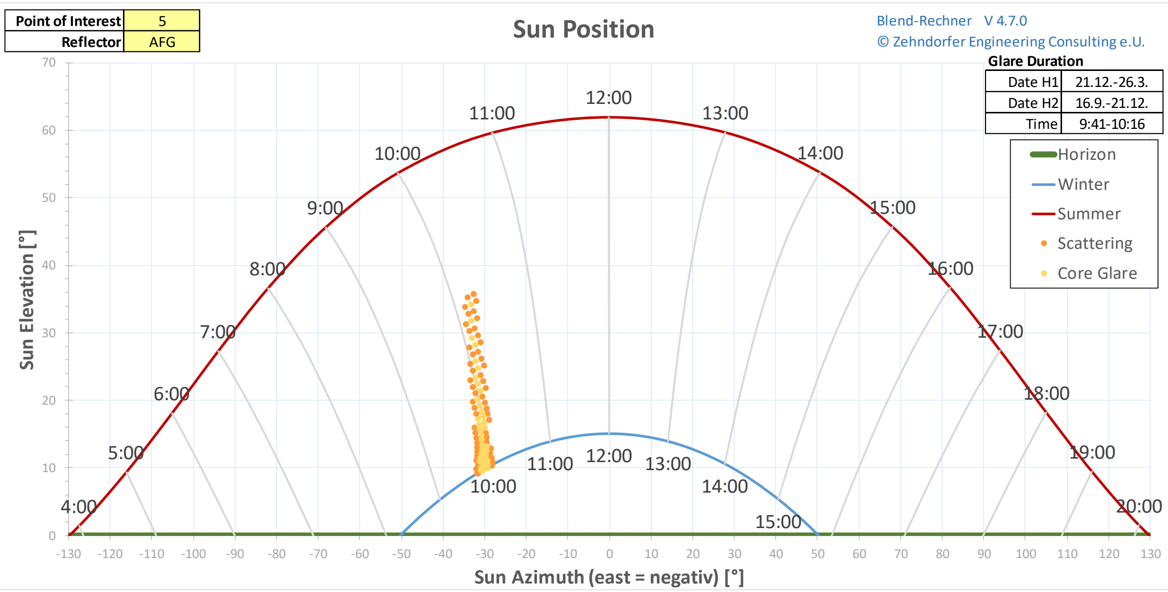


	Out of bounds	Scattering	Core Glare	
per year	0	26	9	h
max/day	0	15	10	min
> 30 min/day	0	0	0	Days




Point of Interest 4
Reflector AFG
Solar Glare Hazard Plot
Blend-Rechner V 4.7.0
© Zehndorfer Engineering Consulting e.U.
Retinal Irradiance [W/cm²]
1.E+03
1.E+02
1.E+01
1.E+00
1.E-01
1.E-02
1.E-03
1.E-04
1.E-05
1.E-06
1
10
100
1,000
Subtended Source Angle [mrad]
Potential for Permanent Eye Damage (retinal burn)
Potential for After-Image
Low Potential for After-Image


Sun Reflection
Blend-Rechner V 4.7.0
© Zehndorfer Engineering Consulting e.U.
1
2
3
4
5
6
7
A
B
C
D
E
F
G


Point of Interest 5
Reflector AFG
Sun Position
Blend-Rechner V 4.7.0
© Zehndorfer Engineering Consulting e.U.
Glare Duration
Date H1 21.12.-26.3.
Date H2 16.9.-21.12.
Time 9:41-10:16
Horizon
Winter
Summer
Scattering
Core Glare
Sun Elevation [°]
Sun Azimuth (east = negativ) [°]

