URS

DOCKET	
08-AFC-5	
DATE	JUN 10 2010
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June 10, 2010

Mr. Christopher Meyer
Project Manager
Attn: Docket No. 08-AFC-5
California Energy Commission
1516 Ninth Street
Sacramento, CA 95814-5512

Subject: Imperial Valley Solar (formerly Solar Two) (08-AFC-5)
Applicant's Submittal of SunCatcher Glint Conversions and Hazard Assessment

Dear Mr. Meyer:

On behalf of Imperial Valley Solar (formerly Solar Two), LLC, URS Corporation Americas (URS) hereby submits SunCatcher Glint Conversions and Hazard Assessment.

I certify under penalty of perjury that the foregoing is true, correct, and complete to the best of my knowledge. I also certify that I am authorized to submit on behalf of Imperial Valley Solar, LLC.

Sincerely,

Angela Leiba
Project Manager

AL: ml

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SunCatcher™ Glint Conversions and Hazard Assessment

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06/08/2010

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Section 1 Introduction:

The SunCatcher™ is comprised of up to forty individual parabolic mirrors organized in a radial fashion on a steel support structure as indicated in Figure 1, below.

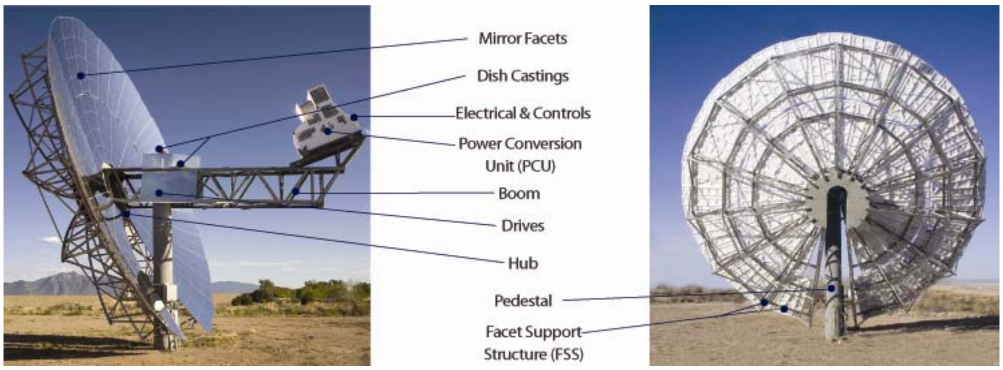

Figure 1 Key components of a SunCatcher™ System

The solar mirrors are designed to track the sun and project reflected light into the aperture of a power conversion unit, PCU.

However the reflective nature of the mirrors could present a number of viewing hazards to both people working in the solar field or passerby on local roads etc.

In this document, we describe these hazards, their severity and the distances at which the SunCatcher™ may be safely viewed.

We will provide established safe optical exposure limits, show experimentally measured data, and calculate the relationship between these values.

Finally, we will show that possible SunCatcher™ optical hazards are mitigated by either distance or standard operating procedures.

Section 2 Summary of Results:

The results of this analysis indicate that the SunCatcher™ is,

- Not optically dangerous to human sight at ranges exceeding the safety zone of 17 ft for glare hazards.

- Not optically dangerous to human sight at ranges exceeding the safety zone of 100 ft for glint hazards.

Glint hazards can be further mitigated,

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- by modifying the slewing angle of the dish as it comes on and off sun (4)

Where,

Glare is defined as continuous source of excessive brightness, relative to ambient lighting also know as diffuse reflections.

Figure 2 Schematic showing primary source of glare on SunCatcher™ system

Glint is defined as a flash of light, also known as specular reflection, produced as a direct reflection of the sun in the parabolic mirror surface of the SunCatcher™

