BrightSource

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May 23, 2012

Pierre Martinez
Project Manager
Systems Assessment & Facility Siting Division
California Energy Commission
1516 Ninth Street, MS-15
Sacramento, CA 95814

Subject: Supplemental Response to Data Requests, Set 1B, #143 and #144 (11-AFC-04)

Dear Mr. Martinez:

On behalf of Rio Mesa Solar I, LLC, Rio Mesa Solar II, LLC, and Rio Mesa Solar III, LLC, please find enclosed a copy of our Supplemental Response to Data Requests #143 and #144. Electronic copies will be sent to the Staff and the Proof of Service List.

Sincerely,

Todd A Stewart

Todd Stewart
Director, Project Development

Enclosure

Cc: POS List
Project File

BrightSource Energy, Inc.
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SRSG and Heliostat Irradiance and Luminance Data

Background:

This document is BrightSource's response to Dr. Gregg Irvin's request in his email of 3rd May 2012:

> "The bottom line from my perspective is that the appropriate assessment of the impact of reflected solar energies by either the heliostats or the tower SRSGs on human observers requires knowledge of both the retinal irradiance (W/m2, from the perspective of ocular damage and hazards) and the luminance (cd/m2, from the perspective of glint, glare, apparent brightness and visual salience). Like we had discussed there are no issues with eye safety and MPEs. However, sufficient information is lacking with respect to luminance for a cogent assessment of glint, glare and apparent brightness effects.
>
> What I could really use is both irradiance and luminance for the SRSGs at a small set of ranges on the ground during nominal plant operational conditions (like 200, 500, 2000, 5000 and 20000 meters) and for the heliostats in standby at a small set of intercept airborne ranges (like 1000, 5000, 10000, and 20000 meters with respect to the tower SRSG). This would essentially close out all of the glint and glare issues."

Response:

The following describe the irradiance and luminance of the SRSG and heliostats at the distances requested by Dr. Irvin for the purpose of glint, glare and apparent brightness calculations. The SRSG irradiance is calculated assuming a SRSG operating at maximum capacity conditions and includes both the flux reflected by the SRSG itself and the adjacent refractory material.

There are several assumptions in the following calculation that are conservative; that is, applying these conservative assumptions, actual potential impacts will be even less than the calculated values. To begin, the irradiance calculations assume an observer at the same elevation as the SRSG (750 feet above ground) when, in reality, observations would be made from ground-level, or in the hypothetical case of aerial observation, at several thousand feet above the SRSG. Thus, it is reasonable to assume a further reduction in the irradiance for an observer on the ground close to the receiver. As a second conservative assumption for far distant observers is that the potential effects would be further attenuation by the viewing distance due to the atmosphere. This distance attenuation is not included in the following calculations. Therefore the actual luminance for the observer at a distance greater than 1000m will be less than the numbers quoted here (i.e., this is a worst case scenario).

The irradiance was converted to luminous flux using the luminous efficacy of the direct and circumsolar component of the standard air mass 1.5 spectrum, which is calculated to be approximately 110 lm/W (ASTM 173G). The luminance was directly calculated using the solid angle subtended by the receiver and the luminous flux. Because the SRSG is a diffuse source, both the irradiance experienced by an observer and the solid angle subtended by the SRSG as seen by that observer decrease as the inverse square of the distance from the source. Therefore, as may be seen in the following table, irradiance decreases with distance while the luminance of the SRSG stays constant with distance.

Distance From SRSG [m]	Irradiance [W/m^2]	Luminance [kcd/m^2]
200	76	2.3x10^2
500	12	2.3x10^2
1,000	3.0	2.3x10^2
2,000	0.76	2.3x10^2
5,000	0.12	2.3x10^2
20,000	0.008	2.3x10^2

The following calculation also include certain conservative assumptions that tend to overstate the calculated potential impacts compared to the expected potential impacts. The heliostat irradiance is calculated using a ray-tracing method, assuming 1kW/m^2 Direct Normal Irradiance (DNI) (the maximum value for DNI) and 95% heliostat reflectivity (i.e., a 5% loss, which is typical for a very clean mirror). The sun and the observer are also both assumed to be directly normal (the optimal orientation). All of the above conservative assumptions represent "worst case" assumptions which are not expected to typically occur simultaneously, if at all. Furthermore attenuation due to the atmosphere will have significant effect at large distances and is not included in the following.