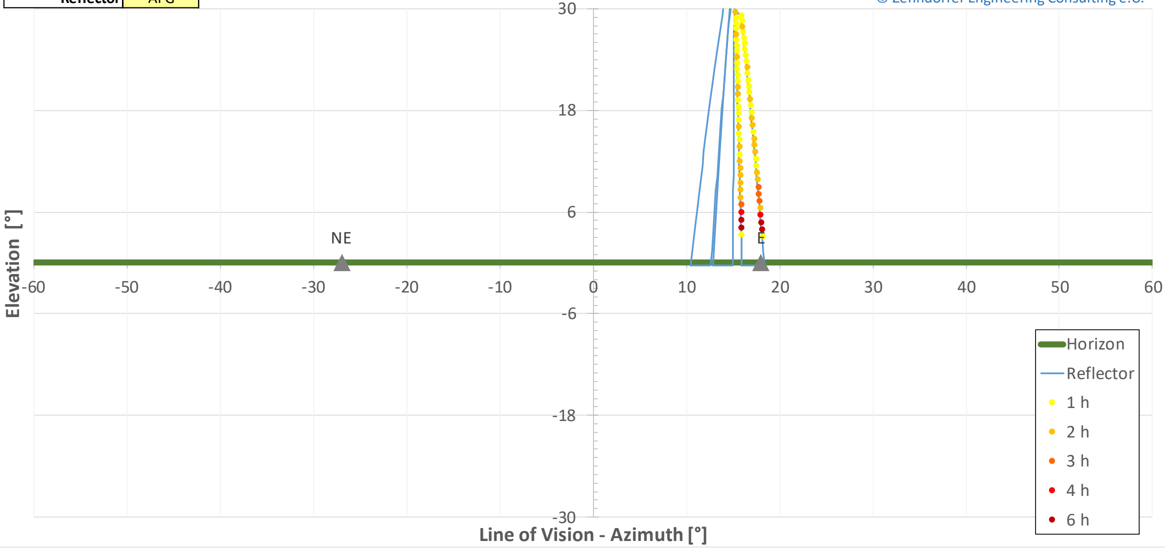
Point of Interest	5
Reflector	AFG

Glare Duration

	Out of bounds	Scattering	Core Glare	
per year	5	46	20	h
max/day	15	20	10	min
> 30 min/day	0	0	0	Days