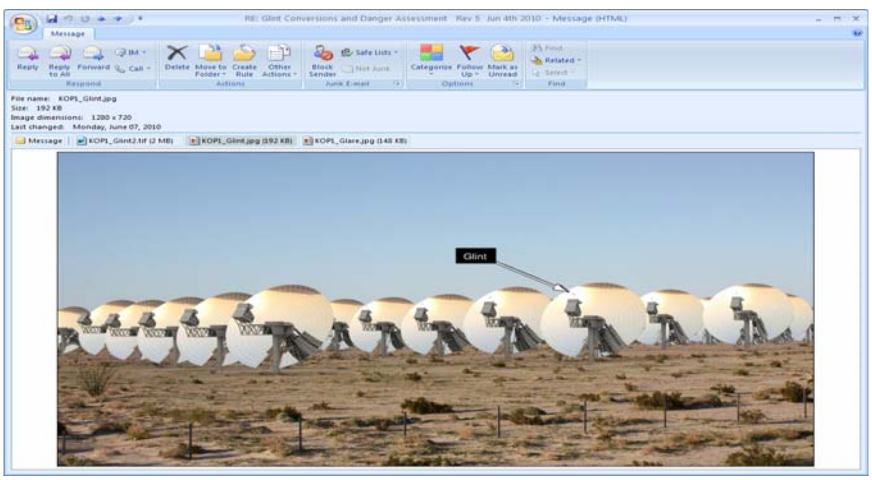

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Figure 3 Schematic showing glint from edge of SunCatcher™ ,
Glint is seen predominantly when a dish is off set tracking

Section 3.0 Optical Hazards Mitigation Requirements:

The key optical hazard mitigation requirements are that we should neither thermally damage, optically blind, nor optically "flash blind" observers.

Optical "flash blinding" can be considered to be a situation where an "after image" of the dangerous light-source causes an after-image to obstruct the field of view of the observer.

The values of theses optical safety metrics are explained in Ho et al. (1) (2), and a figure is reprinted here,
Figure 4, for clarity.

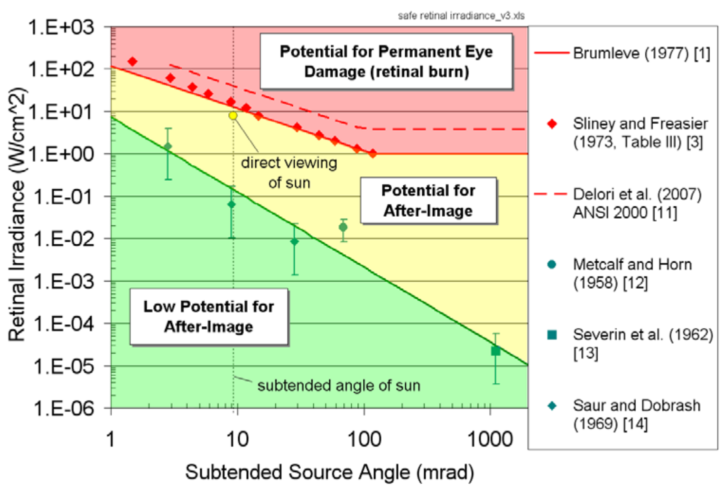

Figure 4 Potential impacts of retinal irradiance as a function of subtended source angle for 0.15 second exposure (typical blink response), (2). (1000 mrad = 57°)

The subtended source angle (ω) is the angle created by an object viewed by an external source, Figure 5

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Figure 5
Illustration of a subtended angle of a viewing point, in this case a person, to a radiation source. The closer a person stands to the source the larger the angle

As we are discussing the impact of light radiation on the eye it should also be noted that the larger the subtended angle i.e. the closer you are to the source the larger the area of one's retina that is exposed and the safe retinal irradiance threshold therefore diminishes (2).

According to Ho et al, (1) safe retinal irradiance value from viewing the sun is 12.6 W/cm^{-2} where the subtended angle is 0.52° (9.3 mrad).

Section 3.1: Introduction to Analysis

An optical study of the luminance values of Suncatcher™ systems was carried out at the Tessera Solar Maricopa facility, April 14^{th} 2010.

Measurements were taken throughout the day from dawn to dusk using a calibrated UBS spectrophotometer. The largest luminance value measured was 117,521 lux from an effective area of 0.283 m^2. This represents the largest luminance for a dish while tracking the sun in normal operation, and the worst measured case for observer exposure to glare. This occurs at the aperture of the power conversion unit, PCU. Values are reported in reference (5).

A similar luminance value has been calculated for the most optically dangerous situation we have yet predicted – exposing the observer to the direct focused energy of the dish.

In this case, we predict that the luminance of a 4 inch diameter patch would be approximately 1.3×10^8 lux with a solid angle of 3.77 sr. This is where a dish with the sun reflected in it is pointing directly at an observer. This value should represent the worst case scenario for observer exposure to glint.

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Luminance is a measure of how bright a surface appears when viewed from a given direction. It is measured in candela/meter^2 or lux .