The solid angle subtended by the light source was also calculated using ray-tracing method. Using a luminous efficacy of 110 lm/W, the irradiance and the solid angle subtended by the light source the luminance was calculated. The following gives the irradiance and luminance for heliostats with focal distance of 250m, 450m and 1000m.

Distance From Heliostat [m]	250m Focus		450m Focus		1000m Focus	
	Irradiance [W/m^2]	Luminance [kcd/m^2]	Irradiance [W/m^2]	Luminance [kcd/m^2]	Irradiance [W/m^2]	Luminance [kcd/m^2]
1,000	103	5.9×10^5	227	1.3×10^6	252	1.5×10^6
5,000	2.7	4.6×10^5	7.1	1.0×10^6	9.7	1.4×10^6
10,000	0.62	4.3×10^5	1.8	1.0×10^6	2.4	1.4×10^6
20,000	0.15	4.2×10^5	0.44	1.0×10^6	0.60	1.4×10^6

By way of further background, please note the following observations. With respect to luminance for the heliostats, the luminance does not stay the constant with distance because the heliostat is not a diffuse source like the SRSG but rather a focusing specular light source. Also, with respect to irradiance for the heliostats, the irradiance does not decrease inversely proportionally to the distance from the heliostat at all distances (but do so at large enough distances). The solid angle subtended by the light source does not decrease inversely proportionally to the square of the distance; rather, for distances of the order of the focal length of the heliostat, the solid angle is that of the entire reflective area of the heliostat. For distances much farther or closer than the focal length, the subtended angle is smaller than that of the entire area of the heliostat due to rays from the sides of the heliostat either reflecting at a too large an angle (when the observer is very far) or too small an angle (when the observer is very close) to reach the observer. For an observer just at the mirror surface, the angle subtended is roughly that of the sun. Finally, while we have confidence in these calculations, especially given the conservative assumptions employed, our models are created to calculate potential effects within our working range) i.e., within distances associated with reflection from the farthest heliostats to the tower’s SRSG.

BEFORE THE ENERGY RESOURCES CONSERVATION AND DEVELOPMENT COMMISSION OF THE STATE OF CALIFORNIA
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APPLICATION FOR CERTIFICATION
FOR THE *RIO MESA SOLAR ELECTRIC GENERATING FACILITY*

DOCKET NO. 11-AFC-04
PROOF OF SERVICE
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*indicates change

DECLARATION OF SERVICE

I, Michelle L. Farley, declare that on May 23, 2012, I served and filed a copy of the attached Supplemental Response to Data Requests #143 and #144, dated May 23, 2012. This document is accompanied by the most recent Proof of Service list, located on the web page for this project at: http://www.energy.ca.gov/sitingcases/riomesa/index.html

The document has been sent to the other parties in this proceeding (as shown on the Proof of Service list) and to the Commission's Docket Unit or Chief Counsel, as appropriate, in the following manner:

(*Check all that Apply*)

For service to all other parties:

_X__ Served electronically to all e-mail addresses on the Proof of Service list;

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AND

For filing with the Docket Unit at the Energy Commission:

_X__ by sending electronic copies to the e-mail address below (preferred method); *OR*

____ by depositing an original and 12 paper copies in the mail with the U.S. Postal Service with first class postage thereon fully prepaid, as follows:

CALIFORNIA ENERGY COMMISSION – DOCKET UNIT
Attn: Docket No. 11-AFC-4
1516 Ninth Street, MS-4
Sacramento, CA 95814-5512
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OR, if filing a Petition for Reconsideration of Decision or Order pursuant to Title 20, § 1720:

____ Served by delivering on this date one electronic copy by e-mail, and an original paper copy to the Chief Counsel at the following address, either personally, or for mailing with the U.S. Postal Service with first class postage thereon fully prepaid:

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I declare under penalty of perjury under the laws of the State of California 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.

Michelle L. Farley

*indicates change