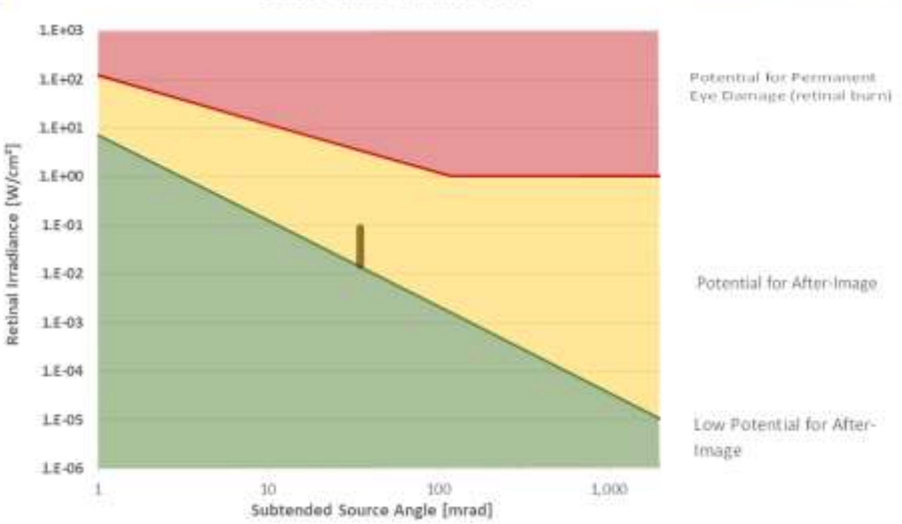
Point of Interest	5
Reflector	AFG

Glare Frequency



Point of Interest	5
Reflector	AFG

Solar Glare Hazard Plot



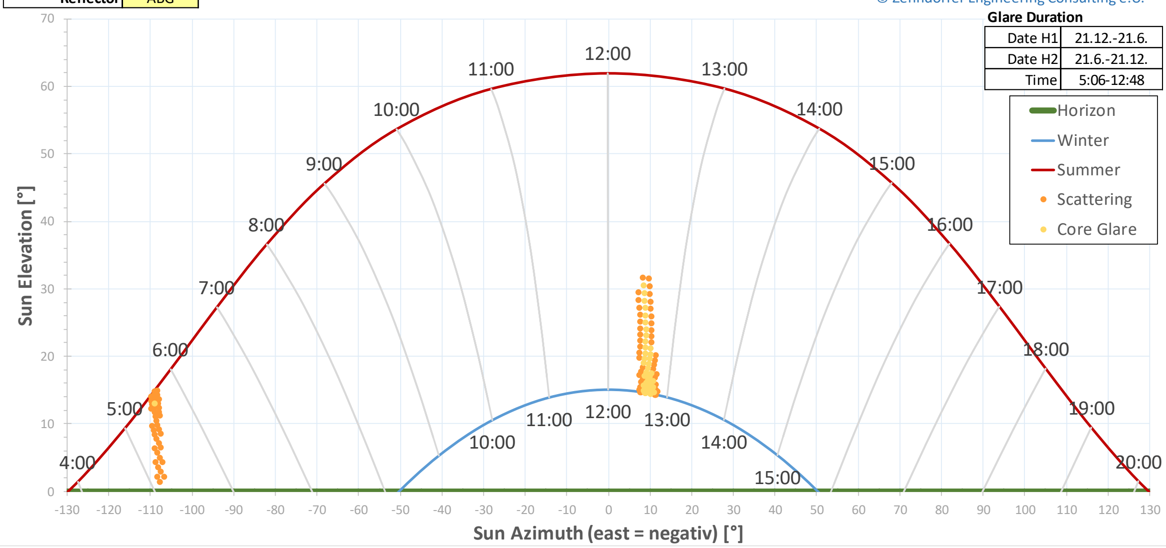
Sun Reflection

Blend-Rechner V 4.7.0
© Zehndorfer Engineering Consulting e.U.

Point of Interest	6
Reflector	ABG

Sun Position

Blend-Rechner V 4.7.0