A body of literature (1), (2), (3), exists that enable the incorporation of luminance measurements with values such as diameter of the pupil of an eye, refractive index of eye fluid, the subtended or solid angle of radiation entering the eye, surface area of retina effected etc. This literature in conjunction with luminance measurements was used to evaluate the irradiance thresholds for potential retinal burns, flash blindness of glint and glare from the SunCatcher™ System

Section 3.2 Analysis

Sliney (3) reports that the *threshold irradiance for potential retinal burn*, $E_{r,burn}$, is,

$$E_{r,burn} = \frac{0.168\, E_r \frac{W}{cm^2}}{\omega}$$

ω is the subtended angle in radians.

Likewise, a potential for after image occurs when the irradiance exceeds $E_{r,flash}$, where

$$E_{r,flash} = \frac{3.59 \times 10^{-8}\, E_r \frac{W}{cm^2}}{\omega^{1.77}}$$

In order to use these values, we need to calculate the retinal irradiance (W/cm^{-2}) from the illumination sources on the dish i.e. glint on the dish and glare from aperture of the PCU.

We note that the irradiance from an extended source can be calculated from the luminance and solid angle of the source, as

$$E = \left(\frac{n_2}{n_1}\right) L \Omega_s$$

Where,

E = irradiance,

L = luminance,

n_1 = index of refraction in medium where luminance is measured i.e. air = 1.0

n_2 = index of refraction in medium where irradiance is to be calculated, eye fluid = 1.34

Ω_s = subtended angle of the source

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And

$$\Omega = 2\pi \ (1 - \cos\omega)$$

The effective solid angle can be found from the area of the radiator in the space of the image, A_s, and the distance from the image of the aperture, l, as,

$$\Omega_s = \frac{A_s}{l^2}.$$

Similarly, the solid angle of the pupil of the eye can be found from,

$$\Omega_p = \pi\frac{D_p^2}{4l^2}.$$

Where,

D_p^2 = diameter of the pupil of the eye (about 2mm when accustomed to daylight)
f' = focal length of the uncorrected eye (about 17 mm)

For a human bystander, the aperture stop of the system is the smaller of the two solid angles, or Ω_p. We can use the equivalence principle to replace Ω_s with Ω_p, allowing us to calculate the retinal irradiance as

$$E = \left(\frac{n_2}{n_1}\right)L\pi\frac{D_p^2}{4l^2}.$$

Section 3.3 Results

A graphical summary of the results is presented below, Figure 6. The spreadsheets of the calculations are presented in Appendix A.

Coupled with previous studies/ submissions, (4), (5) and the Glint Mitigation plan the SunCatcher™ under normal operation conditions is,

- Not optically dangerous to human sight at ranges exceeding the safety zone of 17 ft for glare hazards.
- Not optically dangerous to human sight at ranges exceeding the safety zone of 100 ft for glint hazards.

For someone working in the solar field it is always recommended if a PCU aperture is being viewed while on sun or mirror areas with glint that a welding glass is used to protect a person's eyes.

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Furthermore when the SunCatcher™ is off set tracking, modification of the offset tracking angle, for example from 10° to 25° will minimize unnecessary glint from the dish.

Spreadsheets of the calculations are also presented in the attached spread-sheets. Appendix A.

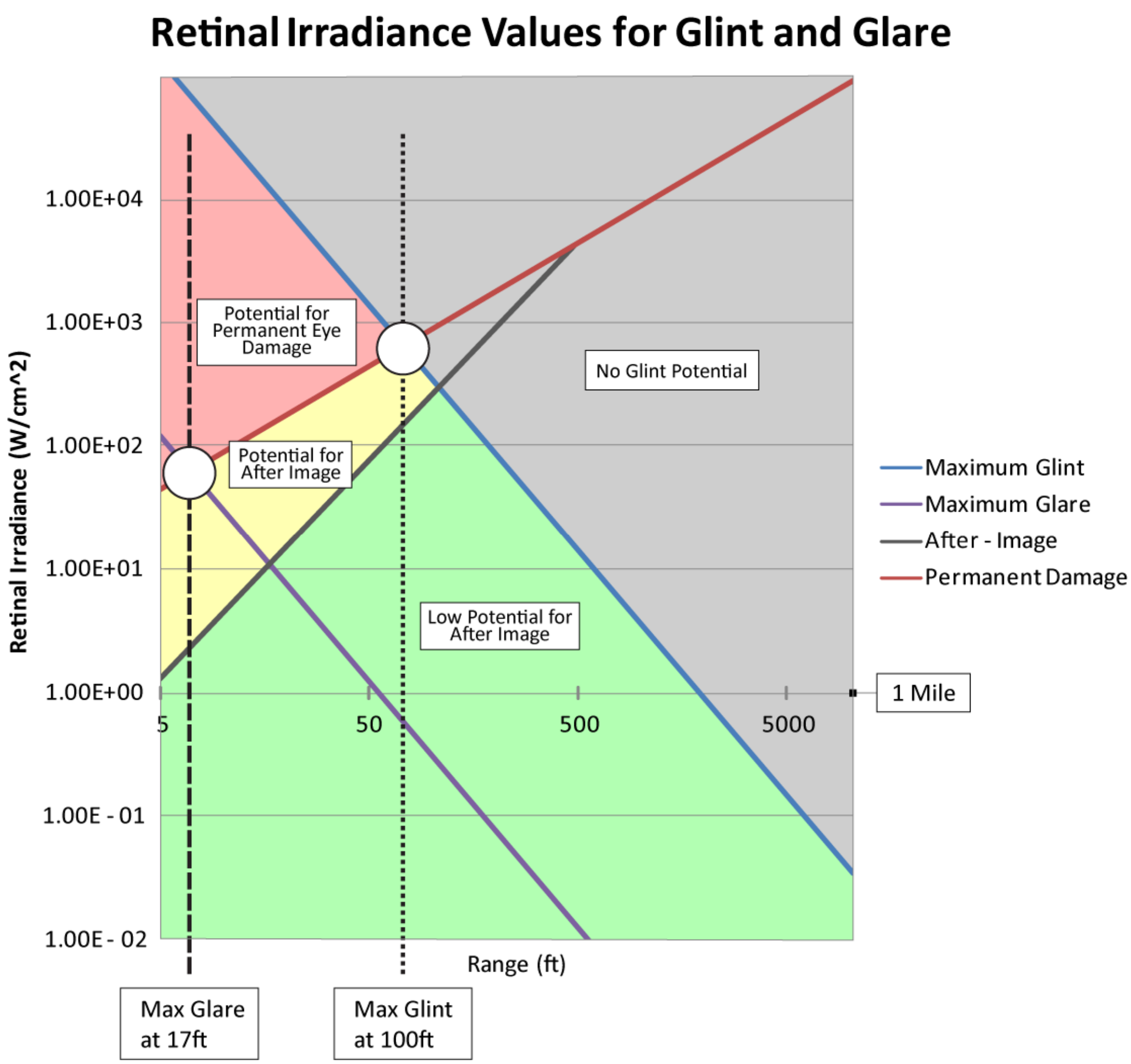

Figure 6 Retinal irradiance values for glint and glare hazards in the vicinity of a SunCatcher™ system. Axes - log/log scale

Bibliography:

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1. *Hazard Analyses of Glint and Glare from Concentrating Solar Power Plants.* **Ho, Clifford K., Ghanbari, Cheryl M. and Diver, Richard B.** Berlin, Germany, September 15-18 : s.n., 2009. proceedings of SolarPACES 2009.

2. *Methodology to Assess Potential Glint and Glare Hazards from Concentrating Solar Power Plants: Analytical Models and Experimental Validation.* **Ho, Clifford K., Ghanbari, Cherul M. and Diver, Richard B.** Phoenix, AZ : s.n., 2010. Proceedings of the 4th International Conference on Energy Sustainability.

3. *Evaluation of Optical Radiation Hazards.* **Sliney, D. H. and Freasier, B. C.** 1, 1973, Applied Optics, Vol. 12, pp. 1-24.