© Zehndorfer Engineering Consulting e.U.



Point of Interest	6
Reflector	ABG

Glare Duration

Blend-Rechner V 4.7.0
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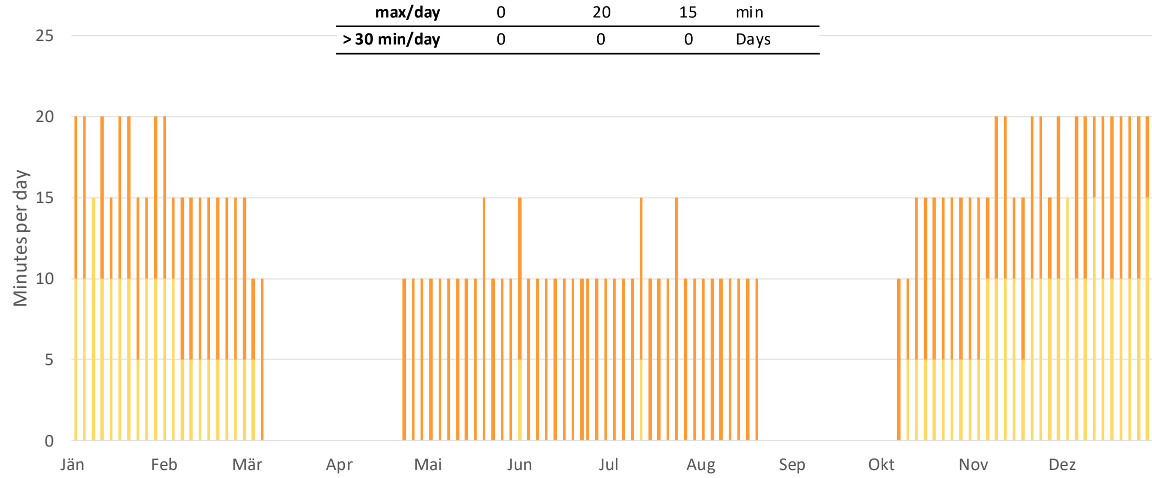
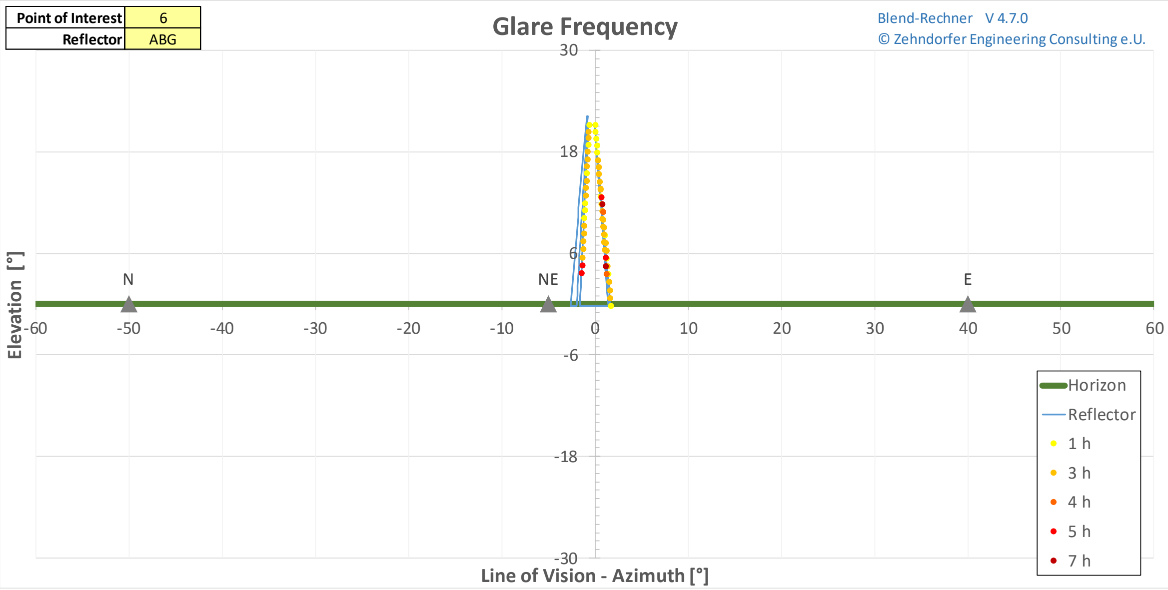
	Out of bounds	Scattering	Core Glare	
per year	0	64	21	h
max/day	0	20	15	min
> 30 min/day	0	0	0	Days




Point of Interest 6
Reflector ABG
Glare Frequency
Blend-Rechner V 4.7.0
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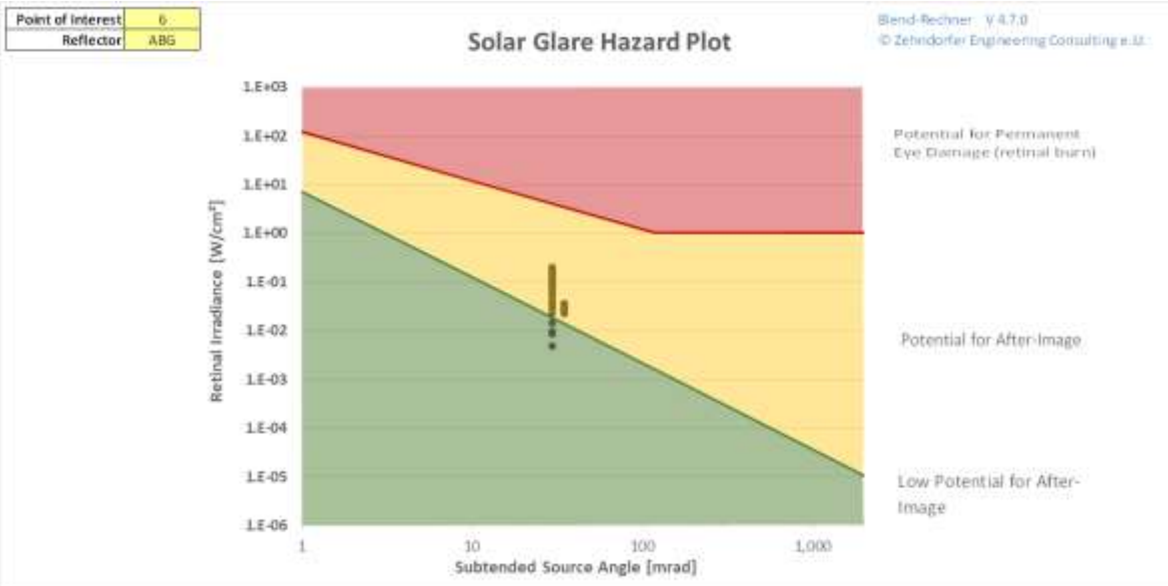
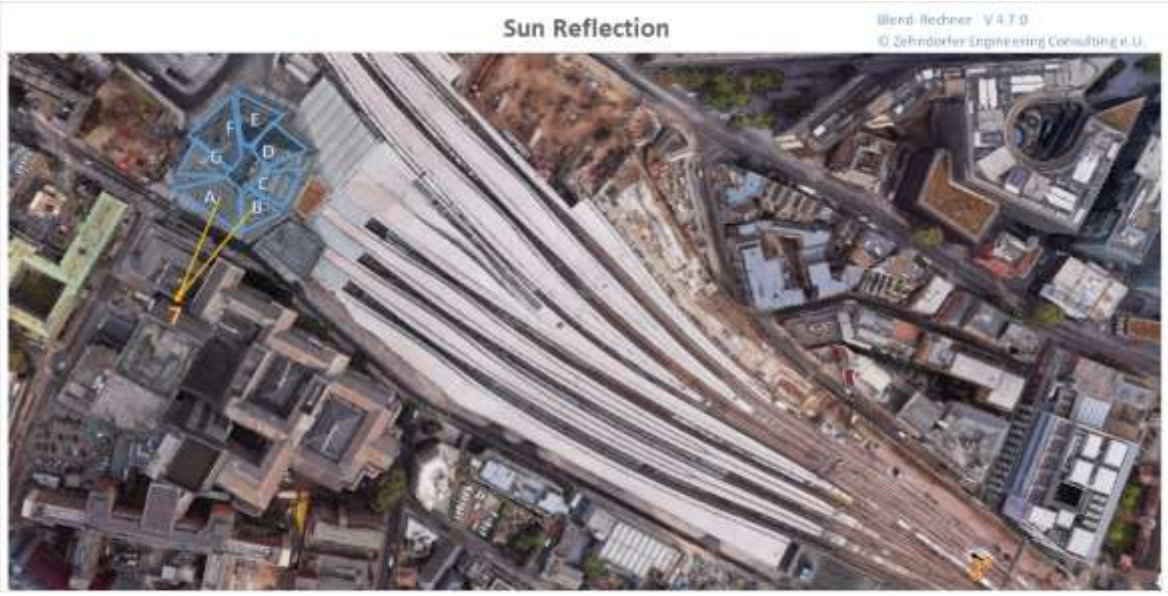