4. *Imperial Valley Solar Project, Glint / Glare Study*, **Tessera Solar & Power Engineers**, April 26 2010, pp 20

5. *Report for URS on SunCatcher™ Luminances*, **Lighting Sciences Inc**, April 20 2010, pp 3

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Appendix A

Table 1 Assessment of Glint from SunCatcher™ under normal tracking conditions

Range (ft)	Range (m)	Range (miles)	Ωsource (sr)	Ωpupil-object (sr)	Ωlimiting (sr)	Eretinal(W/m2)	Eretinal(W/cm2)	ωlimiting (rad)	Eburn-limit (W/cm2)	Eflash-limit (W/cm2)	Optical Risk
5	1.524	0.00094697	3.60325E-05	5.41052E-06	5.41052E-06	13.49934476	134993.4476	0.00262467	44.95802581	1.32840988	Permanent Damage
10	3.048	0.001893939	9.00813E-06	1.35263E-06	1.35263E-06	3.374839461	33748.39461	0.001312336	89.91601289	4.530591002	Permanent Damage
15	4.572	0.002840909	4.00361E-06	6.0117E-07	6.0117E-07	1.499928919	14999.28919	0.000874891	134.8740086	9.286163485	Permanent Damage
16	4.8768	0.003030303	3.5188E-06	5.28372E-07	5.28372E-07	1.318296924	13182.96924	0.00082021	143.8656081	10.40991444	Permanent Damage
17	5.1816	0.003219697	3.117E-06	4.68039E-07	4.68039E-07	1.167764767	11677.64767	0.000771962	152.8572075	11.58909109	Permanent Damage
18	5.4864	0.003409091	2.78029E-06	4.17479E-07	4.17479E-07	1.04161735	10416.1735	0.000729075	161.8488072	12.82292541	Permanent Damage
19	5.7912	0.003598485	2.49533E-06	3.74691E-07	3.74691E-07	0.934858795	9348.58795	0.000690703	170.8404068	14.11070303	Permanent Damage
20	6.096	0.003787879	2.25203E-06	3.38158E-07	3.38158E-07	0.843710069	8437.10069	0.000656168	179.8320065	15.45175694	Permanent Damage
30	9.144	0.005681818	1.0009E-06	1.50293E-07	1.50293E-07	0.374982269	3749.822693	0.000437445	269.7480045	31.67082537	Permanent Damage
40	12.192	0.007575758	5.63008E-07	8.45396E-08	8.45396E-08	0.21092753	2109.275303	0.000328084	359.6640031	52.69882585	Permanent Damage
60	18.288	0.011363636	2.50226E-07	3.75731E-08	3.75731E-08	0.09374557	937.4557037	0.000218723	539.4960011	108.0146002	Permanent Damage
80	24.384	0.015151515	1.40752E-07	2.11349E-08	2.11349E-08	0.052731883	527.3188301	0.000164042	719.3280038	179.7314297	After-Image
100	30.48	0.018939394	9.00813E-08	1.35263E-08	1.35263E-08	0.033748405	337.484052	0.000131234	899.1600039	266.780911	After-Image
120	36.576	0.022727273	6.25565E-08	9.39328E-09	9.39328E-09	0.023436393	234.3639303	0.000109361	1078.991993	368.388062	None
140	42.672	0.026515152	4.59599E-08	6.90119E-09	6.90119E-09	0.017218574	172.1857387	9.37383E-05	1258.824013	483.9509862	None
160	48.768	0.03030303	3.5188E-08	5.28372E-09	5.28372E-09	0.013182972	131.8297162	8.2021E-05	1438.65596	612.9811167	None
200	60.96	0.037878788	2.25203E-08	3.38158E-09	3.38158E-09	0.008437101	84.37100864	6.56168E-05	1798.320054	909.8668944	None

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Table 2 Assessment of Glare from SunCatcher™ under normal tracking conditions