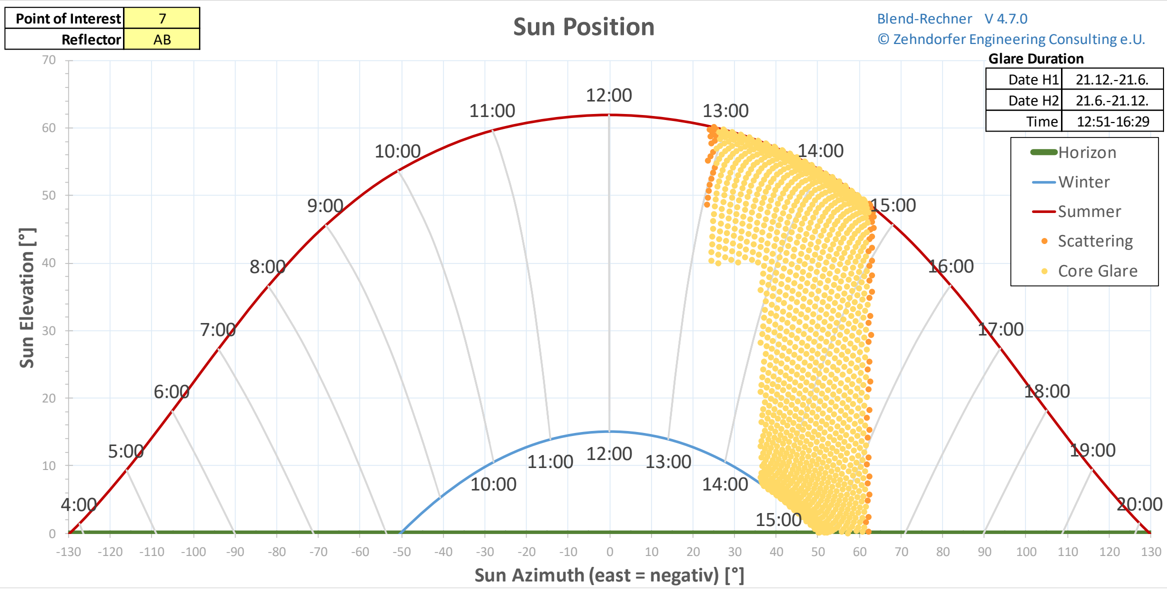
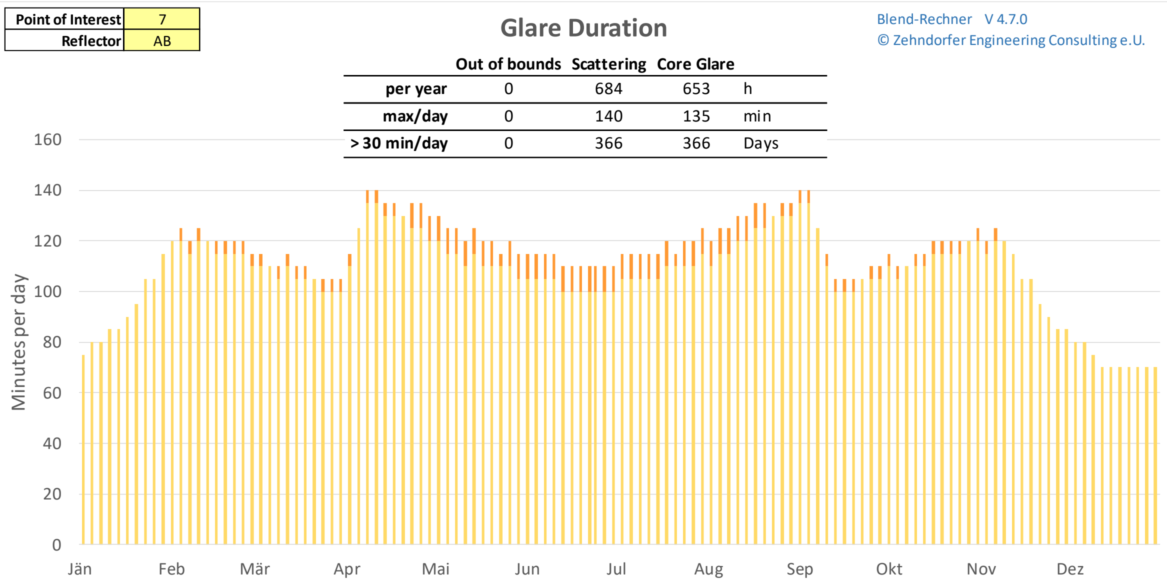
Elevation [°]
Line of Vision - Azimuth [°]
N
NE
E
Horizon
Reflector
1 h
3 h
4 h
5 h
7 h

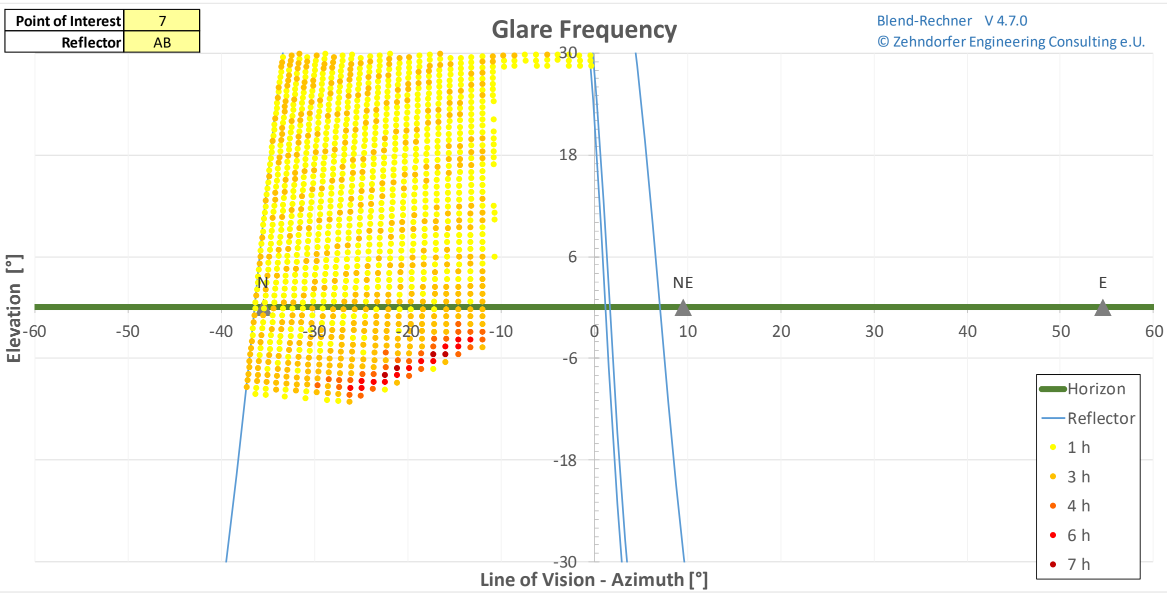

Point of Interest 6
Reflector ABG
Solar Glare Hazard Plot
Blend-Rechner V 4.7.0
© Zehndorfer Engineering Consulting e.U.
Retinal Irradiance [W/cm²]
Subtended Source Angle [mrad]
Potential for Permanent Eye Damage (retinal burn)
Potential for After-Image
Low Potential for After-Image

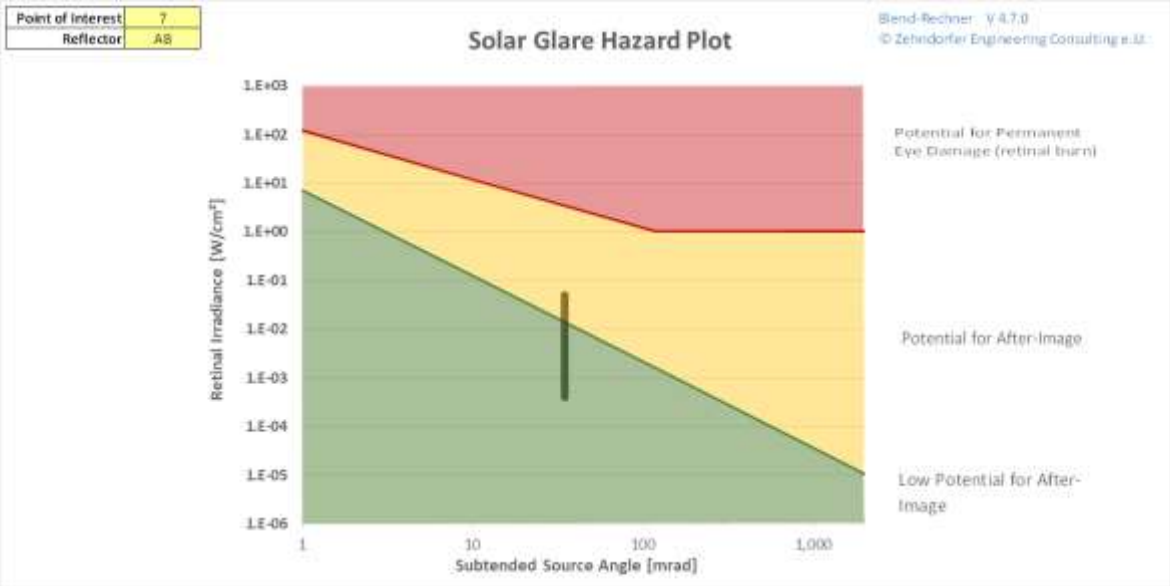

Sun Reflection
Blend-Rechner V 4.7.0
© Zehndorfer Engineering Consulting e.U.





	Out of bounds	Scattering	Core Glare	
per year	0	684	653	h
max/day	0	140	135	min
> 30 min/day	0	366	366	Days





You can find background notes, legal regulations and assessment examples regarding Solar Glare at

www.zehndorfer.at