Range (ft)	Range (m)	Range (miles)	Wsource (sr)	Wpupil-object (sr)	Wlimiting (sr)	Eretinal(W/m2)	Eretinal(W/cm2)	wlimiting (rad)	Eburn-limit (W/cm2)	Eflash-limit (W/cm2)	Optical Risk
5	1.524	0.00094697	0.095703244	5.41052E-06	5.41052E-06	0.012203512	122.0351151	0.00262467	44.95802581	122.0351151	Permanent Damage
6	1.8288	0.001136364	0.066460586	3.75731E-06	3.75731E-06	0.008474664	84.74664114	0.002187226	53.94962151	84.74664114	Permanent Damage
7	2.1336	0.001325758	0.048828186	2.76047E-06	2.76047E-06	0.006226285	62.26285321	0.001874765	62.94121844	62.26285321	After-Image
8	2.4384	0.001515152	0.03738408	2.11349E-06	2.11349E-06	0.004767	47.67000435	0.00164042	71.93281613	47.67000435	After-Image
9	2.7432	0.001704545	0.029538038	1.66992E-06	1.66992E-06	0.003766519	37.66519261	0.001458151	80.92441434	37.66519261	After-Image
10	3.048	0.001893939	0.023925811	1.35263E-06	1.35263E-06	0.003050881	30.50880833	0.001312336	89.91601289	30.50880833	After-Image
11	3.3528	0.002083333	0.019773397	1.11788E-06	1.11788E-06	0.002521389	25.21389259	0.001193033	98.90761173	25.21389259	After-Image
12	3.6576	0.002272727	0.016615146	9.39328E-07	9.39328E-07	0.002118667	21.18667454	0.001093613	107.8992107	21.18667454	After-Image
13	3.9624	0.002462121	0.014157285	8.00374E-07	8.00374E-07	0.001805255	18.05255168	0.001009489	116.89081	18.05255168	After-Image
14	4.2672	0.002651515	0.012207046	6.90119E-07	6.90119E-07	0.001556572	15.56572099	0.000937383	125.8824092	15.56572099	After-Image
15	4.572	0.002840909	0.010633694	6.0117E-07	6.0117E-07	0.001355947	13.55947281	0.000874891	134.8740086	13.55947281	After-Image
16	4.8768	0.003030303	0.00934602	5.28372E-07	5.28372E-07	0.001191751	11.9175056	0.00082021	143.8656081	11.9175056	After-Image
17	5.1816	0.003219697	0.008278827	4.68039E-07	4.68039E-07	0.001055668	10.55668332	0.000771962	152.8572075	11.58909109	None
18	5.4864	0.003409091	0.00738451	4.17479E-07	4.17479E-07	0.00094163	9.416300968	0.000729075	161.8488072	12.82292541	None
19	5.7912	0.003598485	0.006627648	3.74691E-07	3.74691E-07	0.00084512	8.451195419	0.000690703	170.8404068	14.11070303	None
20	6.096	0.003787879	0.005981453	3.38158E-07	3.38158E-07	0.00076272	7.627203924	0.000656168	179.8320065	15.45175694	None
21	6.4008	0.003977273	0.005425354	3.06719E-07	3.06719E-07	0.00069181	6.918098848	0.000624922	188.8236062	16.84546194	None
22	6.7056	0.004166667	0.004943349	2.7947E-07	2.7947E-07	0.000630347	6.303474415	0.000596516	197.8152058	18.2912302	None
23	7.0104	0.004356061	0.004522838	2.55696E-07	2.55696E-07	0.000576726	5.767262065	0.000570581	206.8068056	19.78850743	None
24	7.3152	0.004545455	0.004153787	2.34832E-07	2.34832E-07	0.000529667	5.296669533	0.000546807	215.7984052	21.33676944	None
25	7.62	0.004734848	0.00382813	2.16421E-07	2.16421E-07	0.000488141	4.881410659	0.000524934	224.7900051	22.93551945	None

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APPLICATION FOR CERTIFICATION FOR THE
IMPERIAL VALLEY SOLAR PROJECT
(formerly known as SES Solar Two Project)
IMPERIAL VALLEY SOLAR, LLC

Docket No. 08-AFC-5

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(Revised 5/10/10)

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DECLARATION OF SERVICE

I, Corinne Lytle, declare that on June 10, 2010, I served and filed copies of the attached, Applicant's Submittal of SunCatcher Glint Conversions and Hazard Assessment. The original documents, filed with the Docket Unit, are accompanied by a copy of the most recent Proof of Service list, located on the web page for this project at: [http://www.energy.ca.gov/sitingcases/solartwo/index.html]

The documents have been sent to both the other parties in this proceeding (as shown on the Proof of Service list) and to the Commission's Docket Unit, in the following manner:

(*Check all that Apply*)

FOR SERVICE TO ALL OTHER PARTIES:

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______ by personal delivery;

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AND

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__X__ sending an original paper copy and one electronic copy, mailed and emailed respectively, to the address below (*preferred method*);

OR

_____ depositing in the mail an original and 12 paper copies, as follows:

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Sacramento, CA 95814-5512
docket@energy.state.ca.us

I declare under penalty of perjury that the foregoing is true and correct, that I am employed in the county where this mailing occurred, and that I am over the age of 18 years and not a party to the proceeding.

___________Original Signed By_________
Corinne Lytle

*indicates change